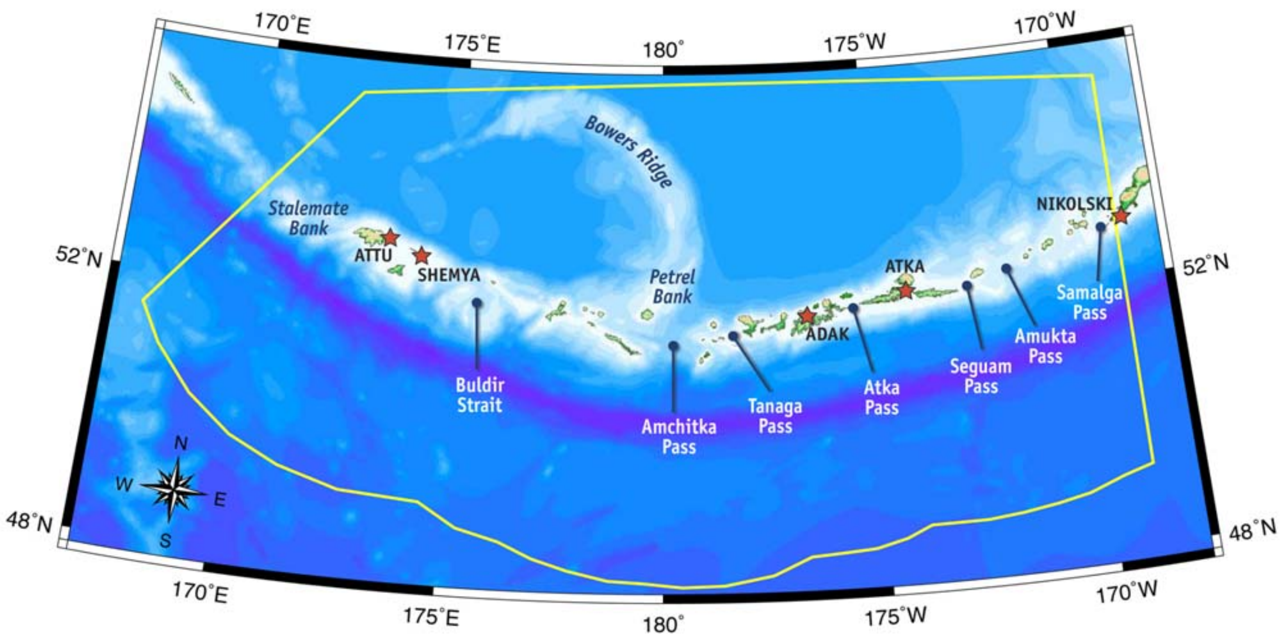
Aleutian Islands Fishery Ecosystem Plan

December 2007



"Our creation story tells us that we dropped from the heavens above onto these islands that stretch across the stormy seas like a lifeline."

by Allan Hayton, Alaska Initiative for Community Engagement
(http://www.alaskaice.org/material.php?matID=535)

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List of Acronyms

AAC	Alaska administrative code
ABC	acceptable biological catch
ACC	Alaska Coastal Current
ADF&G	Alaska Department of Fish and Game
AFSC	Alaska Fisheries Science Center (of the National Marine Fisheries Service)
AI	Aleutian Islands
ANSC	Aleutian North Slope Current
APAWSA	Aleutian Ports and Waterways Safety Assessment
BSAI	Bering Sea and Aleutian Islands
BSC	Bering Sea Current
C	Celsius
CDQ	community development quota
cm	centimeter(s)
Council	North Pacific Fishery Management Council
DIC	dissolved inorganic carbon
DNA	deoxyribonucleic acid
DOE	US Department of Energy
E	east
EAF	ecosystem approach to management
EBS	eastern Bering Sea
EEZ	exclusive economic zone
EFH	essential fish habitat
EPA	US Environmental Protection Agency
EPAP	Ecosystem Principles Advisory Panel
ESA	Endangered Species Act
F	Fahrenheit
FAO	U.N. Fishery and Agriculture Organization
FATE	AFSC Fate and the Environment program
FEP	Fishery Ecosystem Plan
FIT	AFSC Fisheries Interaction Team
FMP	fishery management plan
ft	foot/feet
HAPC	habitat area of particular concern
IFQ	individual fishing quota
INPFC	International North Pacific Fisheries Commission
IPHC	International Pacific Halibut Commission
IWC	International Whaling Commission
km	kilometer(s)
m	meter(s)
M/V	master vessel
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MMPA	Marine Mammal Protection Act
mph	miles per hour
MSA	Magnuson-Stevens Fishery Conservation and Management Act
mt	metric ton(s)
mtDNA	mitochondrial DNA
N	North
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
NRC	National Research Council
OFL	overfishing level
OY	optimum yield
pCO^2	partial pressure of carbon dioxide
pH	potential of hydrogen (measure of acidity)
PL	Public Law
POP	Pacific ocean perch
PSC	prohibited species catch
PSEIS	Alaska Groundfish Fisheries Preliminary Supplemental Environmental Impact Statement
s	second
S	South
SAFE	Stock Assessment and Fishery Evaluation
SHARC	Subsistence Halibut Area Registration Certificate
SSC	North Pacific Fishery Management Council's Scientific and Statistical Committee
SSL	Steller sea lion
TAC	total allowable catch
TALK	total alkalinity
US	United States
USFWS	US Fish and Wildlife Service
USGS	US Geological Service
W	West
WWII	World War II

1 Introduction

The North Pacific Fishery Management Council (hereafter 'the Council') is faced with a growing national momentum to adopt an ecosystem approach to fisheries management. NOAA has articulated a mission goal that management should "be adaptive, specified geographically, take account of ecosystem knowledge and uncertainties, consider multiple external influences, and strive to balance diverse societal objectives" (NOAA 2004). In many ways, the Council's current management approach reflects these elements. Where possible, and given the current level of understanding, ecosystem considerations are incorporated into North Pacific fishery management, particularly with regard to conservative harvest levels and spatial and temporal closure areas to protect vulnerable species. Yet there is always progress to be made, especially as pertains to the development of a formal process to integrate ecosystem considerations.

A great deal of national attention has focused on the concept of Fishery Ecosystem Plans (FEPs; NOAA 1999, Sissenwine and Mace 2003). Yet examples of FEPs or other types of fishery ecosystem management documents, both nationally and internationally, are few. There is no template for their development and implementation, nor is there a clear and direct relationship to the fishery management plans (FMPs) that currently authorize Federal fisheries under the Magnuson-Stevens Fishery Conservation and Management Act.

The Council has a unique opportunity to take the lead in moving forward with an ecosystem approach to fishery management and to design a FEP that is appropriate and useful to Alaskan fishery management. The Council has chosen the Aleutian Islands as the pilot ecosystem area for this first Alaskan FEP. The Aleutian Islands area is an ideal candidate as it is ecologically and historically unique in several aspects. Many Council management actions in the past have focused on the area's important resources, such as Steller sea lions, seabirds, benthic habitats that support coral and sponges, and other special resources of public interest (such as deep sea coral gardens). The Aleutian Islands have also been at the center of allocation issues related to the Aleutian Islands pollock and Pacific cod fisheries. Far less is understood about the ecological interactions in the Aleutians than in the eastern Bering Sea, yet the two areas are managed conjointly in the Federal fishery management plans. The Council recognizes that the Aleutian Islands contain unique and valuable ecological qualities that should be preserved, and wishes to build upon past actions by considering fishery interactions and cumulative impacts within this ecosystem more explicitly. Applying an ecosystem approach to fisheries management through the implementation of a FEP may promote this goal.

1.1 Purpose of the Fishery Ecosystem Plan

The Council has summarized the goal of the FEP with the following statement:

> *The goal of this FEP is to provide enhanced scientific information and measurable indicators to evaluate and promote ecosystem health, sustainable fisheries, and vibrant communities in the Aleutian Islands region.*

The Aleutian Islands (AI) ecosystem is complex, and the least predictable of the ecosystems in which the Council manages. This FEP is intended to be an educational tool and resource that can provide the Council with both an 'early warning system', and an ecosystem context to fishery management decisions affecting the Aleutian Islands area. This document should help the Council respond to changing conditions in a proactive rather than reactive mode.

Council purpose statement

The FEP document, and associated process, is anticipated to be evolutionary in nature; the purposes listed below are intended to be achieved over time. The purposes of the FEP are:

a. to integrate information from across the FMPs with regard to the Aleutian Islands, using existing analyses and reports such as the Groundfish PSEIS, the EFH EIS, and the Ecosystem Considerations chapter

   NOTE: this integration should be user-friendly, i.e., short, simple, and avoiding redundancy

b. to identify a set of indicators for the Aleutian Islands to evaluate the status of the ecosystem over time

c. to provide a focal point to develop and refine tools, such as ecosystem models to evaluate the indicators

d. to identify sources of uncertainty and use them to determine research and data needs

e. to assist the Council in (1) setting management goals and objectives, and (2) understanding the cumulative effects of management actions

1.2 Scope and role of the FEP

The scope of the FEP encompasses all Federal fisheries within the area, and considers the interactions of Federal and State fisheries with each other, and with other components of the ecosystem. Figure 1-1 is a conceptual illustration of the scope of the FEP, encompassing relationships among fisheries, prey and predators of target and non-target species, their habitat, the impacts of climate, and the cumulative impact on ecosystems from all fisheries and non-fishing impacts.

The Ecosystem Principles Advisory Panel (NOAA 1999) describes the role of the FEP to:

- "provide Council members with a clear description and understanding of the fundamental physical, biological, and human/institutional context of ecosystems within which fisheries are managed; [and]
- direct how that information should be used in the context of FMPs…".

Consequently, the FEP was developed to provide the Council with an understanding of important relationships among ecosystem components, which are not always considered together by managers. The FEP also identifies areas of uncertainty, describes how the Council may currently be addressing the associated risk, and provides suggestions for other tools the Council may wish to consider.

The FEP is intended to be a guidance document for the Council. The FEP does not authorize management measures or changes to fishery regulations. Under the Magnuson-Stevens Act, only a FMP can authorize regulations to implement management measures. The role of the FEP is to provide an understanding of the ecosystem context in which the FMPs operate, thereby assisting the Council to better integrate ecosystem principles into fishery management. Because the FEP evaluates relationships among components of the ecosystem that are typically managed separately, this geographically-based ecosystem perspective may suggest areas for changes and improvements, which would be implemented through the normal fishery management plan amendment process.

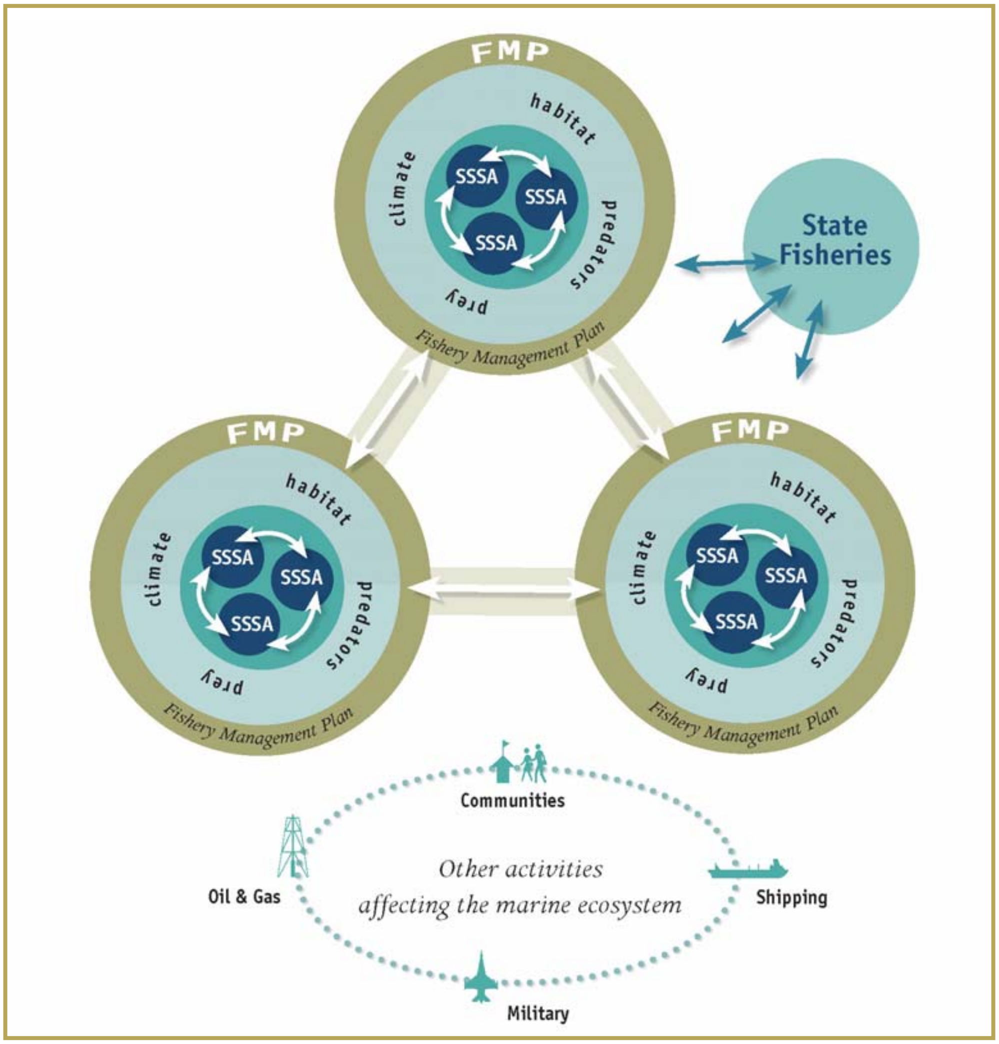

Figure 1-1 Scope of a Fishery Ecosystem Plan.

Note: FMP = Federal Fishery Management Plan, SSSA = single species stock assessments

1.3 Implementation and use of the FEP

To be effective, the FEP should annually provide information to the Council process at every level: stock assessment scientists, FMP teams, the Council's Scientific and Statistical Committee (SSC) and Advisory Panel, and the Council itself (Figure 1-2). Integration and information-sharing must begin at an early stage in the process to develop recommendations for the Council. The FEP document also needs to be a living document, in which ecosystem goals, indicator status, research priorities, and data gaps are updated on a 3-5 year schedule or more frequently as necessary. Updates to the FEP should be coordinated with programmatic reviews of the Council's FMPs.

The FEP has been written by the Aleutian Islands Ecosystem Team, as appointed by the Council (see Section 2.1). The Council has directed the team to remain active. The team will have the following tasks. The Team is to refine the FEP on a periodic basis as new information becomes available. The Team will bring forward the assessment of FEP indicators and AI modeling to the Plan Teams, on an annual basis, and will report to the SSC with regard to the FEP indicators and updates to the document. Finally, the Team will serve as a conduit for the Council to provide Aleutian Islands FEP information to other agencies, through the Alaska Marine Ecosystem Forum. Section 8.1, at the end of this document, addresses this issue further.

The first iteration of the AI FEP has been prepared by synthesizing currently available information about the Aleutian Islands ecosystem. In evaluating this information, many research and data gaps have been highlighted, as have areas where information may be available but has not yet been analyzed in the context of the AI ecosystem. As such, the FEP process has identified many areas that the Council may choose to focus on to improve its understanding of the ecosystem's interactions. In the short-term, however, the FEP can be used to improve management action analyses, and to provide a broader context for actions affecting the AI ecosystem.

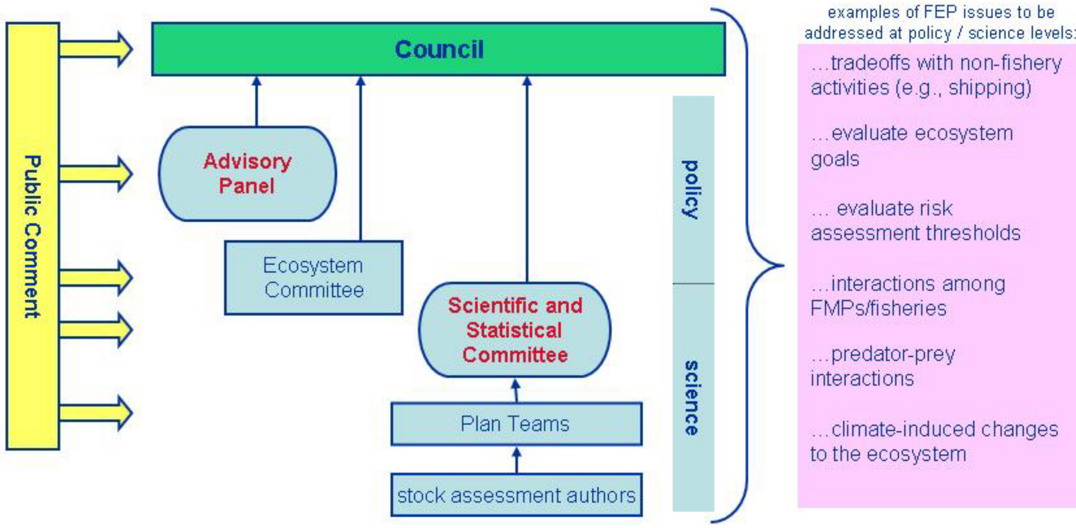

Figure 1-2 Schematic of how the FEP will interact with the Council process

Stakeholder participation is an important element of any form of ecosystem-based management. The AI Ecosystem Team attempted to contact and consult with communities located within or close to the ecosystem area, during the development of the FEP. Appendix A summarizes the outreach efforts made during the FEP development.

Relationship of the FEP to other Council documents and projects

The idea for the FEP began originally as part of the Council's programmatic review of the groundfish fisheries, completed in 2004 (NMFS 2004). As part of that process, the Council analyzed a component looking at 'area-specific management for the Aleutian Islands'. After initiating a discussion paper on this component in June 2004 (NPFMC 2005), the Council determined that a Fishery Ecosystem Plan was the appropriate way to move forward.

The FEP draws on many existing Council documents for its information, in particular the Alaska Groundfish Fisheries Programmatic Supplemental Impact Statement (NMFS 2004), the Environmental Impact Statement for the Identification and Conservation of Essential Fish Habitat (NMFS 2005), and the annual Ecosystem Considerations report that is part of the annual groundfish Stock Assessment and Fishery Evaluation reports (Boldt 2006). The FEP has a different perspective than these documents, however. The purpose of the FEP is to look holistically at the AI ecosystem, at the relationships between the different FMP fisheries, physical and biological characterstics of the ecosystem, human communities, and other socio-economic activities ongoing in the ecosystem area. This FEP demonstrates that the interactions and relationships within the AI area are clearly distinct from neighboring ecosystems, yet the AI is rarely considered as an independent ecosystem in current fishery management.

It is the Council's intent that the improved understanding and information provided from the FEP's perspective on the AI ecosystem will feed back into the Council process, and, as appropriate, into stock assessments and management analyses affecting the area. The relationship between the FEP and other Council documents and projects will therefore hopefully be a synergistic one. The FEP has no legal standing, and is purely a guidance document and resource for the Council. If the Council decides to initiate any action as a result of the evaluations in the FEP, those actions will be subject to the existing process for analysis.

1.4 Approach of this document

The approach of this document is somewhat different than a standard Council management analysis. The intent of the FEP is to look at the AI ecosystem in a holistic fashion, and not to parse out impacts on a species by species basis. The FEP approach is to look at the interactions and relationships of the AI ecosystem as a whole, and evaluate whether there is anything critical to our understanding of the ecosystem that is being missed through our current management process.

Chapter 3 describes the ecosystem, beginning with a historical overview, and addressing the ecosystem's current physical, biological, socioeconomic, and management relationships.

Chapter 4 develops a framework of the key interactions in the AI ecosystem. The AI Ecosystem Team has identified 22 critical interactions that characterize the ecosystem, recognizing that other interactions exist and that this list will change over time. Each of the interactions is analyzed through a non-quantitative risk assessment, and a discussion of implications of the assessment for managers. Also, indicators for monitoring each interaction and research needed to better understand the interaction are identified.

Chapter 5 compares the critical interactions to the existing management objectives for the individual fisheries in the ecosystem.

Chapter 6 synthesizes implications for the Council based on the evaluation in the FEP. The chapter also highlights some broad considerations for the Council resulting from the AI perspective of the document.

Chapter 7 reflects on the benefit of the FEP as a tool for ecosystem-based management. Through the development and use of the AI FEP, the Council has the opportunity to determine whether a FEP will be useful for Alaskan fishery management, or whether other ecosystem tools are equally effective.

Chapter 8 identifies future steps for the FEP.

In summary, the Aleutian Islands FEP:

- describes and synthesizes some of the main ecosystem processes and interactions,
- delineates the regulatory and bio-physical boundaries of the Aleutian Islands,
- conducts a qualitative risk assessment of AI interactions,
- uses management objectives of Aleutian Islands fisheries to identify Council priorities for the FEP,
- identifies ecological indicators appropriate to monitor key ecosystem interactions,
- identifies knowledge gaps and research needs, and
- provides a framework by which ecosystem considerations identified herein could be implemented within the current Council structure and management practice.

2 Geographic definition of Aleutian Islands ecosystem

The Aleutian-Commander Island archipelago extends more than 3,000 km between Alaska and Russia, and forms the southern border of the Bering Sea. The Aleutian Islands portion ranges from Unimak Island to Attu Island, approximately from 165º W. to 170º E. longitude. Numerous straits and passes through the Aleutian Islands connect the Bering Sea to the North Pacific Ocean (Figure 2-2). The islands are mostly peaks of steep submarine volcanoes, so the exposed portions are surrounded by narrow shelves descending to a steep dropoff. This subarctic region is highly productive, and the richness in marine life includes large concentrations of seabirds, marine mammals, sessile invertebrates, and fish.

Native Aleuts have occupied the islands for over 10,000 years, living off the marine bounty. Influxes of other people have occurred in waves (e.g., fur harvests following Bering's voyage in 1741, commercial fishing and whaling beginning in 1850, military during World War II and the cold war, and modern commercial fishing).

For the purposes of this Fishery Ecosystem Plan, the Aleutian Islands ecosystem is defined as the portion of the archipelago ranging from Samalga Pass (at 169ºW) to the western boundary of the exclusive economic zone, at 170ºE (Figure 2-1). Samalga Pass represents a known ecological boundary with the neighboring eastern Bering Sea and Gulf of Alaska ecosystems (described further in Section 3.2; Hunt and Stabeno 2005). This boundary is also approximately similar to an important management boundary for the Federal groundfish fishery.

Spatial variation is high along the longitudinal axis of the islands, and there is some evidence that there may be other ecological boundaries within the identified Aleutian Island ecosystem (Logerwell et al. 2005, Ortiz 2007). Nevertheless, this iteration of the FEP focuses at the ecosystem scale, and on the characteristics and relationships that make the AI ecosystem uniquely distinct from its neighboring ecosystems.

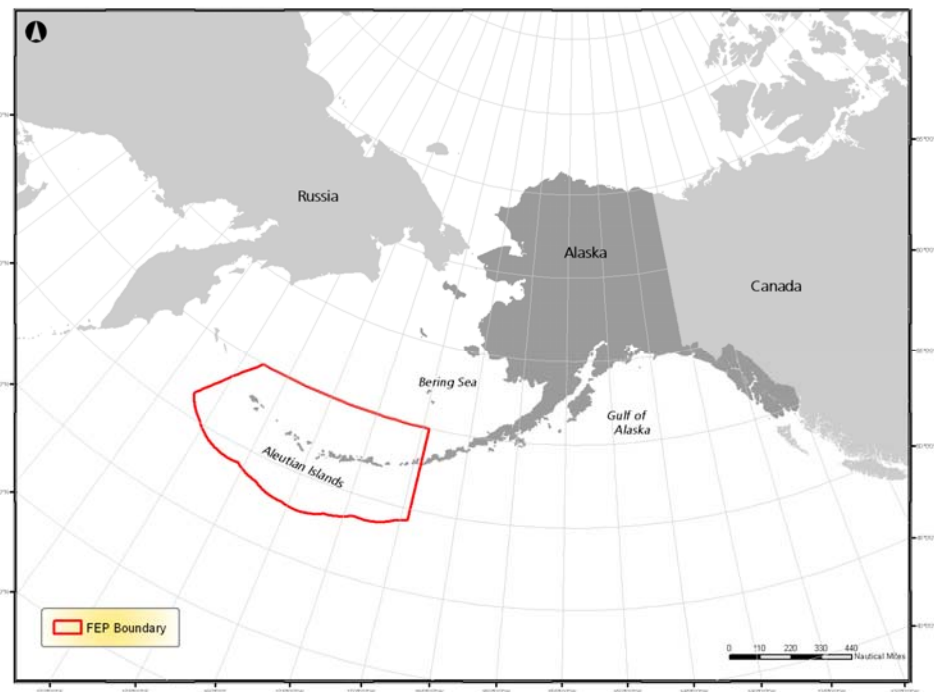

Figure 2-1 Boundary for the Aleutian Islands Fishery Ecosystem Plan

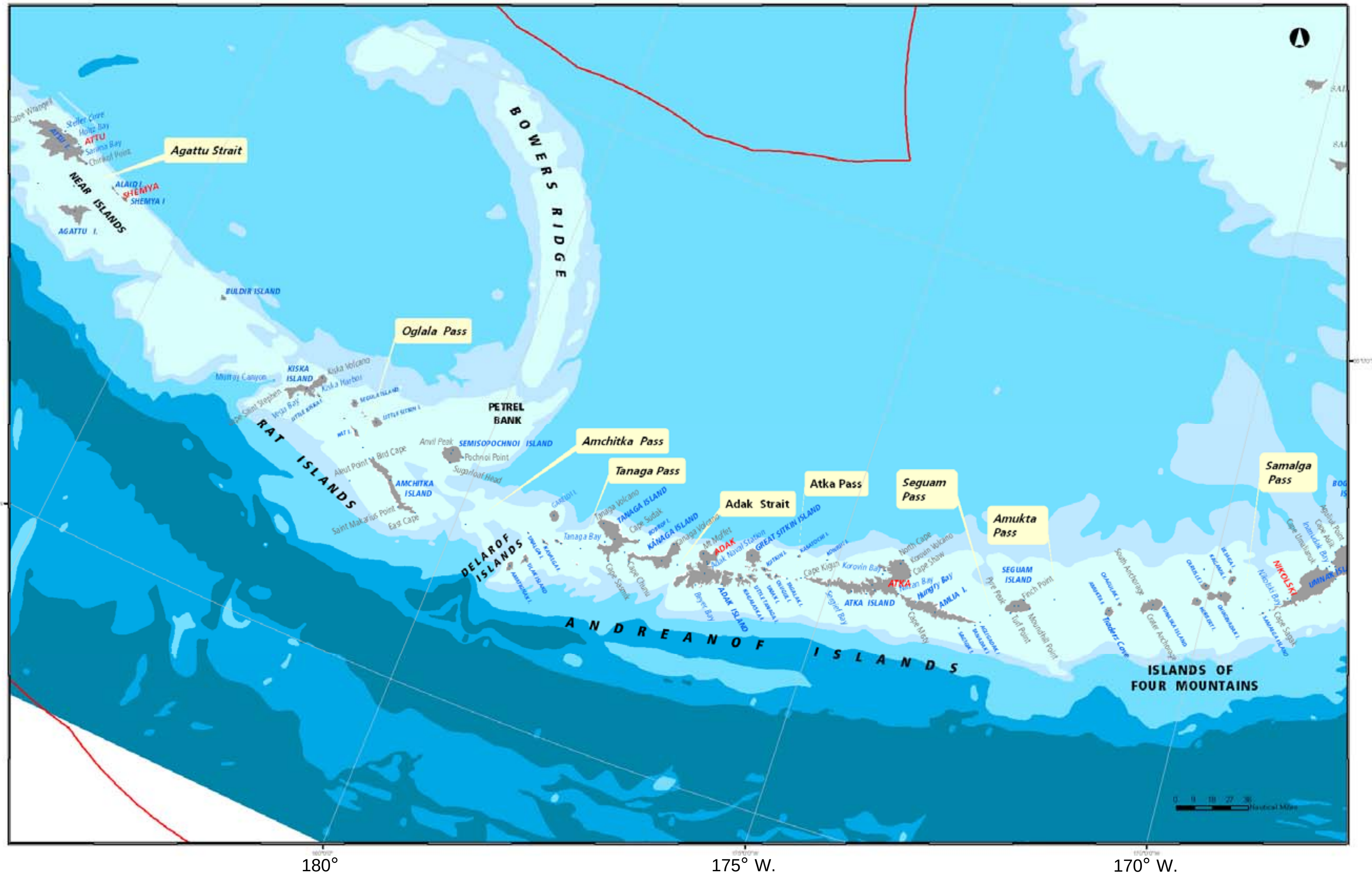

Figure 2-2 Map of the Aleutian Islands ecosystem

3 Understanding the Aleutian Islands ecosystem

3.1 Historical perspectives

3.1.1 Aleutian human populations

Early Aleutian history

Both archaeological excavations and ethnographies of the Aleutian archipelago continue to challenge and refine theories of Aleutian prehistory. Standard perspectives for American scholars have maintained that humans entered the Aleutian Islands from the east, perhaps 8000 or 9000 years ago, traveling down through the Alaska Peninsula and spreading slowly to the far western islands (Laughlin 1963; McCartney 1984). Researchers have maintained that once established in the islands, these Paleo-Aleuts evolved in relative isolation, and were buffered from contact with other groups until Russian traders arrived in the 18th century (Laughlin 1980:22). This assumption has been challenged by recent evidence. Recently examined evidence and excavations indicates Aleuts engaging in a lengthy history of profound movement, contact, and integration with other coastal areas of Alaska for 10,000 years (Black 1984; 1983; Knecht 2001:276). These findings, and early ethnographic material, suggest that “Aleutian prehistory is complex and dynamic, as one would expect in a similarly well-populated region with a rich resource base” (Knecht 2001: 279) and a picture emerges of a dynamic culture with sophisticated technology adapted to a dependence on the sea “as the direct or indirect provider of virtually all basic necessities of life” (Veltre and Veltre 1980:12).

At the time of Russian contact in 1741, the population in the Aleutian Islands and Alaska Peninsula was estimated at 12,000 – 15,000 (McCartney 1984, Lantis 1984) although some evidence suggests it may have been higher. Most Aleuts lived on the larger eastern islands although settlements extended all the way to Attu, the island farthest west. Settlements were usually in defensible areas near natural resources – around coves and bays, rookeries, reef systems yielding subsistence resources at low tide, and near passes that channeled fish and sea mammals. Complex and flexible settlement patterns were critical to survival, as people often moved between permanent and seasonal settlements following fish or marine mammal migrations.

Harbor seals and sea lions were the mammals of greatest importance to the Aleut diet and provided materials important for non-food uses such as clothing and construction. Whales, beached or hunted, were also an important resource that was surrounded with particular ceremonialism. Generally, although there were periods of hardship and starvation, the Aleuts maintained themselves for several millennia and were adept at exploiting every part of their environment.

The Aleut autonym (the name Aleut people call themselves) is Unangan, meaning ‘the people.’ ‘Aleut’ itself is a term that was applied by the Russians to all natives in the area, regardless of ethnicity or language.

Russian and American colonial periods

When the survivors of Vitus Bering’s second (1741) expedition across the northern Pacific Ocean returned to Russia, they carried with them news of a “great land.” More importantly, they bore hundreds of valuable sea otter pelts that would soon prompt a “fur rush” through the Aleutian Islands, leading to a wave of Russian colonization and competition for land and resources with Spanish, British, and American rivals (Gibson 1996). The fur trade and Russian occupation of Aleutian territory resulted in precipitous declines in Aleut populations. By some accounts, the population was literally decimated (Jones 1976:18) or by more conservative estimates, the decline was at least 20% during the first 75 years of contact (Veltre and Veltre 1980:26). Much of this decline in population was due to epidemic, violent conflict with Russians and Tlingit, and forced resettlement and impressment into the labor force, especially to harvest fur seals in the previously unoccupied Pribilof Islands (Black et al.1999).

With the ascencion of Russian-American Company control over Alaska's commercial activity in 1799, some of the more oppressive practices towards Aleuts were halted, but not before Company officials relocated entire populations of Eastern Aleuts. The Russian American Company maintained the political independence of Aleut polities and made it a policy to use and retain Aleut environmental knowledge and traditional skills in areas like watercraft construction, hunting, trapping, fishing, and architecture (Black et al.1999). The portion of today's Aleutian residents who are the descendants of unions between Russian men and Native women often bear Russian family names, and maintain cultural and religious practices of both Russian and Native influence.

The United States purchased Alaska in 1867 bringing administrative changes that replaced a governmentally regulated economy with a *laissez-faire* capitalist system. For the first fifteen years of US rule, Alaska was designated a "department" under military jurisdiction. Aleuts and other Native Alaskans were slotted into a highly racialized regime in which "social mobility of Natives and people of mixed origin became nearly impossible" and the only social services available were those offered by the Orthodox Church (Black 1999:16).

Not long after the purchase of Alaska, the vacancy left by the departure of the Russian-American Company was filled by the North America Commercial Company and the Alaska Commercial Company. The Eastern Aleutians were invaded by an influx of people seeking quick, easy wealth – an immigration unprecedented under Russian settlement restrictions. With an additional dismantling of Russian conservation restrictions, and additional pelagic sealing by Canadians and Japanese, the sea otter and fur seal populations were decimated by the end of the century. Local Aleut communities were able to profit from the sea otter industry, but the eventual monopolization of the fur industry by the Alaska Commercial Company limited their successful economic participation. Nearly extinct, sea otters were protected internationally by a complete ban on hunting in 1911 – "the first international convention aimed at conservation and protection of wildlife" (Black 1999: 17), and the Aleutians were designated a wildlife reservation in 1913.

With the decrease in seal and sea-otter populations, fox farming became an important fur source in the Aleutians, with Unalaska serving as an important distribution location for pelts. Although foxes had originally been introduced by Russians on several islands in the early 1800s, the United States government promoted fox farming as an economic program for the territory. Fox farm leasing peaked between 1910 and 1925. High fur prices after World War I accelerated the industry, however, the world market for fur declined during the Depression. Trapping in the Aleutians remained an important activity for residents of Atka, Umnak, and Unalaska into the second half of the 20th century, though the market for their long fur was never the same as it was before the Depression (Ross Oliver 1988).

Commercial fishing for cod and salmon was developing as rapidly as the fur industry was declining, and by the early 1900s, commercial fishing became the largest source of employment in the Aleutians. Herring fisheries also began to emerge in the 1920s, leading to a cottage industry of salted herring. Canneries often employed local workers seasonally, but typically relied on imported labor, especially from China and Japan.

The educational system also changed dramatically with the sale of Alaska to the United States. Bilingual schools opened in the Russian period were entirely sustained by local Orthodox Church congregations between 1867 and 1884. In 1884 Dr. Sheldon Jackson, a Presbyterian missionary, became the General

Agent for Education in Alaska. During that same year, the Organic Act "authorized the support of mission schools and the right of missions to claim up to 640 acres of land" (Black 1999: 20). Jackson partitioned Alaska into 'spheres of influence,' assigning different religious denominations to each area (excluding the Orthodox Church). The Aleutian area fell under the sphere of influence of the Methodist Church. For the most part, Aleut-led Orthodox Church community schools could not compete with this public school system, and eventually they closed down.

In 1924 Congress granted all Native Americans Citizenship. The citizenship status of Aleuts, however, remained ambiguous until 1936, when the Indian Reorganization Act of 1934 was applied to Alaska, granting native limited sovereignty to indigenous groups and establishing several Alaskan reservations (Black, 1999). It was also under the authority of the 1936 act that Aleut groups later organized into "tribes," a legal term that denotes "Native American communities, which exercise powers of self-government" (Black, 1999). Alaska has had a lengthy history of native participation in elections. Native candidates began to be elected routinely to the territorial legislature in 1944.

World War II

Unalaska was attacked by Japanese forces on June 3 and 4, 1942, due to the recently built up US military presence of over 50,000 personnel. A few days later, the Japanese took Attu Island, and brought all 42 Aleut villagers to prison camps in Japan where 16 died during three year's internment. Aleut villages at Akutan, Biorka, Kashega and Makushin and Nikolski were all forcibly evacuated by the United States government on July 6, 1942. Atka was forcibly evacuated on June 14, 1942 and the village was burned to the ground by the US Navy. The Aleut residents of Unalaska were forcibly removed on July 22nd. All of the evacuations took place with little advance notice and few belongings permitted. Virtually everything not taken was destroyed or looted during the war. Along with the residents of the Pribilof Islands (also forcibly evacuated), the entire Aleut population of 820 men women and children was sent to internment camps in Southeast Alaska where they were kept under horrendous conditions for three years (Kohlhoff 1995).

Population and villages since World War II

The modern population history of humans the Aleutian Islands is dominated by the continuing consolidation of villages and a decline in the Native population due to the effects of World War II on the Aleut people. At one time there were more than 100 villages in the Aleutians. At the beginning of World War II there were eight Aleut villages in the islands, but only four villages survived (Akutan, Atka, Nikolski, and Unalaska).

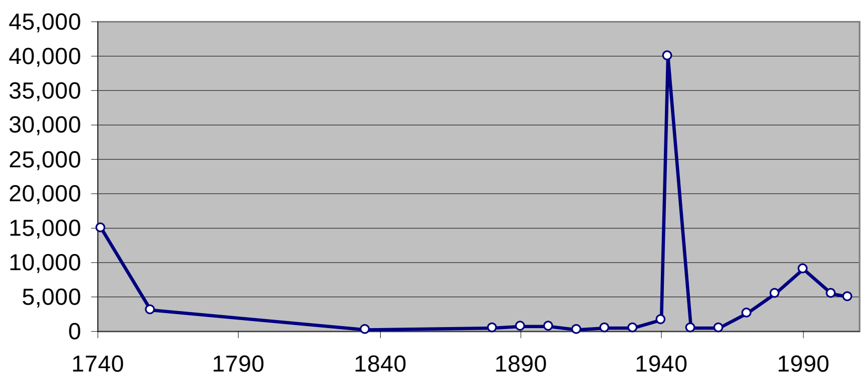

Figure 3-1 Estimated population trend of the Aleutian archipelago, 1740-2006.

NOTE: Based on community data from US Census and State of Alaska Department of Commerce, Community, and Economic Development.

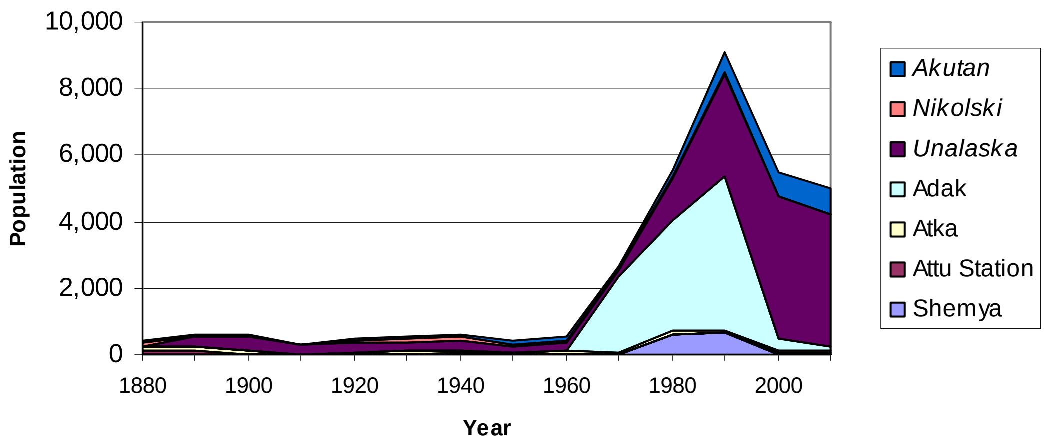

Figure 3-2 Populations for present-day Aleutian Islands communities, 1880-2000.

NOTE: Does not include estimates of military personnel stationed in the Aleutian Islands during World War II. Villages listed in italics are not located in the ecosystem area.
Source data: US Census and State of Alaska Department of Commerce, Community, and Economic Development.

Following the war, the government repatriated villagers to Akutan, Atka, Nikolski and Unalaska. Villagers from Biorka, Kashegan, and Makushin were compulsorily resettled in Unalaska, while villagers from Attu were compulsorily resettled at Atka. These regroupings were not easily absorbed in the social landscape (for example, Atkans and Attuans spoke different dialects and had longstanding rivalries) and village fidelity remains high to this day. Four village locations have been lost, and numerous individuals (who died in Japan and in the internment camps). In 1988, the United States government apologized to the Aleut people and authorized financial reparations to survivors and communities.

Following World War II, several military bases remained active through the cold war era. Adak was used as a U.S. Navy base, with up to 6,000 personnel, until it was closed in 1997. When the base closed, the occupied part of the island reverted to the US Fish and Wildlife Service (Adak is part of the Alaska Maritime National Wildlife Refuge), and was subsequently traded to the Aleut Corporation, which is promoting the location as a commercial center and fishing community. It is also the site of a recent national Missile Defense System installation. Shemya also has remained active since WWII and currently supports missile defense operations, and Attu continues to support a Coast Guard Loran Station.

Other population changes in the Aleutians have been associated with the development and globalization of the fishing industry (Sepez et al. in press). First came the king crab boom from the late 1960s until 1982, followed by the Americanization of the deep sea fishing fleet under the Magnuson Act, in the early 1980s. Much of the industrial effect of these fisheries has been centered east of the FEP area in Unalaska and Akutan. Contemporary Atka and Adak, both villages within the FEP ecosystem area, are discussed in Section 3.4.

3.1.2 Aleutian animal populations

Changes in human populations and their marine-related activities often resulted in direct or indirect changes in marine animal populations (Figure 3-3). Below is a synopsis of the main documented changes, organized by ecosystem components.

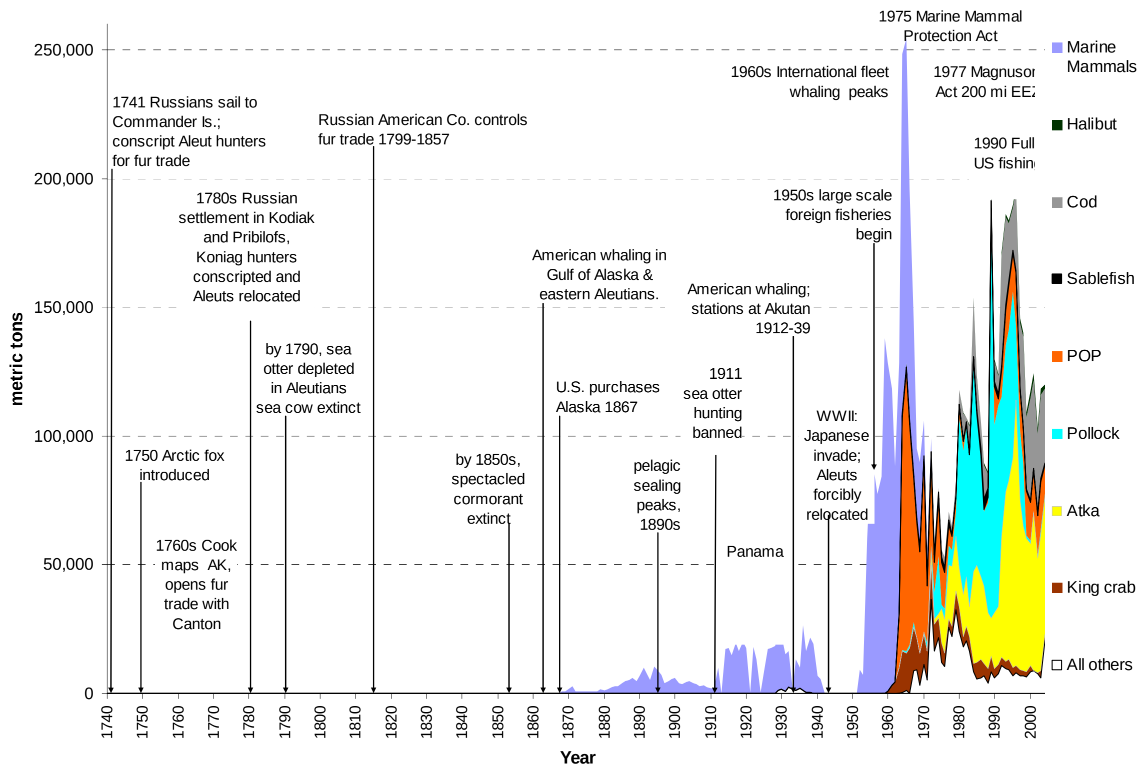

Figure 3-3 Aleutian Islands socio-ecological history (1740-2005): significant impacts on Aleuts, commercial exploitation, and species introductions and extinctions.

Modified from Ortiz (2007).

NOTE: Some early (pre-1950) biomass removals which are included do not show up at this scale (e.g., sea otters, salmon, Pacific cod).

- An estimated 500,000 sea otters were removed from the Aleutians and far Western Gulf of Alaska between 1742 and 1792 (derived from Kenyon 1969, Lensink 1960), which averages approximately 250 tons of otters annually over this period. Better records from later years suggest that sea otter removals peaked in 1805 at over 400 tons, then steadily declined.
- Salmon catch records from the Aleutians show intermittent catches from 1911 through 1927 ranging from 24 to 1800 tons annually (INPFC 1979). No salmon catches were recorded for this area again until 1951.
- The schooner fishery for Pacific cod operated in the western Gulf of Alaska and eastern Bering Sea between 1865 and 1950 (Mohr 1977, Shields 2001); this fishery likely did not range into the Aleutians, although we include information here for context. Overall the landings from the Gulf of Alaska are estimated to have ranged from 1,000 to 3,000 tons of Pacific cod annually between 1865 and 1900, increasing to a maximum of 6,800 tons in 1906 and remaining in the range of 2,000 to 4,000 tons annually until the fishery shifted to the Bering Sea (where annual catches ranged from 10,000 to 20,000 tons at the height of the fishery from 1915-1935, Shields 2001, Paulson 2006 personal communication referencing Cobb 1915).

Marine Mammals

The Aleutian Island ecosystem is home or seasonal host to Steller sea lions, northern fur and habor seals, sea otters and many whale and porpoise species. Little is known about changes in mammal and bird populations prior the arrival of Russians in 1741, although there is indication of changes in abundance of mammals and birds based on archeological material from Aleut midden sites (Causey et al. 2005). After the arrival of Russian fur hunters, some marine mammal populations declined due to hunting. By the beginning of the 20th century, Steller sea cow (*Hydrodamalis gigas*) was extinct (Stejneger 1887, Anonymous 1892), and sea otter and sea lion populations in the region were substantially reduced (Alekseev 1990, Bureau of Fisheries, 1906). Northern fur seals, which forage near the Aleutians, also declined due to harvest on breeding grounds in the Pribilof Islands and by pelagic sealing (Reeves et al.

1992). By the early 1900s whaling in the region was beginning to deplete whale stocks of some species (Starbuck 1878, Tønnessen and Johnsen 1982, Shelden et al. 2005, Mizroch and Rice 2006).

Due to protective legislation for some of the marine mammals (e.g., Fur Seal Treaty, 1911) and changes in world markets (e.g., for fox fur and whales), marine mammal populations went through a period of recovery from 19th and early 20th century population lows. By the mid-1980s sea otters had recovered over most of the Aleutians (Doroff et al. 2003). Although whaling ended in 1972, sperm whales and possibly other whale stocks in the Aleutians remain depleted (Shelden et al. 2005, Mizrock and Rice 2006), even though slow recovery may now be underway.

Nevertheless, most marine mammals in the Aleutians have declined in the past 30 years. Although under the protection of the Marine Mammal Protection Act from 1972, Steller sea lions started declining in the mid 1970s throughout the eastern Aleutians. The decline extended to the central and western islands in the mid 1980s (Angliss and Lodge 2004), and its continuation resulted in their classification as “endangered” under the Endangered Species Act in 1997 (NOAA 2006, Appendix C). Northern fur seal (*Callorhinus ursinus*) pup production has declined in the Pribilof Islands since the mid-1970s, resulting in reduced populations passing through the Aleutians (NMFS 2004). Harbor seals (*Phoca vitulina*) also showed a decline between the late 1970s and the late 1990s (Small et al. submitted). Furthermore, sea otters have been declining since the mid-1980s, and consequently were listed as “threatened” under the Endangered Species Act in August 2005.

The Aleutian Island ecosystem is home or seasonal host to Steller sea lions, northern fur and harbor seals, sea otters, and many whale and porpoise species.

Seabirds

Bird populations declined due to predation by foxes introduced for fur production in the early 1900s (Gibson and Byrd 2007). Some endemic birds, like Aleutian Cackling goose (*Branta hutchensii leucopareia*) and formerly common, nearshore foraging short-tailed albatross (*Phoebastria albatrus*) – a species nearly extirpated by hunting for the feather trade on its breeding grounds in Japan, also were nearly extinct by 1930 (Byrd 1998, Tickell 2000).

Special management of terrestrial systems in the Aleutians resulted due to the establishment of the region as a wildlife reservation in 1913 and in 1980 as part of the National Wildlife Refuge System (formerly the Aleutian Islands National Wildlife Refuge and now the largest unit of the Alaska Maritime National Wildlife Refuge). One of the primary objectives of the Refuge has been to restore native bird populations, including more than 20 species of seabirds by removing introduced foxes. Arctic foxes were the original target of the fur traders, and they moved foxes to the Aleutians from the Commander Islands as early as 1750 (Black, 2004). Most islands in the Aleutians were stocked during the heyday of fox farming between about 1913 to 1940 (Bailey 1993). Foxes depleted multiple seabird populations and other endemic taxa, extirpating some species from the larger islands (Byrd et al 2005). Ongoing eradication efforts started in 1949 and by 2002 only 6 refuge islands still had non-native foxes (Ebbert 2000, Ebbert and Byrd 2002). Removal of foxes has allowed the restoration of most native birds through natural expansion (e.g., Byrd et al. 1994) or translocation (Byrd 1998). Aside from foxes, there have been a series of other introductions that have influenced seabird populations as well as the local flora. Norway rats were introduced in Rat Island after a Japanese shipwreck in 1780 (Black 1984) and have since become established on at least 11 additional islands larger than 500 ha (including Atka, Adak, Shemya, and Attu) and dozens of nearby satellite islands (Bailey 1993, Murie 1959). Rats are voracious predators with the potential to extirpate ground nesting seabirds such as Cassin’s auklets, storm petrels, tufted puffins (Bailey 1993) and an effect on auklets on Kiska has already been documented (Major et al. 2006). They also cause economic damage in communities. Ground squirrels were introduced at first by Native Alaskans and early Russians for clothing (parkas) and food (Ebbert and Byrd 2002). They were later introduced again by American ranchers as food for foxes after the seabirds had declined and the islands were running short on food supplies. Arctic ground squirrels are known to take passerine eggs, chicks and eggs of seabirds (Geist 1933; Sealy 1966). The impacts of both rats and squirrels extend to the local flora: they feed on stalks, stems, seeds and fruits, thereby modifying the plant communities and affecting the associated fauna (Courchamp et al. 2003, Bailey 1993).

Although not well documented, native animal populations were further stressed by habitat destruction and the presence of large numbers of troops during World War II (WWII) on islands such as Atka, Adak, Amchitka, Kiska, Shemya, and Attu. Shipwrecks, cargo transfer, and fuel spills certainly had at least short-term negative impacts on animal populations, and the introduction of rats on several islands caused serious modifications to native biodiversity from intertidal invertebrates to nesting seabirds (e.g., Croll et al. 2005).

Most of the population reductions of birds occurred decades ago following various introductions, but as indicated above, some species recovered following removal of foxes. Independent of invasive species-related changes, no widespread declines of seabird populations have been detected throughout the Aleutians in the past 30 years, eventhough there have been local declines for several species of nearshore feeders (cormorants, gulls, and pigeon guillemots; Byrd et al. 2005). Today, the ecosystem area hosts approximately thirty species of breeding seabirds.

Fish

Little is known about fluctuations in marine fish populations prior to the start of the commercial fisheries in the early 1900s, and prior to that period, fish take consisted mainly of localized harvests (Figure 3-3). Fish and crab populations that have exhibited significant declines, at least in part due to fisheries, include Pacific Ocean perch and red king crab. The first was severely depleted in the 1960s by the foreign fishery and current estimates seem to indicate the stock has been consistently increasing since the 1990s (Spencer et al. 2004). In contrast, the American fleet obtained record catches of red king crab during the early 1960s both off Adak and Dutch Harbor and the stocks have not recovered, remaining at low levels and in some cases forcing the fishery to close (NPFMC 2006).

A summary of the history of commercial exploitation is provided below. Figure 3-4 and Figure 3-5 illustrate the stock assessment estimated biomass trends and survey biomass trends for species in the Aleutians.

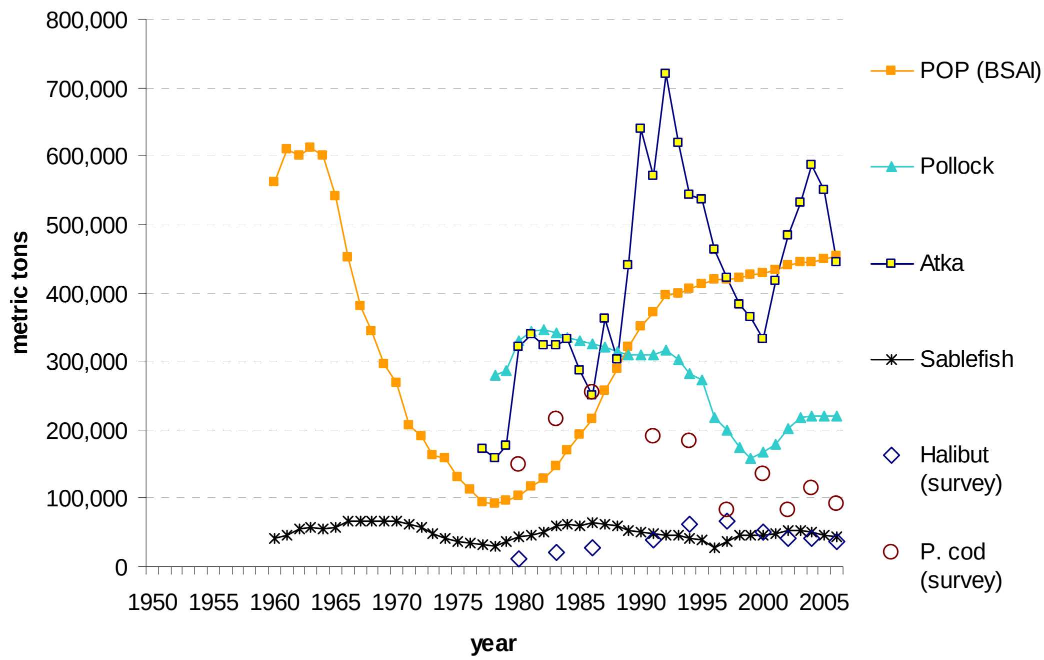

Figure 3-4 Stock assessment biomass trends for key commercial species in the Aleutian Islands, 1960-2005.

Note: Estimated biomass comes from the stock assessment, where possible; for halibut and Pacific cod, which have no specific AI assessment, biomass figures are estimated from the AI bottom trawl survey.

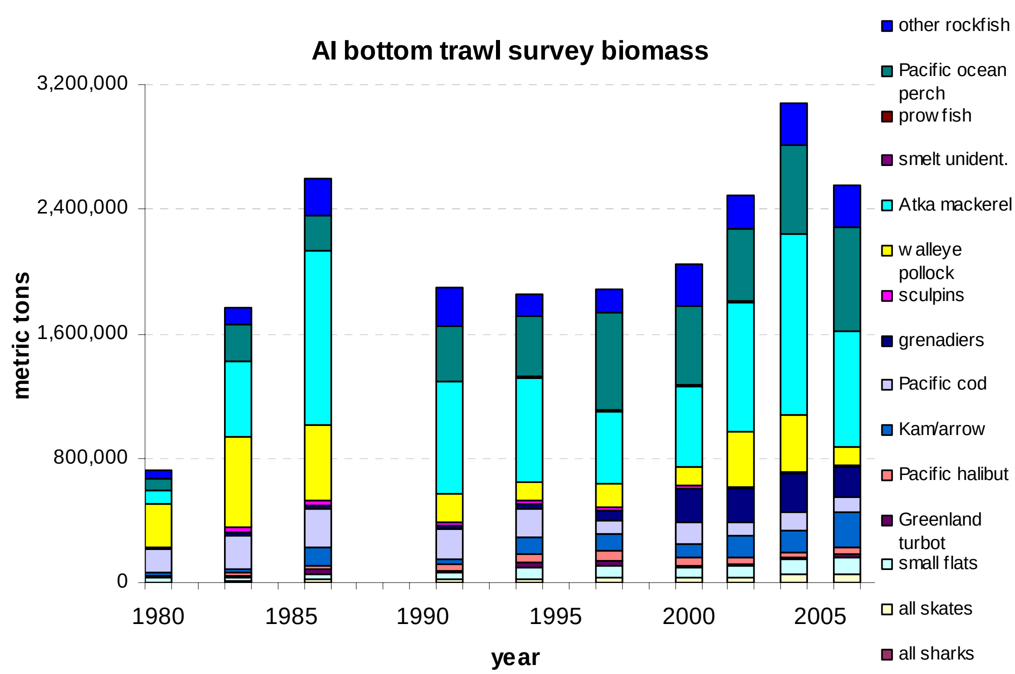

Figure 3-5 Survey biomass trends for major fish species, from the Aleutian Islands bottom trawl surveys, 1980-2006.

NOTE: Although survey trends show an increase between 1980 and 1983, it should be noted that there was also a major change in survey gear and methodology in this period, making it difficult to determine whether the apparent biomass increase reflects ecosystem change.

Habitat

There is currently very little marine habitat mapped in the Aleutian Islands. Human-based disturbance of habitat through commercial fishing effects has been occurring for more than 50 years, but the effect on both managed species and other biota is largely unknown. Corals and sponges regularly appear in survey trawl tows and there does not seem to be a clear trend in frequency of occurrence throughout the years; sponge and stony coral occurrence has remained frequent, while gorgonian corals appear less frequently now than formerly (Martin 2006a).

Historical relationships illustrate connections across ecosystems and food webs

Perhaps the most widespread effect of depleted populations throughout the Aleutian archipelago is the islands' change in terrestrial landscape from grasslands to maritime tundra. The reduction of seabird's nutrient rich guano (resulting from population declines from introduced fox predation) to the plant communities favored less productive shrubs and forbs over more productive grasses and sedges. The marine derived nutrients delivered via guano reach beyond the plant community and are traceable to terrestrial mollusks, passerines, dipterans, and arachnids, illustrating the intricate nature of nutrient transport among ecosystems (Croll et al. 2005).

Within the marine environment, the extirpation of local sea otter populations had widespread consequences. Kelp is unevenly distributed throughout the islands but wherever they form forests, they support a marine community that includes multiple fishes, limpets, bryozoans, amphipods, tunicates, barnacles, mussels, asteroids, octopus, and other invertebrates (Simenstad et al. 1978, Isakson et al. 1971). The kelp forest's extension is regulated through herbivory by sea urchins that in turn are controlled via predation by sea otters. At sites being recolonized by sea otters, sea urchin abundances have declined and kelp forests have increased as the sea otters increase; kelp and urchins have remained the same where sea otters populations have been stable (Estes and Duggin 1995). Kelp forests also incorporate nutrient inputs from offshore in the form of seabird's guano, exemplifying the importance of nutrient transport across habitats (Wainwright et al. 1998). The organic detritus originating from kelp support a variety of benthic suspension feeders, such as mysids, barnacles, and amphipods, enhancing secondary production in the nearshore areas (Duggins et al. 1989). The current contraction of kelp forests is a potential contributing factor in the decline of nearshore seabirds (Byrd et al. 2005).

As exemplified by seabirds and sea otters, changes in parts of the Aleutian Islands ecosystem can be linked to the cycling of nutrients and energy across environments, but the processes can unfortunately go easily unnoticed until broken or degraded. The changes in landscape were observed at local or small spatial scales, however the patterns behind them required studies over larger spatial scales, reaffirming Levin's (1992) proposition for studies at multiple scales. The influence of seabirds on vegetation and sea otters on kelp also show the usefulness of food webs to identify connections among species and understand how changes in abundances and distribution manifest themselves when processed through the food web. Large scale food webs can help us identify fundamental processes of nutrient cycling across areas, while local food webs and life history traits can help identify distinct ecological areas.

3.1.3 Commercial exploitation

Large scale exploitation began with the arrival of Russians in 1741 (Figure 3-3). In their quest for pelts, particularly of sea otters, Russian fur hunters and others associated with the fur trade had significant impacts on the local people including introduction of diseases, forced displacement, and servitude of the skilled Aleut hunters through violent coercion which included murdering some local people (Gibson 1996). The result was a significant decline in the population of Aleuts during the Russian colonial period

(1741-1867). Other ecological changes included the reduction of sea otter populations and the introduction of arctic foxes to several large islands which drastically reduced native bird populations. Although there were significant social and ecological impacts associated with the Russian fur trade, the maximum number of Russians ever in Alaska at one time between 1741 and 1867 was 823 (Haycox 2002). Further discussion of the Russian colonial period is presented in Appendix B.

Larger scale commercial fishing started in the early 1900s when cod stations were opened at Sanak and Unimak Island, east of the area addressed in this FEP, by various companies (Bureau of Fisheries 1907). Other fishing stations opened in 1916 throughout the eastern Aleutians, and one shore station opened at Attu (western Aleutians) where Atka mackerel and other greenling were caught. Salmon canneries opened in the eastern islands of Unalaska and Umnak, with limited success, as the total salmon catch from 1916 to 1939 was only 5,521 metric tons. A purse seine fishery for herring developed in the vicinity of Unalaska. Catches peaked in 1932 at about 2,800 metric tons and ranged between 1,000 and 2,000 metric tons until 1937. From then on herring catches declined until the fishery was abandoned in 1946 (INPFC 1979, Bakkala 1981). American vessels stayed in nearshore areas during the 1920s and 1930s. Through the first part of the 20th century, these fishing operations in the eastern Aleutians and fur seal harvesting jobs in the Pribilof Islands attracted people from Atka and Attu.

A shore whaling station was built in 1907 by a Norwegian company in Akutan (eastern Aleutians). The Akutan whaling station's operations lasted from 1912 to 1939 (Tønnessen and Johnsen 1982). With the introduction of floating factories in the 1920s, Japan initiated pelagic whaling offshore of the Aleutians; however these catches were outside the 3 mile limit (the territorial water limit at that time), and hence there are no records of catches (Tønnessen and Johnsen 1982). In 1939, with the threat of World War, the facilities in Akutan were sold to the navy, and the shore-whaling industry came to an end in the Aleutians.

In 1913, the Aleutian Islands Reservation (later called the Aleutian Islands National Wildlife Refuge) was established and one of its functions was to administer the use of islands by fox trappers. Nearly every island was stocked with non-native arctic foxes and until the 1930s, trappers, often Aleuts from Attu, Atka, or eastern Aleut villages, spent winters on most of the islands.

World War II interrupted these activities, as the occupation of Attu and Kiska by Japanese soldiers brought WWII to the Aleutians (Figure 3-3). Aleut villages were forcibly evacuated by the United States government, and tens of thousands of troops occupied bases at Adak, Amchitka, Shemya and other islands. The era of fur farming was largely over after the war, but a few trappers continued to lease islands from the refuge until the late 1940s. Other commercial activities in the central and western Aleutian Islands, which had begun prior to the war (e.g., commercial fishing and whaling), continued. After World War II, whaling and fisheries by foreign fleets expanded to areas immediately outside the territorial waters (3 miles then) of the Aleutian Islands. Figure 3-6 summarizes commercial exploitation history in the Aleutian Islands from 1950-2005. Whaling was the first fishery to be reactivated in Aleutian waters, primarily by Japanese and Soviet Union fleets. Baleen whales were half or less of the catch, and sperm whales made up the rest of it. The whaling fleets operated offshore, seldom within 30 km of the coast until 1972 (Merrel 1971) when catches north of 50°N ceased, although globally stocks kept declining until a moratorium was set in 1982 (Tønnessen and Johnsen 1982, IWC 2006).

Japan began fishing off the Aleutian Islands waters in the early 1950s for salmon, and were later joined by other nations. The initial targets were Pacific Ocean perch (POP) and walleye pollock, but soon expanded to other groundfish species. Peak foreign groundfish harvest occurred in 1965 when almost 112,000 metric tons were taken (Figure 3-6). Most was Pacific Ocean perch, taken off the entire central and western Aleutians (Merrel 1971). Pacific Ocean perch remained the primary target until the 1970s when the stock declined (Figure 3-4) and catches comprised only about a third or less of the total harvest in the region.

The American fleet started fishing for red king crab near Adak and Dutch Harbor in 1960 (NPFMC 2006). As the abundance of red king crab declined in the Aleutian Islands, fishers gradually transitioned to harvesting golden king crab and by 1982, golden king crab landings exceeded those for red king crab, although the total volume of golden king crab landed was never as high as for red king crab (Otto 1981). At its peak, the red king crab harvest in the Aleutian Islands exceeded 17,000 metric tons.

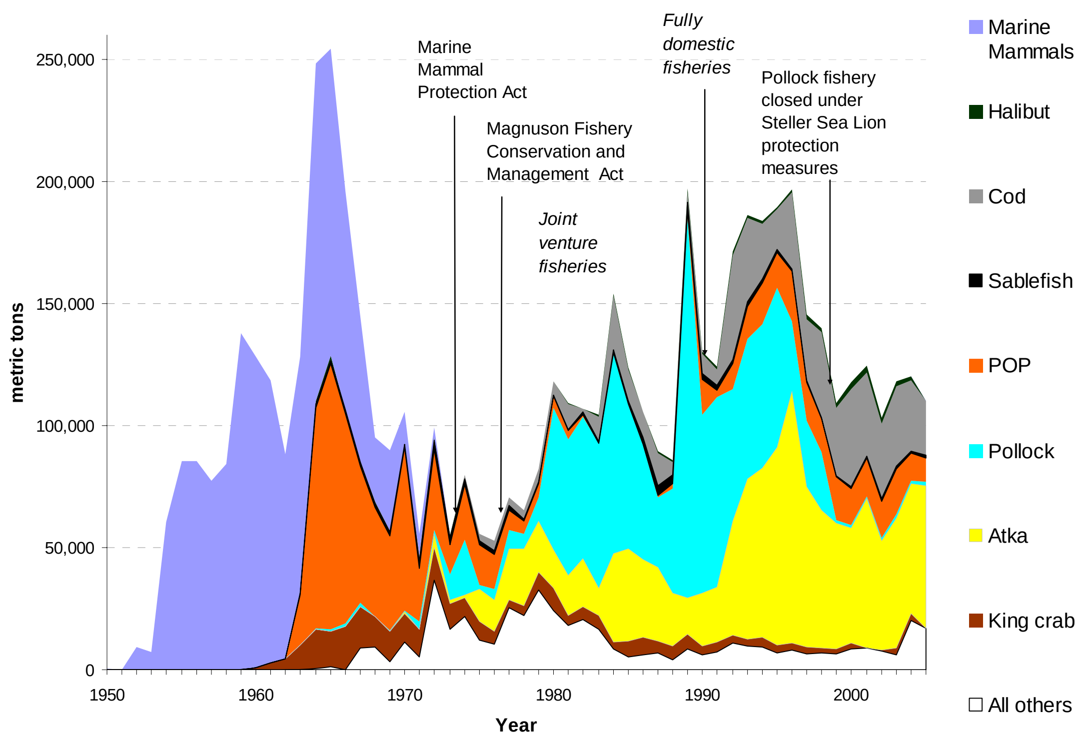

Figure 3-6 Aleutian Islands recent (1950-2005) commercial exploitation history with total annual tons removed, and significant management actions.

Modified from Ortiz (2007).

In response to foreign high exploitation rates in waters adjacent to its 3 mile limit (Figure 3-7), the United States passed the Magnuson-Stevens Fishery Conservation and Management Act in 1976 which established the Fishery Conservation Zone (later the Exclusive Economic Zone) from 3 to 200 miles offshore. Foreign countries were allocated quotas based on their contribution to developing the domestic industry, and so the groundfish fisheries went through a period of joint ventures that lasted through the 1980s. Japan's new shipboard methods to produce surimi at sea allowed the pollock fishery to rapidly expand (Bakkala 1981), and pollock catches peaked in the Aleutians during the 1980s. By 1990 the fleets were domestic, and total catches remained in excess of 150,000 metric tons throughout the decade. In 1999 the pollock fishery was severely restricted due to concerns regarding the fishery's impact on Steller sea lions (Barbeaux 2004). Since then, total groundfish catches have averaged slightly above 100,000 metric tons and are roughly 50% Atka mackerel, 30% Pacific cod and 15% Pacific Ocean perch. Recently, the highest exploitation rates on groundfish are for Pacific cod and Atka mackerel, followed by halibut, Pacific ocean perch and sablefish (Figure 3-7).

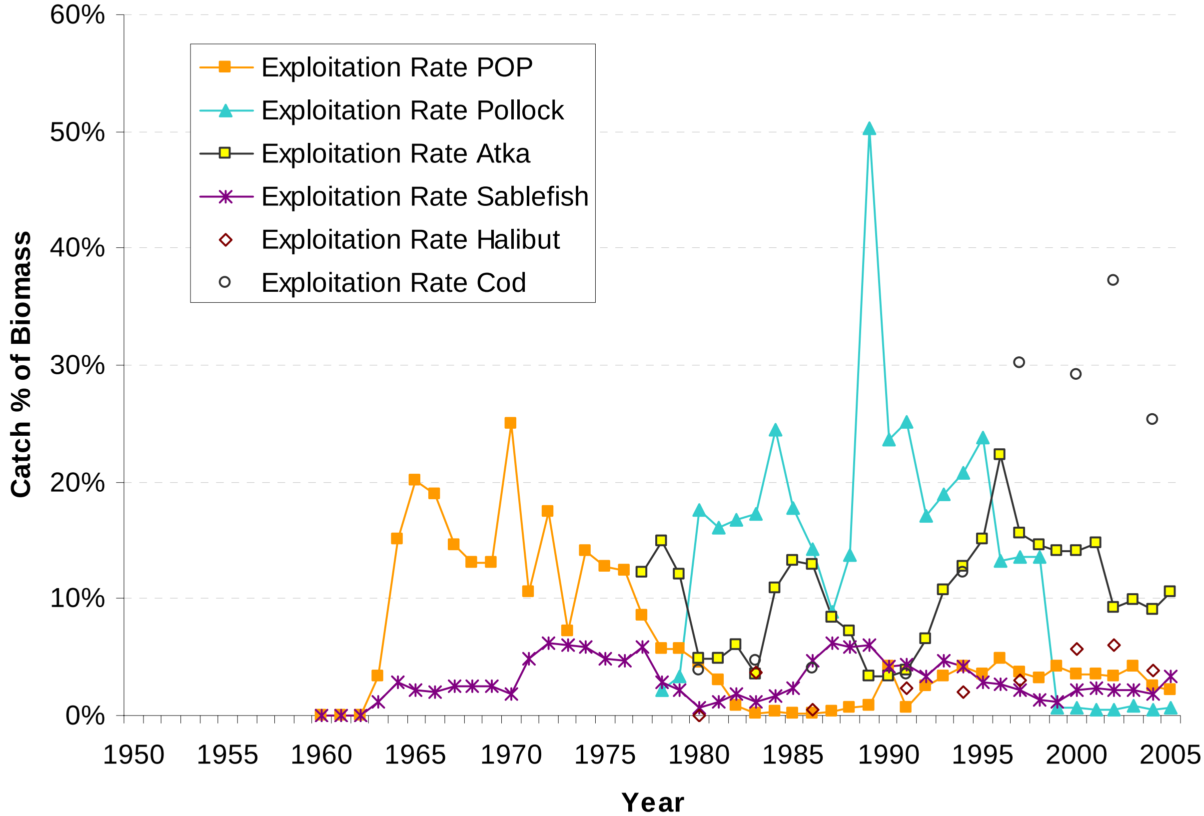

Figure 3-7 Exploitation rate trends in the Aleutian Islands: catch (from Figure 3-6) as a percentage of biomass (from Figure 3-4).

3.2 Physical relationships

3.2.1 Physical description

The Aleutian Archipelago consists of hundreds of small, volcanic islands, separated by oceanic passes that connect the waters of the North Pacific with the Bering Sea. The island chain marks the tectonic subduction zone between the North American and Pacific Plates. Bathymetry changes dramatically in a very short distance, from the depths of the Aleutian Trench (greater than 7,000 m deep) to sea level to volcanoes (greater than 1,000 m high) in a distance of less than 150 km. The passes between the islands vary from narrow shallow passes in the east, to wider, deeper passes in the west (Figure 3-8). The north-south width of the shelf also varies from east to west, with the greatest shelf-width (greater than 80 km) occurring east of Samalga Pass (Stabeno et al. 2005).

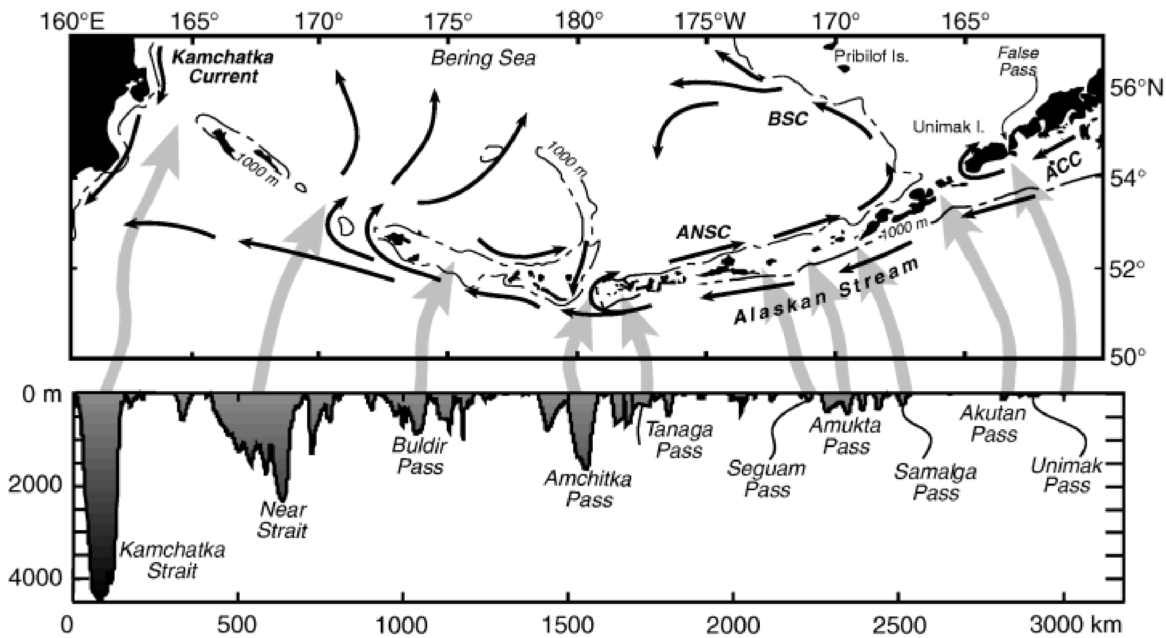

Figure 3-8 The mean circulation along the Aleutian Arc is shown together with geographic place names. The lower panel shows the depth of the passes in the Aleutian Arc.

Reprinted from Stabeno et al. 2005.

Note: ANSC = Aleutian North Slope Current, ACC = Alaska Coastal Current, BSC = Bering Sea Current.

3.2.2 Benthic habitat

The AI region has a complicated mixture of substrates, including a significant proportion of hard substrates (pebbles, cobbles, boulders, and rock). Two distinct zones are evident. East of Samalga Pass, the Aleutian Islands rise from shallow continental shelf covered by several sediment types deposited mainly during periods of glaciation. West of Samalga, in the FEP area, steep rocky slopes to the north and south surround a mostly submerged mountain range resting on the Aleutian ridge (Hampton 1983). Cold-water corals and sponge communities are a dominant feature of benthic communities on the steep rocky slopes of the Aleutian Islands and likely provide important habitat for a variety of fish and invertebrate species (Heifetz et al 2005). The geographical split in substrate type at Samalga Pass is coincident with a shift in coral species diversity (with higher diversity to the west) as well as shifts in surface water properties and populations of fish, invertebrates, seabirds, and marine mammals (Figure 3-9).

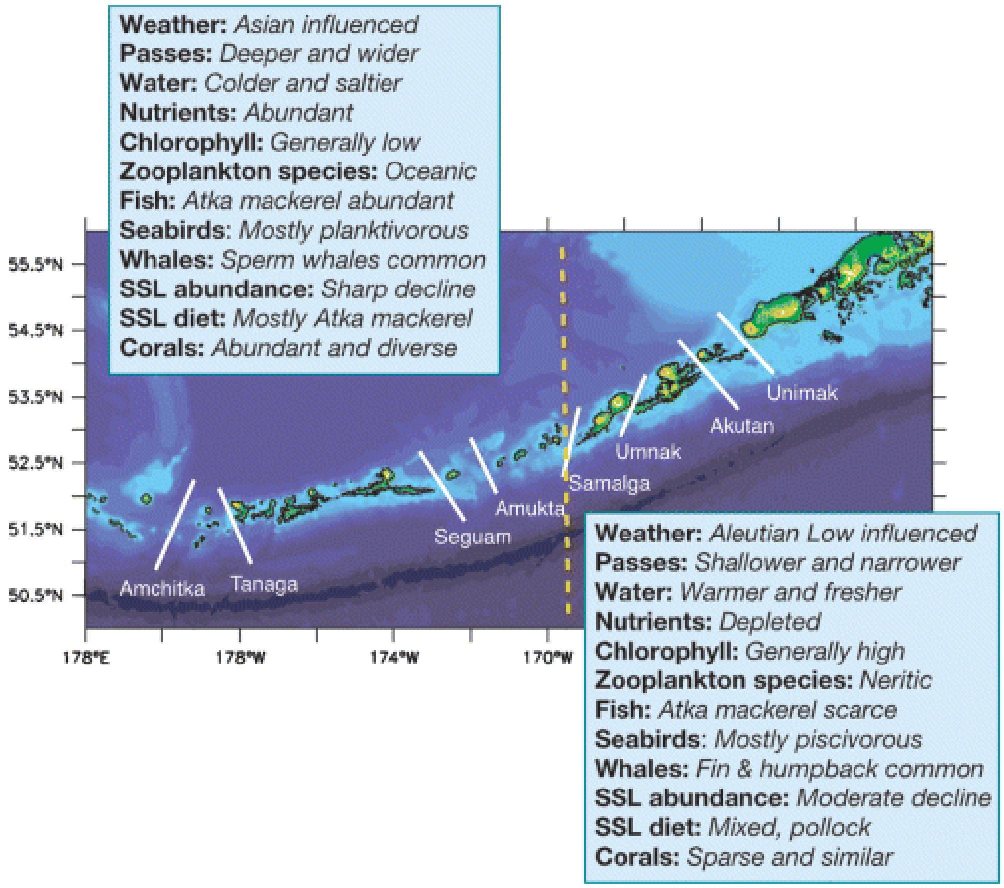

Figure 3-9 Many Aleutian environmental attributes change in the vicinity of Samalga Pass, suggesting that the marine ecosystem of the archipelago may be differentiated into multiple, ecologically distinct regions.

Reprinted from Hunt and Stabeno 2005.

3.2.3 Oceanography (pelagic habitat)

The Aleutian Archipelago is influenced by three primary currents: the Aleutian North Slope Current (ANSC) in the Bering Sea, and the Alaska Coastal Current (ACC) and Alaskan Stream in the North Pacific (Favorite et al. 1976, Stabeno et al. 1999). East of Samalga Pass (170°W), the ACC flows southwestward along the southern side of the Aleutian Islands. This relatively fresh and shallow current hugs the shoreline and turns northward entering the Bering Sea through the eastern passes (Unimak, Akutan, Umnak, and Samalga; Ladd et al. 2005). West of Samalga Pass, in the FEP ecosystem, the shelf south of the islands is much narrower. This narrow shelf allows the Alaskan Stream, the deep current that flows along the continental slope in the western Gulf of Alaska, to come close to the islands. The Alaskan Stream flows southwestward along the southern side of the islands, connecting the Gulf of Alaska to the Aleutian Islands region (Favorite et al. 1976). Waters from the Alaskan Stream flow northward through the central and western Aleutian Passes to feed the Aleutian North Slope Current, which flows northeastward along the northern side of the islands (Reed and Stabeno 1999; Figure 3-8).

While oscillating tidal currents are responsible for the extreme current speeds and mixing within the passes, the net northward transport of water from the Pacific to the Bering Sea plays a role in transport of nutrients and biota. There is evidence that transport in the Alaskan Stream influences transport in some passes. In particular, in the winter of 2001/2002 transport variations in the Alaskan Stream were shown to be related to transport variations through Amukta Pass (Stabeno et al. 2005). Large variations in transport in the Alaskan Stream may be related to the passage of mesoscale eddies (Okkonen 1996; Crawford et al. 2000) that move westward along the shelf-break from the Gulf of Alaska (GOA). Occurrence and persistence of these eddies is crucial for the understanding of productivity hotspots observed throughout the region (Batten et al 2006).

Due to the influence of the Alaska Coastal Current, the shallow, narrow passes east of Samalga Pass (170° W) can be classified as a coastal environment with a strong influence of coastal freshwater discharge. These waters are warmer, fresher, more strongly stratified, and nitrate poor compared with the Aleutian waters west of Samalga Pass. West of Samalga Pass, in the FEP area, the passes are deeper and wider. The marine environment can be classified as oceanic with primary influence from the Alaskan Stream (Ladd et al. 2005). The wider passes allow bidirectional currents with mean flow to the north (from the Pacific to the Bering) on the eastern side of the passes and to the south on the western side (Stabeno et al. 1999). However, the northward flow is generally stronger, more consistent, and occurs over most of the cross-section of the passes so, except in Kamchatka Strait far to the west, the net transport through the Aleutian Passes is northward from the Pacific Ocean to the Bering Sea.

Within the passes, fierce tidal currents, often exceeding 100 cm/s (Stabeno et al. 2005), present hazards to navigation and equipment. The tides result in substantial mixing within the passes. As the tidal current pushes water over the shallow sills of the passes, salt, nutrients, and plankton from deeper water can be mixed into the surface waters. The influence of tidal mixing on surface nutrient concentrations depends on the depth of the pass. Passes with depths between 120 and 200 m, such as Seguam and Tanaga Passes, are shallow enough to mix top to bottom but deep enough that the mixing can access the deep nutrient reservoir. Thus, these passes are most efficient at mixing nutrients into the euphotic zone. In contrast, nutrient concentrations at the bottom of shallower passes, such as Unimak and Akutan Passes, are lower so mixing does not result in substantially increased surface concentrations. In even deeper passes (greater than 200m), such as Amukta and Amchitka Passes, the interaction of tidal currents and the bottom topography can not result in mixing that reaches the surface.

Although tidal mixing can result in high surface nutrients in the passes, it can hinder the development of phytoplankton blooms by mixing the phytoplankton out of the euphotic zone and reducing their access to light (Sverdrup 1953). Thus, blooms often occur north of the passes, away from the intense mixing in the passes, but utilizing the nutrients supplied by the mixing (Mordy et al. 2005). The vertical circulations created by interactions of tidal currents with steep and variable bathymetry can also result in surface convergences (i.e., fronts, eddies) creating regions of increased concentrations of prey for seabirds (Hunt et al. 1998) and other predators.

3.2.4 Climate (terrestrial habitat)

The windswept islands of the Aleutian Archipelago experience a wet and stormy maritime climate. Wind, fog, and rain are ubiquitous while sunny days are rare. The average temperature range during the summer is 7 – 14°C (45 – 57°F) and during the winter is -3 – 3°C (27 – 37°F). Temperature variability is determined by the Aleutian Low, a low pressure center that may be located east of 180°W or be split in two: one center located east of the Kamchatka peninsula, and the other in the Gulf of Alaska. Depending on the strength and location of the Aleutian Low, the dominant storm track can cross the Aleutians anywhere between 170°W and 150°W.

Precipitation is highly variable with annual averages ranging between 75 and 160 cm per year depending on the location. Wettest conditions normally occur during the winter[1]. The storms that frequently batter

[1] Western Regional Climate Center, http://www.wrcc.dri.edu/summary/Climsmak.html

the Aleutian Islands typically originate east of Japan, moving northeastward along the Aleutian Chain toward the Gulf of Alaska. These storms result in high winds, often in excess of 22 m/s (50 mph), during all but the summer months (Rodionov et al. 2005).

Regime shifts, abrupt changes from one mean state to another, have had substantial impacts on the marine ecosystems of the North Pacific (Hare and Mantua 2000). East of 170°W, there is evidence that a regime shift towards a warmer climate occurred in 1977 and influenced the eastern Aleutian Islands. The shift to a warmer physical environment was coincident with many biological changes including an increase in the Alaskan catch of many species of salmon (Hare and Mantua 2000). Although these regime shifts have had dramatic consequences for the Gulf of Alaska and the eastern Bering Sea, impacts on the Aleutian Islands weather west of 170˚ W have been insignificant (Rodionov et al 2005). Contrary to the warming signal elsewhere, the Aleutian Islands have experienced a long-term cooling trend between 1956 to 2002 with an associated increase in surface air temperature variability (Rodionov et al. 2005).

3.2.5 How is the Aleutian Islands ecosystem different from the surrounding ecosystems?

The marine environment of the Aleutian Islands is very dynamic. The islands form a porous boundary between two ocean basins, the Bering Sea and the North Pacific. Thus, the islands are bathed by the warmer North Pacific on one side and the colder Bering Sea on the other. Bathymetry changes dramatically in a very short distance, from the depths of the Aleutian Trench (greater than 7,000 m deep) to sea level or above in a distance of less than 150 km, providing a huge variety of habitat and enabling tighter coupling between onshore, nearshore, and offshore systems. The eastern Bering Sea shelf, on the other hand, is more than 500 km wide. There, the nearshore environment has little or no connection with the outer shelf or slope environment (Figure 3-10). Due to the interaction of steep bathymetry with fierce tidal currents, mixing and convergences and divergences are ubiquitous in the Aleutian passes and variable on small spatial and temporal scales.

In most of the world's oceans (with the notable exceptions of the Arctic and Antarctic), boundaries are often oriented north/south. The Aleutian Archipelago is oriented east/west. This orientation could have profound implications in the face of large scale temperature changes. If a boundary is oriented north/south, as temperature changes, species that are dependent on the boundary can shift north or south along the boundary to remain in their preferred temperature range. If the boundary is oriented east/west, species would have to move away from the boundary to stay within their preferred temperature range. Thus species that are dependent on the environment of the Aleutian Islands may be less resilient or able to adapt to changes in temperature.

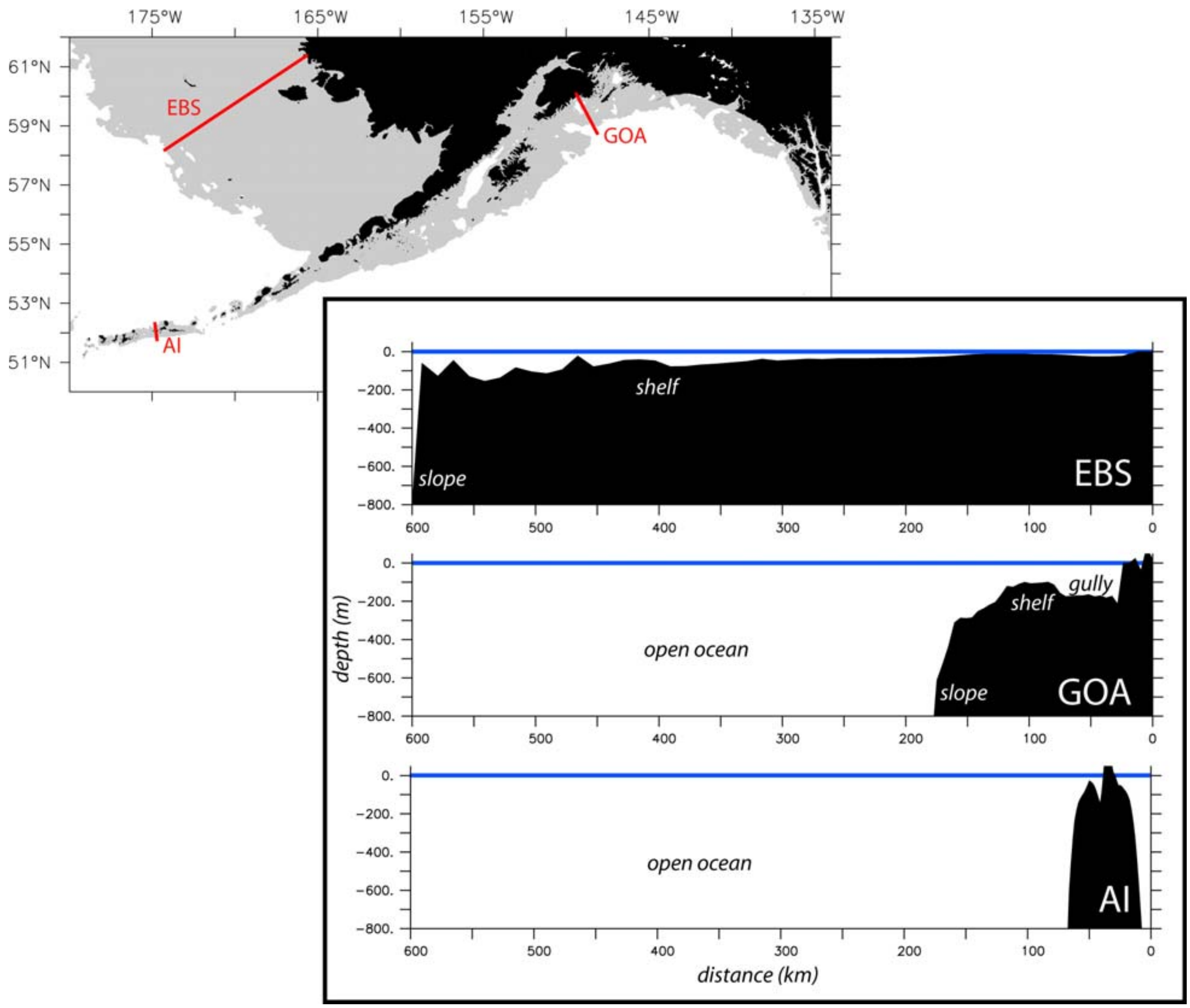

Figure 3-10 Aleutian Islands (AI) bathymetric profile and resulting oceanic-shelf-nearshore habitat proximity compared with other Alaskan ecosystems, to the Eastern Bering Sea (EBS) and the Gulf of Alaska (GOA).

3.3 Biological relationships

In this section, we first describe Aleutian Islands biological relationships ("species distribution, richness, and diversity") using Ortiz's (2007) spatial analysis of data collected aboard National Marine Fisheries Service (NMFS) bottom trawl surveys, seabird surveys and marine mammal surveys. Then we describe our selection of key species in the Aleutians which help focus the analysis of biological relationships, and we look at energy flow in the Aleutians using a regional food web model. This model is based on the 1991-1994 data from trawl surveys used in the first section, plus marine mammal and seabird surveys and diet studies, as well as studies of benthic invertebrates. The regional AI food web model with detailed methods and data sources is described in Aydin et al (in press), and in Ortiz (2007), but we briefly outline its structure in the "key species and energy flow in the AI food web" section below. We go on to describe predator prey relationships for key species in the AI based on the regional food web model, as well as diets for key species at smaller spatial scales based on survey data from 1981-2001. Ortiz (2007) developed smaller scale food webs based on those spatially explicit diets which demonstrate important changes in food web relationships along the Aleutian chain. Finally, we describe the "leaky boundaries" of the AI ecosystem with respect to energy flow, migratory species, and stock structure for key species, and compare the scales of these biological relationships with the scale of current management.

3.3.1 Species distribution, richness, and diversity

In the Aleutian Islands, oceanography determines major physical attributes of the habitat. It also defines geographical boundaries for fish, playing a critical role in distributions of individual species, which in turn creates gradients of species richness (number of species), and species diversity (proportion of each species available within a unit of area). All of these processes operate at large scales, but can translate into smaller scale differences in biological relationships, which are observed as local habitat partitioning. We illustrate these relationships in general for the Aleutians here using data from 1991-1994 NMFS surveys. We first describe longitudinal abundance trends along the islands for fish, seabirds, and Steller sea lions, and then discuss how these spatial patterns translate into species richness and diversity in the ecosystem.

The longitudinal trends in Aleutian Islands fish distribution can be illustrated as biomass densities per depth layer in two degree blocks (Figure 3-11). In this early 1990s snapshot, the first largest step increase in groundfish biomass from west to east is at area 172°W, the Yunaska/Amukta Passes. Atka mackerel and Pacific ocean perch (POP) density increases significantly towards the west and they are split vertically, with the first inhabiting mostly above 200m depth and the second between 200-300m depth. In contrast, pollock and Pacific cod are found at all depths, but not at random. Pollock inhabit shallow waters (less than 200 m depth) east of area 170°W and deeper waters (greater than 200 m) towards the west where it shares the 200-300 depth layer with POP. Pacific cod remains mostly within 100 to 200 m depth, in between Atka mackerel and pollock, but closer to whichever is more abundant (Ortiz 2007). Atka mackerel have shown large shifts in survey biomass along the Aleutian Islands chain in surveys from 1981-2006 (Lowe et al 2006), so some deviations from this early 1990s snapshot should be expected over time. Because the changing distributions of major groundfish species will alter biological relationships at local scales, repeating this multispecies spatial analysis for other survey years would provide valuable information on the stability of the relationships presented here.

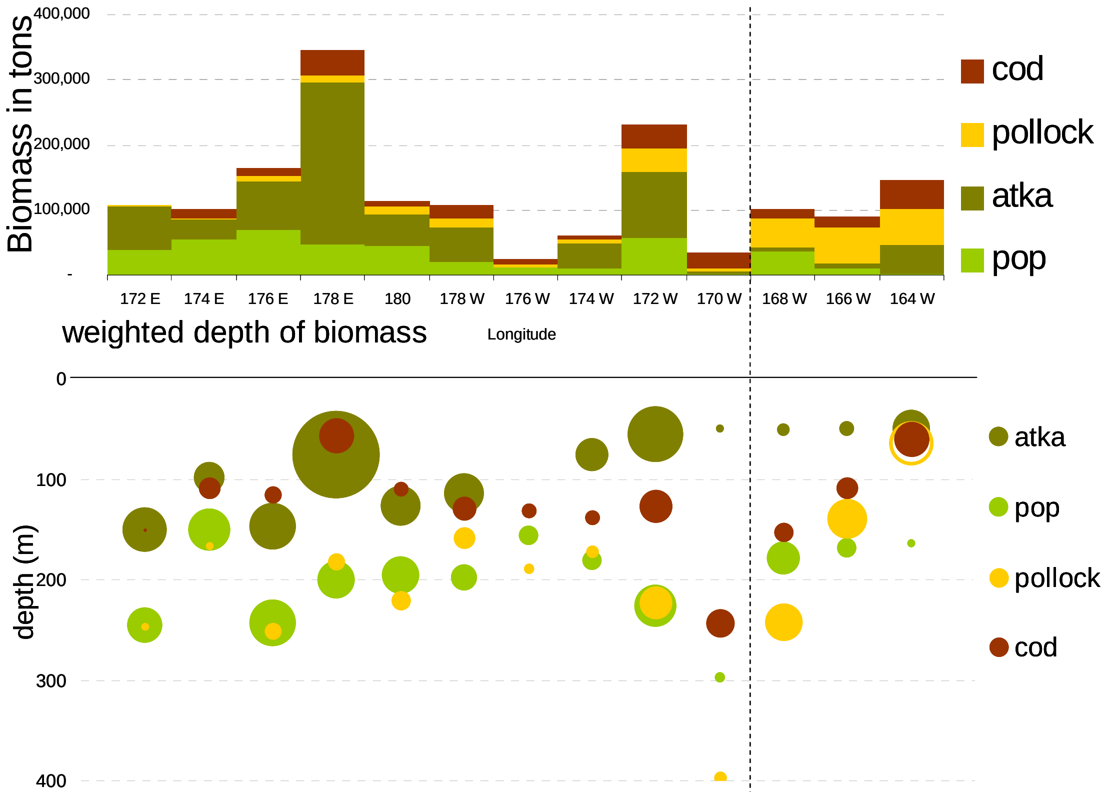

Figure 3-11 Longitudinal (upper) and depth (lower) biomass distribution of major groundfish in the Aleutian Islands from averaged 1991 and 1994 NMFS bottom trawl surveys.

Reprinted from Ortiz (2007).

NOTE: Circles in lower plot are sized relative to biomass (average summer biomass from years 1991 and 1994[2]) and placed vertically at the weighted average depth where each species was caught in that longitudinal block. Dashed vertical line represents the current management boundary between the AI and the eastern Bering Sea and GOA management areas.

At a large scale, there is a correspondence in the longitudinal distribution of seabird and groundfish biomass in that fish in general constitute a larger portion of seabird diets east of area 172°W than towards the west (Figure 3-12). The longitudinal trend in the distribution of piscivorous and planktivorous seabirds has been observed and studied in previous seabird biogeography studies (e.g., Stephensen and Irons 2003, Byrd et al. 2005), and reflects the gradient of coastal to oceanic habitats found in the Aleutians (Ortiz 2007). The planktivorous seabirds in the western Aleutians are primarily strom-petrels and auklets, several of which are known to be restricted to highly productive upwelling areas, and are absent in the warmer waters of the Gulf of Alaska (Stephensen and Irons 2003). Most seabirds along the Aleutians have breeding colonies in the western Bering Sea as well (Shuntov 1999), so the shift from piscivorous to planktivorous appears to reflect the overall lower abundance of shallow (less than 50m) small fish resources. The exception is the area near 174° E, the relatively large shelf area around the Near Islands, where both nearshore and offshore piscivorous seabird colonies dominate (see Springer et al 1996). Most seabirds throughout the archipelago are offshore diving feeders, other than northern fulmars which are primarily surface feeders and have their largest colonies near large passes, notably Samalga Pass and Buldir Pass (Byrd et al. 2005).

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[2] Although biomass does change between 1991 and 1994, the spatial pattern of the biomass distribution does not change between these two years. Some areas did experience a higher increase in biomass than others, so over a long time span it is possible that the peak abundance may shift to an adjacent 2-degree area.

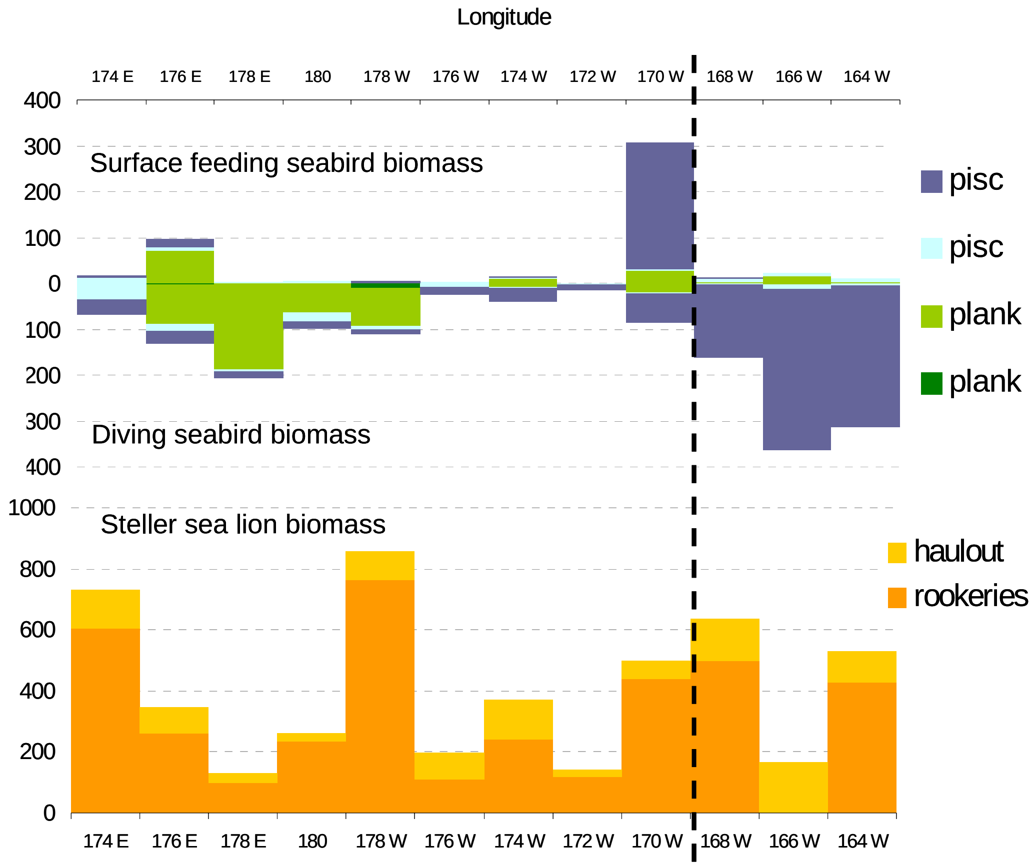


Figure 3-12 Longitudinal and depth biomass distribution of piscivorous (pisc) and planktivorous (plank) seabirds (upper), and Steller sea lions (lower) in the Aleutian Islands.

Reprinted from Ortiz 2007.

NOTE: Dashed vertical line represents the current management boundary between the AI and EBS, GOA management areas.

In contrast with seabirds, early 1990s Steller sea lion abundance shows no longitudinal trend (Figure 3-12), but their highest abundances are all located near the largest passes, from east to west: area 168°W and 170°W (Samalga, Yunaska and Amukta Pass), area 178°W (Amchitka Pass), and 178°E (close to Buldir Pass). The lowest abundance of Steller sea lions (SSL) is at area 178°E, coincident with the highest local density and biomass of Atka mackerel during this temporal snapshot. Ortiz (2007) suggests that this distribution may result from a combined prey diversity and habitat partitioning effect in this local area, examples of which are evident throughout the island chain. Habitat partitioning[3] is a multispecies interaction where the position of predators in space, with respect to each other, determines access to prey (Lehman and Tilman 1997, Pacala and Levin 1997). The displacement of pollock by POP along the Aleutian chain (Figure 3-11) may illustrate another such competitive interaction where competition for zooplankton prey is mediated by spatial changes in physical relationships.

Species richness is simply a measure of the number of species in a given area; this measure is important from an apex predator or fishery perspective because it determines the variety of prey types available. The

[3] Following Agostini's (2005) definition, habitat refers not only to physical structures but to the characteristics of the water column as well. In that respect, the species inhabiting the Aleutians move through a series of contracted and expanded habitats dependent on the amount of shelf and depth, as well as water column characteristics.

only study on fish species richness and community structure covering the entire Aleutian archipelago is that presented by Logerwell et al (2005). The study included 63 species of non-contiguous distribution along the Aleutian chain, and found there was a 28% decline in the number of demersal fish species (within 500 m depth) between Unimak/Samalga and Amukta Passes. The number of species remained relatively constant between Samalga and Amchitka and declined again (20%) west of Buldir Island.

Species diversity can be understood as the overlapping species biomass densities which determine the local proportion of each species present; species diversity, like species richness, affects energy flow in the ecosystem. Within food webs, there are a large number of species interactions, and also a wide range of interaction strengths (e.g., how much mortality a predator causes a prey, how dependent a predator is on a prey). Empirical work on natural food webs (Paine 1992, Power and Mills 1995, Wootton 1997) suggests that interaction strength tends to be skewed towards a few strong links and many weak ones. While it is tempting to assume that weak predator-prey interactions are unimportant in the big picture of the food web (e.g., Pimm et al. 1991; Schoenly and Cohen 1991), in specific contexts weak links may be even more important than the strong links (Martinez and Dunne 1998).

A species and diversity gradient is apparent in local food webs along the Aleutian chain (Ortiz 2007, and discussed below). The food webs to the east of the deeper passes prominently feature forage fish and flatfish, while towards the west, coastal forage fish and flatfish are much less common and instead, demersal fish are more frequent. In the Aleutian Islands, interactions that are strong at only particular locations (and thus “weak” in the aggregated food web) are alternative energy pathways which keep the flow of energy from basal sources to higher levels of the food web uninterrupted, and thus makes the system more resilient (Ortiz 2007). This has important implications for the management of biodiversity; a locally common species may be only a small portion of the diet for a more widely distributed predator, but can represent a vital resource in a particular time and place. Therefore, at a large scale, a small set of key species may account for most of the energy flow in the food web, and impacts on these species are felt throughout the food web through the alteration of food-web wide energy pathways. At a small scale, however, maintaining biological diversity ensures that local pathways remain connected, supporting the larger regional food web.

3.3.2 Key species and energy flow in the regional AI food web

In this section, we aggregate the relationships described in the previous section to the ecosystem-wide spatial scale to examine the food web for the AI FEP area; once large scale relationships are identified, we will return to more local scales in the following sections. The complexity of the relationships in marine food webs can be overwhelming, so in this section we focus on key species from economic, biological, and social perspectives to illustrate relationships within the ecosystem. In recent years, the most economically important commercial species in the AI have been king crabs, Pacific halibut, Pacific cod, Atka mackerel, and (to a lesser extent) sablefish and Pacific ocean perch (see Section 2.1). Species groups with high biomass levels in the AI and which account for considerable energy flow within the pelagic portion of the AI food web include Atka mackerel, pollock, grenadiers, myctophids, and squids. Species that need special consideration due to special legislation[4], regulatory measures, or particular social interest include marine mammals (whales, seals, sea lions, and sea otters) and seabirds (albatrosses, shearwaters, fulmars, storm-petrels, cormorants, gulls, kittiwakes, murres, auklets, and puffins). Historically, many marine mammals and birds were commercially important and heavily exploited in this ecosystem (Figure 3-3, Appendix B), but today most of these species are protected from commercial exploitation. We note that our economic importance and high biomass groupings overlap: both Atka mackerel and pollock are now or historically were also commercially valuable species, and Pacific ocean perch has now recovered to a similarly high biomass level as these two species (Figure 3-8). Below, we

[4] Species listed under the Endangered Species Act are listed in Appendix B.

give a brief overview of the most extensive food web we can describe with the available data, which we then aggregate to focus on these key groups.

A model food web is a simple structure for visualizing and calculating energy flow relationships between species, one of the most basic types of ecosystem relationships – how does each group make a living? The information required to build a model food web includes standard stock assessment data already collected from fisheries, aboard surveys and in life history studies: catch, biomass, and productivity. Food web modeling also requires less standard information on consumption rates and diets of species; this data is also collected during NMFS groundfish surveys. Researchers working in Alaska have studied biomass, productivity, consumption and diets of many of the other species in the ecosystem, including marine mammals, seabirds, and many invertebrates. In the Aleutian Islands as in all Alaskan ecosystems, there is less information on benthic and pelagic forage species, including forage fish, squids, shrimps, and zooplankton. We made common assumptions across all Alaskan ecosystems where data were missing, and use these findings to suggest which data gaps are most important to fill for the Aleutians. The regional Aleutian Islands food web model (Aydin et al in press, Ortiz 2007) focused on information for all species from the early 1990s to include trawl survey data from 1991 and 1994, because it is intended to provide a temporal "snapshot" of relationships within the ecosystem. Once all data are compiled, the food web model estimates the amount of each species production that is consumed by each of its predators and by fisheries. Examining diets and partitioning mortality sources for each species by predator, fishery, and all other sources allows us to compare relative interaction strengths of species and fisheries within the food web. In addition, we can simulate mortality changes within the food web model to see how impacts to one species might transmit to other species through food web relationships (see Aydin et al in press for detailed methods).

The full food web of the Aleutian Islands is vastly complex, and even a relatively simplified quantitative representation still contains 149 groups, 134 of which are predator/prey groups and 15 are fisheries. A visual representation of the food web is shown in Figure 3-13, where box size is proportional to the estimated biomass in the ecosystem, the width of lines is proportional to estimated energy flow between boxes, and the vertical distribution of boxes in the figure represents trophic level. Groups are positioned so that benthic energy pathways originate on the left side of the figure (highlighted in blue) while pelagic energy pathways based on phytoplankton are to the right side of the figure (in green). Much of the pelagic energy flow in the AI food web moves through the key zooplankton groups of copepods and euphausiids (krill), which are discussed in detail below. The colors blend at higher trophic levels to the extent that the energy from benthic and pelagic sources blend. There are 1813 energy flow pathways between predators and prey, and 506 additional links when fisheries (pale orange boxes) are included.

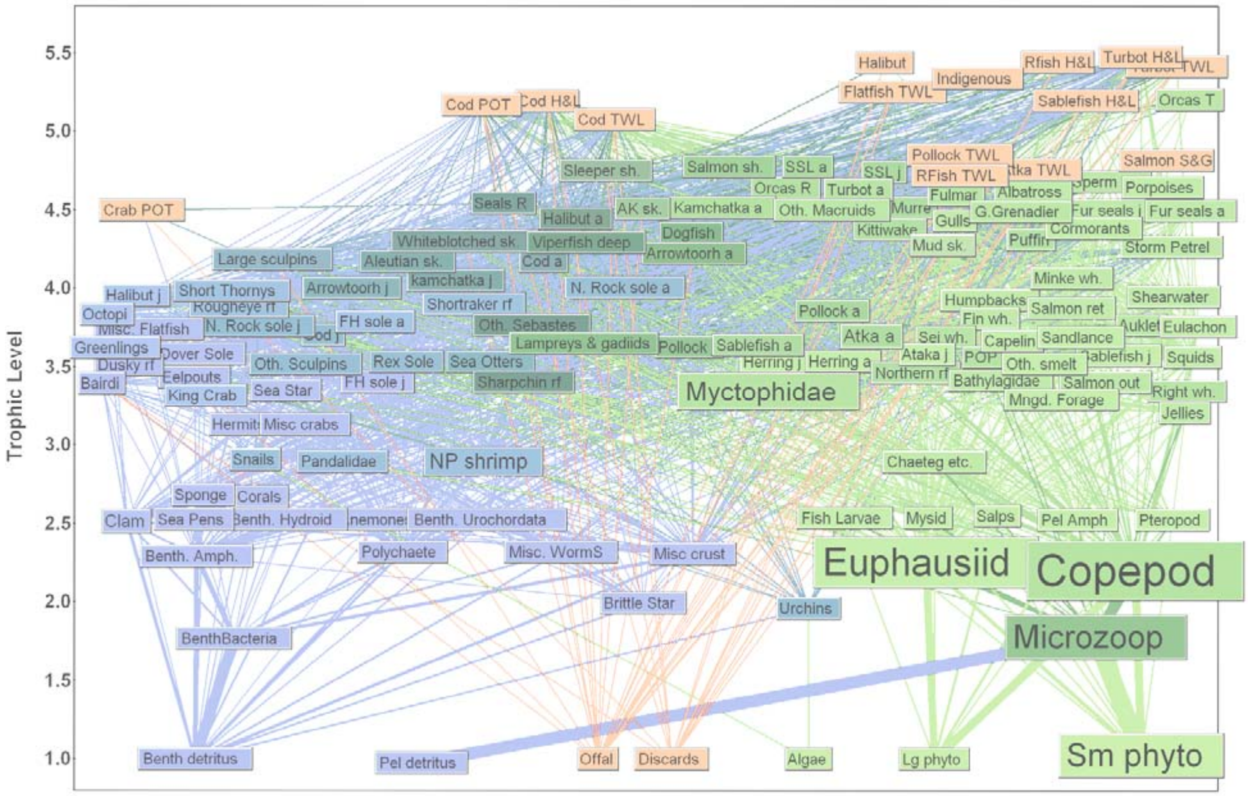


Figure 3-13 Visualization of the Aleutian Islands food web in the early 1990s.

Reprinted from Ortiz (2007).

NOTE: Box size is proportional to the estimated biomass, the width of lines is proportional to the estimated energy flow between boxes, and the vertical distribution of the boxes represents trophic level. Blue indicates benthic energy pathways; green indicates pelagic energy pathways based on phytoplankton. The colors blend at higher trophic levels to the extent that the energy from benthic and pelagic sources blend. Pale orange boxes represent fisheries.

When simplifying this food web to better portray the position of key species and the flows between them (Figure 3-14), several relationships emerge. Viewing the food web structure as a whole, it is apparent that humans are the highest trophic level predators in this ecosystem in the form of longline fisheries for Pacific halibut and Pacific cod, pot fisheries for Pacific cod, and subsistence fisheries. The protected species in pink share a trophic level with other fisheries such as the NMFS (groundfish) trawl fishery and ADF&G crab pot fishery, and are generally lower biomass, and mostly higher trophic level groups relative to the other key species highlighted in yellow and green. The high biomass groups in green (and yellow-green) cluster towards one side of the food web, the pelagic energy pathway, which is anchored on even larger biomass pools of zooplankton and phytoplankton. The high economic value groups in yellow (and yellow-green) share characteristics of both the high biomass groups and the protected species. Halibut and cod tend to be lower in biomass and higher in trophic level, sharing both pelagic and benthic energy pathways, while sablefish, Atka mackerel, and Pacific ocean perch occupy a lower trophic level and share the pelagic energy pathway with high biomass groups. King crabs are distinctive as an economically valuable group at a relatively low trophic level and entirely within the benthic energy flow pathway. Sea otters are distinctive as a protected species group entirely within the benthic energy flow pathway. Grenadiers are also distinctive as a high biomass group in the pelagic energy pathway, occupying a high trophic level comparable to the protected species.

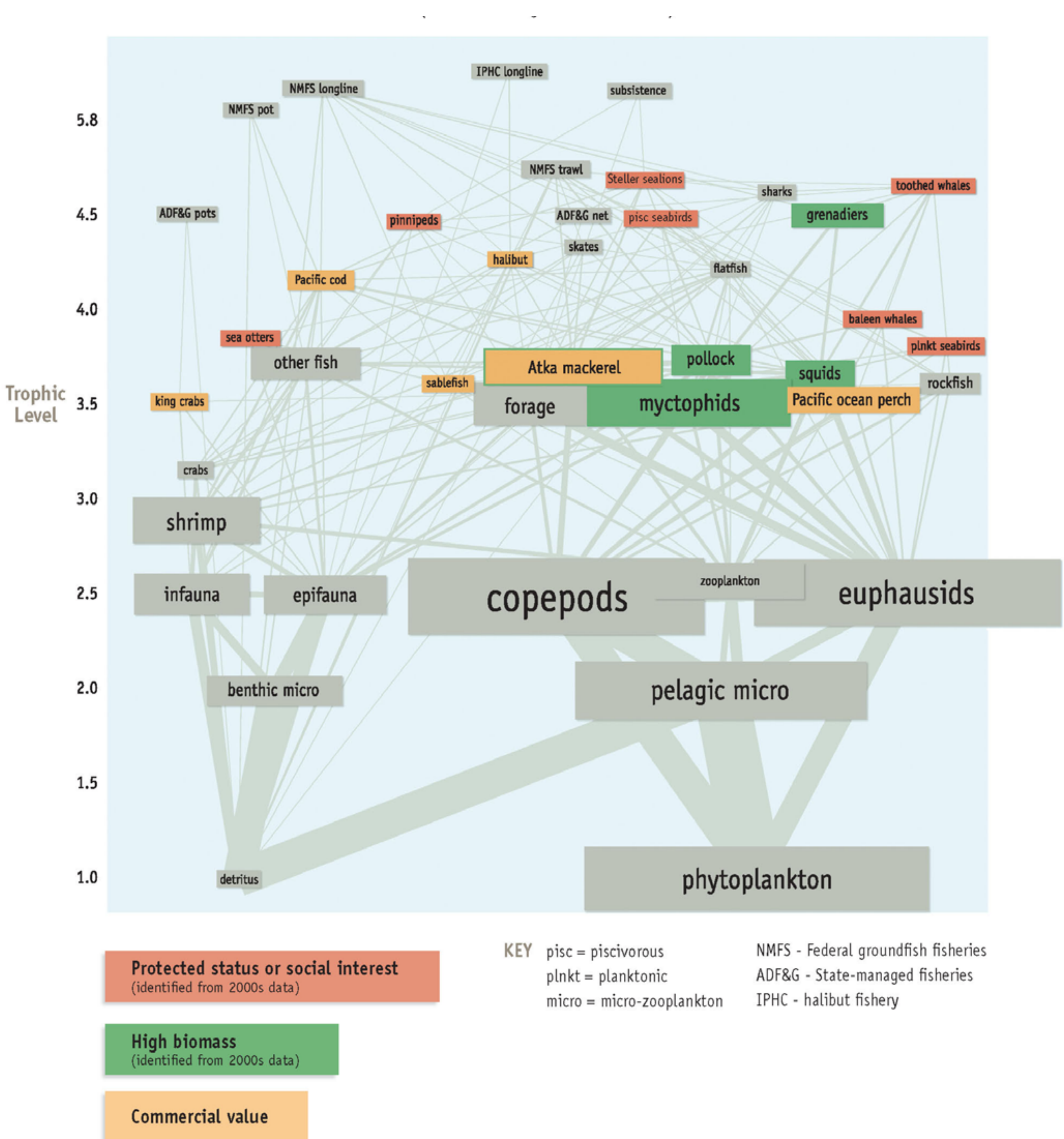


Figure 3-14 Visualization of the aggregated Aleutian Islands food web (diet data from the early 1990s).

NOTE: Focus species are highlighted in green (high biomass), yellow (commercial value), and pink (protected status or social interest). Atka mackerel is both a high biomass and commercially valuable species. Box size is proportional to the estimated biomass in the ecosystem, the width of the lines is proportional to estimated energy flow between boxes, and the vertical distribution of boxes in the figure represents the trophic level.

The high biomass of Atka mackerel, grenadiers, myctophids, and squids is unique to the AI ecosystem compared to the other Alaskan ecosystems (Aydin et al in press), as is the strong pelagic energy pathway which both economically important and protected species share with these high biomass groups (Figure 3-15). The difference in energy flow pathways is likely a result of the close proximity of oceanic habitat to shelf habitat in the AI, contrasted with the shelf-dominated EBS (see Figure 3-10). Therefore, while most of these key species are found in both the EBS and AI, and sometimes managed jointly between the two systems, the food web structure they depend on is distinctly different between the two regions.

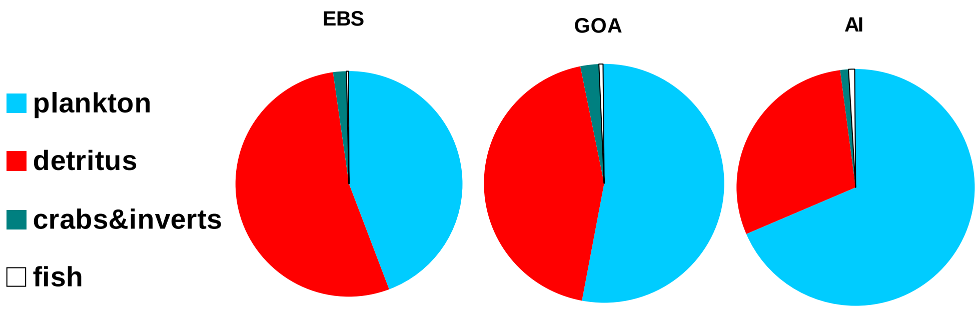


Figure 3-15 Comparison of energy flow between Alaskan ecosystems.

Reprinted from Aydin et al in press.

NOTE: The AI is a plankton / pelagic energy dominated system, the eastern Bering Sea is a detritus / benthic dominated system, and the GOA is intermediate.

3.3.3 Predator-prey relationships for key species

We present detailed relationships for key fish species/groups responsible for major energy flow within the ecosystem: Atka mackerel, Pacific ocean perch and lanternfish (myctophids). All three are high biomass planktivorous species, and two are economically important as well. Together, Atka mackerel and POP comprise 35% of the groundfish biomass and 33% of the total groundfish removals. Historically, they account for the largest catches in the Aleutian Islands ecosystem (Figure 2-1). Myctophids are an important prey item for many species including pollock and grendadier, and comprise 50% of the estimated forage fish biomass (including cephalopods); their mortality from fisheries (based on observer reports and survey data) is minimal (less than 0.0001%).

Atka mackerel, POP, and mytophids share a common zooplankton prey base along with pollock, squids and other forage fish (high biomass), sablefish and other rockfish (economic value), and baleen whales and planktonic seabirds (protected species; Figure 3-16). The production of the pelagic prey base, comprised of euphausiids, copepods, and other zooplankton, dominates the AI food web (Figure 3-14, Figure 3-15). Therefore, the processes maintaining this prey base also maintain many of our focal species at their current productivity levels. Given that there is little monitoring of these pelagic resources and limited understanding of physical factors affecting them in the AI at present, it may be difficult to fully understand key food web processes or to provide early warning of any changes to this important prey base for so many of our key species.

Several members of the zooplankton-feeding group (Atka mackerel, Pacific ocean perch, pollock, squids and other forage fish) are in turn part of the shared prey base of some fisheries, protected species, and other economically valuable species in the AI. Steller sea lions and other pinnipeds share this prey base with Pacific cod, halibut, skates, and the NMFS trawl fishery (Figure 3-16). Effectively, three other fisheries in the food web (NMFS longline, NMFS pot, and IPHC longline) also rely on this prey base because they specialize on Pacific cod and halibut. These relationships between major Aleutian Islands fisheries, key predators, and the shared prey base within the pelagic food web illustrate both the common oceanic energy source for fisheries, and the extent to which fisheries may compete with each other and with other predators for energy within the ecosystem. However, shared prey base alone does not necessarily imply competition. As discussed above, interaction strengths and spatial relationships greatly affect energy flow within this ecosystem. To clarify the relationships further, we first examine relative interaction strengths between predators and prey, and then the potential for habitat partitioning in space to mediate these relationships further. Interaction strengths for all key species are shown in Appendix D, Table 1 (fish) and Table 2 (protected species and fisheries), and are highlighted in detail for Atka mackerel Figure 3-17.

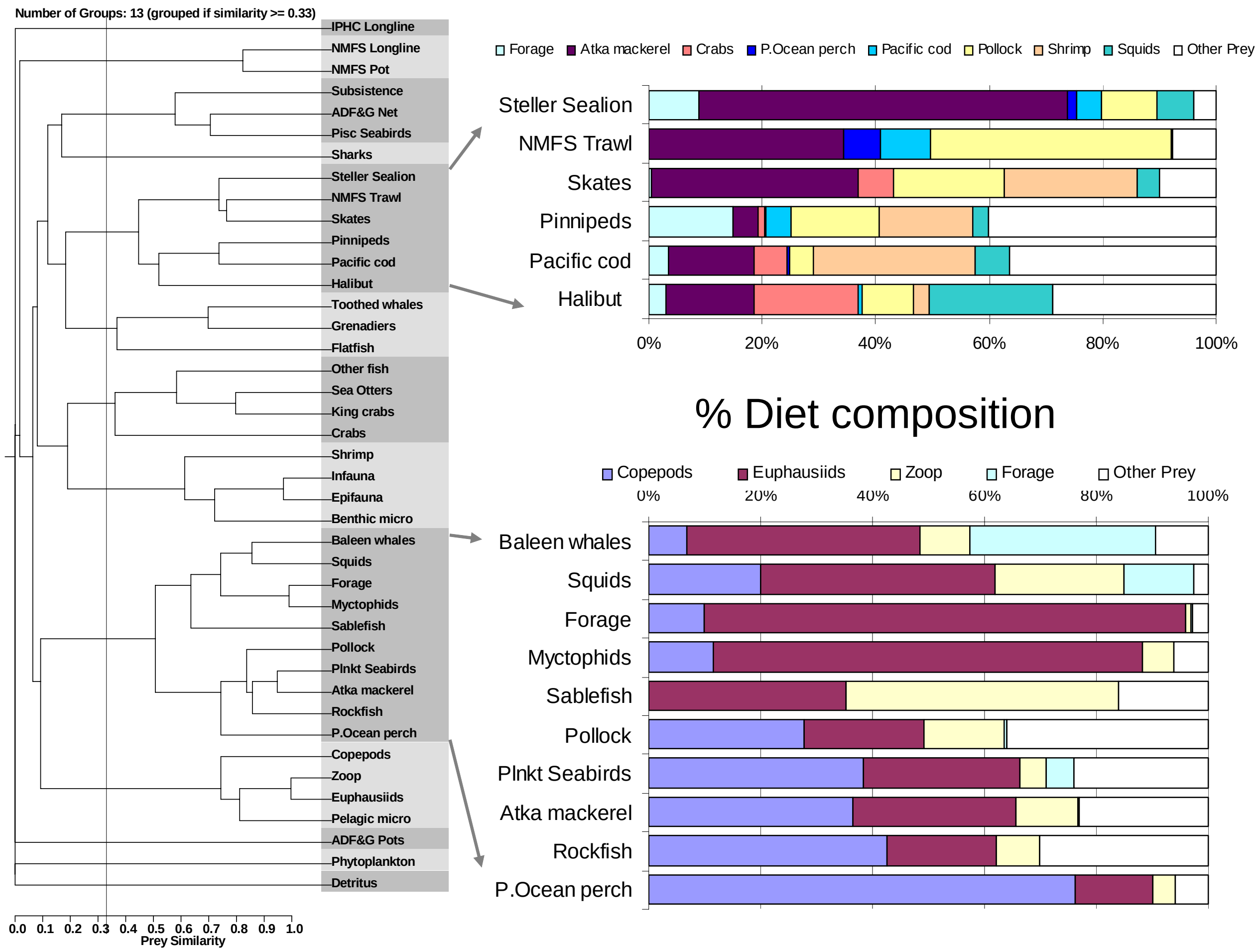


Figure 3-16 Shared prey base in the AI food web (grey boxes indicate at least 33% diet similarity). Diet composition illustrated for Atka mackerel-pollock-squid feeders (upper) and zooplankton feeders (lower).

NOTE: Bars for each species represent percent of diet composition, with major diet components labeled above each chart.

Role of Atka mackerel in the food web

Atka mackerel are commercially and energetically important in the AI, with food web connections to many other key species. Atka mackerel contributed 23% of the groundfish biomass and supported 28% of the total groundfish removals during the 1991-1994 model years, and continue to be the main groundfish target species by volume in the Aleutians today. Assuming the diet, stock assessment, and catch data in the food web model are reliable, the production of Atka mackerel is almost entirely consumed within the ecosystem, and different predators rely on Atka mackerel as prey to different degrees (Figure 3-17). Juvenile Atka mackerel are consumed primarily by adult pollock (53%) and arrowtooth flounder (24%). As adults however, Pacific cod is their major predator (25% total mortality), along with pollock (7%), large flatfish and skates. Overall, groundfish predators cause 52% of combined adult and juvenile Atka mackerel mortality, juvenile and adult Steller sea lions account for 24%, and the directed fishery accounts for 17%. Of groundfish mortality, 20% is caused by Pacific cod predation on adult Atka mackerel and 18% by pollock predation on juvenile Atka mackerel. The extent to which each of these predators depends on Atka mackerel as prey differs substantially, however. Atka mackerel are only 5% of the overall pollock diet, and 15% of Pacific cod diet, whereas they represent 65% of the Steller sea lion diet and 34% of the early 1990s NMFS trawl fishery catch. (The proportion would be higher today, as the pollock fishery no longer contributes to the NMFS trawl fishery catch composition pictured in Figure 3-17). Therefore, while each of these predators is estimated to have a similar mortality effect on Atka mackerel, Atka mackerel energy has a very different effect on each of them. In an extreme example, Atka mackerel are not discernably affected by seabirds, but seabird production can be positively affected by the abundance of juvenile Atka mackerel (Wehle 1983).

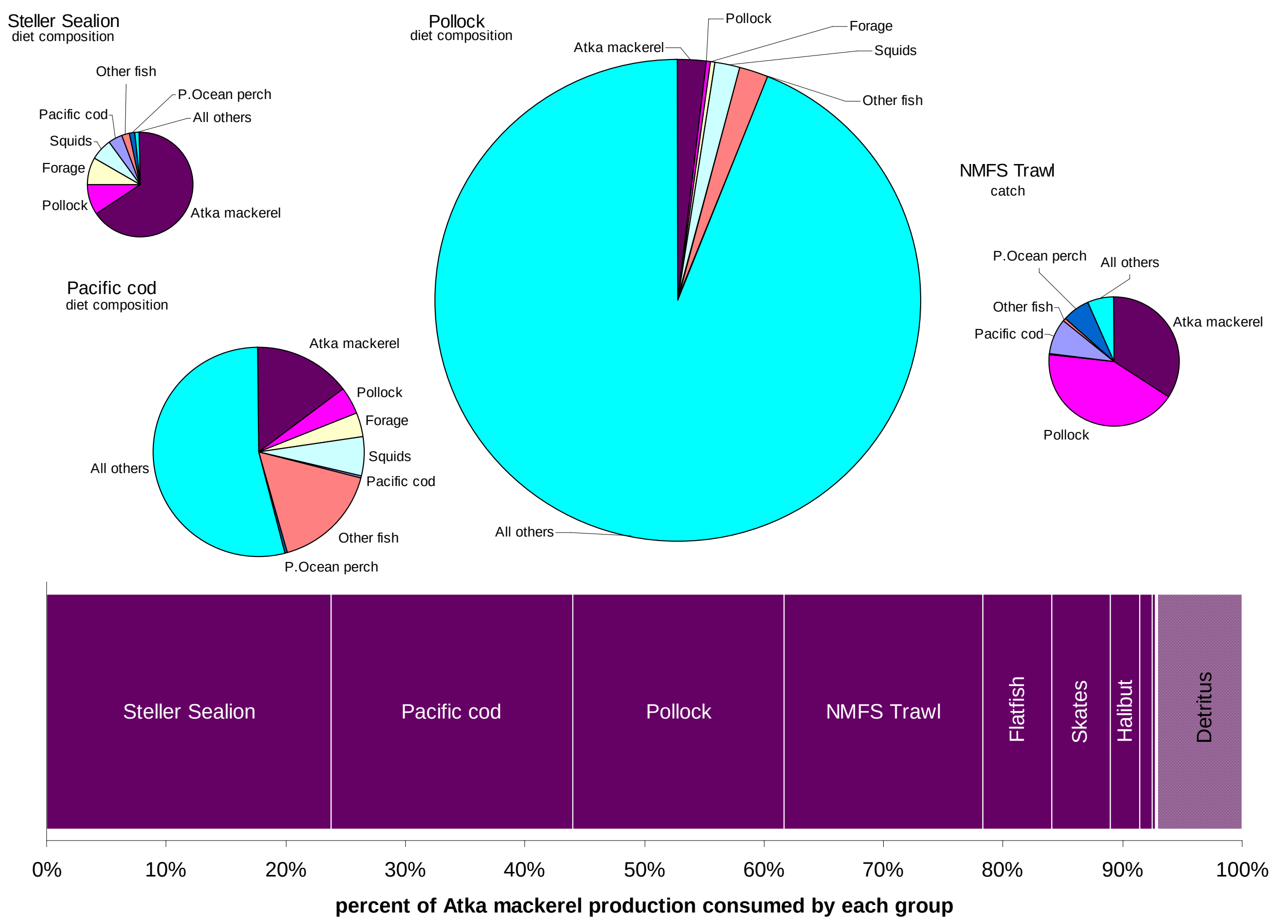


Figure 3-17 Atka mackerel food web relationships

NOTE: The lower bar represents total annual Atka mackerel production, labeled portions indicate the proportion consumed annually by each Atka mackerel predator.

The pie charts above the bar show the proportion of Atka mackerel in the predator's overall diet; size of pies indicates the relative consumption of that predator in the ecosystem.

Role of Pacific ocean perch in the food web

Pacific ocean perch (POP) supported the highest historical catches of any species in the 1960s. Both total biomass and spawning biomass have increased monotonically since 1977 (Spencer et al 2005). The population is currently at around 66% of their estimated biomass in the early 1960s. Pacific ocean perch inhabit the outer continental shelf and upper slope. They are relatively small fish with an estimated lifespan of 90 years (Spencer and Ianelli, 2003). The population is managed BSAI-wide, but the majority of the catches come from the Aleutian Islands subarea where their abundance is estimated to be higher. In contrast to Atka mackerel, few predators consume POP (Figure 3-18a). If we assume the data in the food web are reliable, the main predators of POP are sperm whales (currently depleted), fulmars and Kamchatka flounder. The dominant role of POP in ecosystem energy flow is attributed to its large biomass and relevance as a species exploited commercially. Unlike in the Northern California Current, where juvenile rockfish have been shown to play an important role in the productivity of diving piscivorous seabirds such as auklets and murres (Field et al. in review), no such trophic relationship has been observed at least for the western Aleutian Islands (Springer et al 1996).

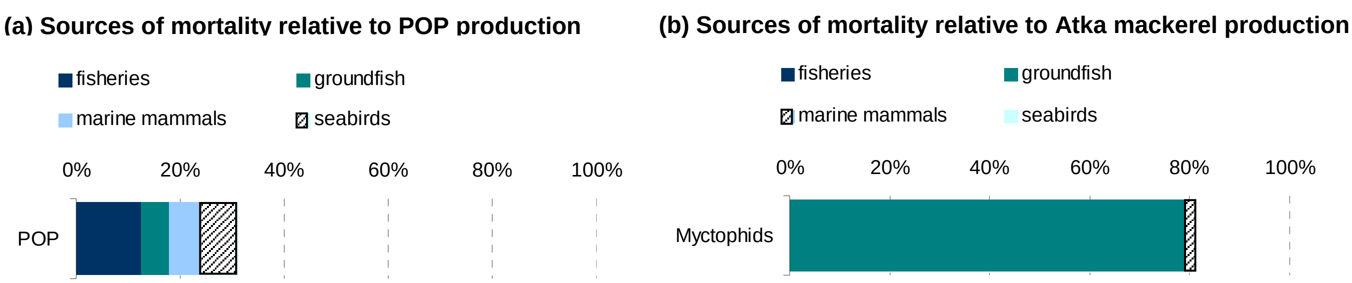


Figure 3-18 Mortality sources for (a) Pacific ocean perch (POP) and (b) Myctophids in the Aleutian Islands.

NOTE: Little information is available for myctophids, so we assumed that 80% of their production is consumed by other species, comparable to pollock and Atka mackerel.

Role of myctophids in the food web

Myctophids are a composite taxonomic group containing all lanternfish members of this family in Alaska. Most myctophids are less than 10 cm long, but some reach up to 30 cm. They exhibit diel migration with peak abundances between 300 and 1200 m during daytime and between 10 and 100 m at night (Nelson 1994). Acoustic surveys show that the horizontal distribution of myctophids extends far off the shelf break but overlaps marginally with that of pollock near the shelf (Steven Barbeaux, pers. comm.). The vertical migration and overlap towards the shelf may make them available to groundfish predation (Figure 3-18b), in particular by pollock (responsible for 30% of their total mortality), giant grenadier (23% of total mortality), and Kamchatka flounder (6% of total mortality). This dependence of pollock on myctophids as prey is unique to the Aleutian Islands among Alaskan ecosystems; Bering Sea and Gulf of Alaska pollock have almost no myctophids in their diets (Aydin et al in press). While current whale and seabird diet data are limited and do not distinguish forage fish families, the model assumption that these predators consume forage species in proportion to their estimated abundance suggests that myctophids would contribute substantially to the diet of killer whales, albatrosses and kittiwakes, making them a key prey item for fish, seabirds, and marine mammals in the Aleutian Islands, particularly towards the west.

Comparative ecosystem impacts of increased mortality changing predator prey relationships for Atka mackerel, Pacific ocean perch, and myctophids

Model simulations were used to compare the relative impact of a 10% increase in unexplained mortality on each of these three key species in the food web to further explore biological relationships in the AI ecosystem.[5] In each case, uncertainty in the base food web parameters was included in the analysis using methods detailed in Aydin et al (in press), and is presented as error bars demonstrating the ecosystem adjustments in 95% of model simulations.

Shown on the same scale, it is clear that a similar change in mortality for each of these species has widely different ecosystem effects (Figure 3-19, Figure 3-20, Figure 3-21). The ecosystem is particularly sensitive to increased mortality of Atka mackerel, and appears relatively insensitive to increased mortality of POP. The ecosystem effects of increased myctophid mortality are intermediate between Atka mackerel and POP. It is notable that the most uncertain and potentially largest (positive) impacts of increased Atka mackerel mortality are on pollock and pollock fisheries, with (negative) potential impacts to Steller sea lions and Alaska skates ranking slightly higher than impacts to the Atka mackerel fishery itself. The uncertainty shown in the plot is the highest found for any species interactions in the ecosystem using this analysis; this uncertainty does not arise from the model parameters for Atka mackerel themselves, which are based on high quality data in this ecosystem. Rather, the uncertainty likely arises from the unstable predator-prey interaction between pollock and Atka mackerel in particular (see further discussion in Section 4.3). The primary conclusion from an analysis of this type is that all things being equal, management of Atka mackerel fisheries and unintended fishery or climate impacts to myctophids might have wider ecosystem effects than management of POP fisheries.

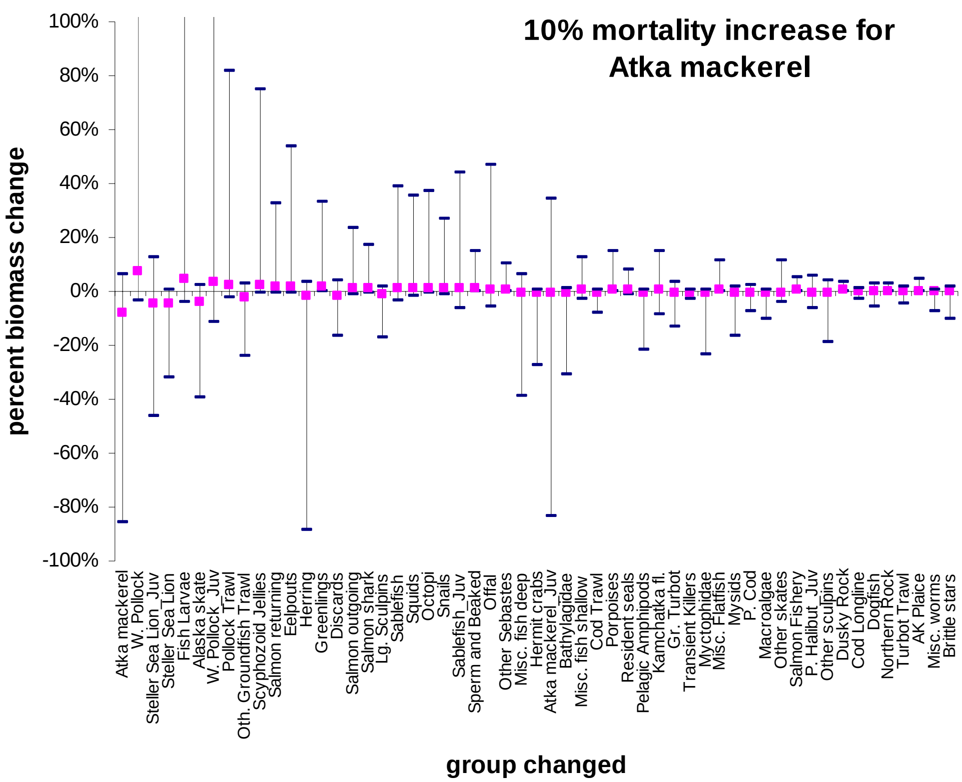


Figure 3-19 Food web model simulation of a 10% mortality increase for adult Atka mackerel

[5] Similar information is available for any species, and alternate scenarios (such as several species having changed mortality at once) can be analyzed using similar methods at the Council's request

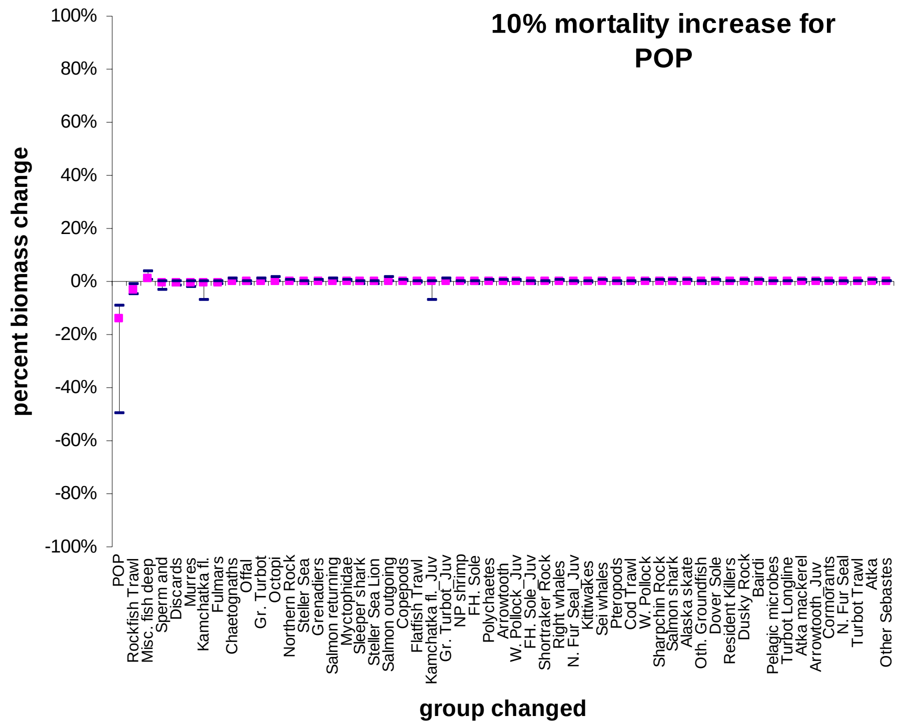


Figure 3-20 Food web model simulation of a 10% mortality increase for adult Pacific ocean perch

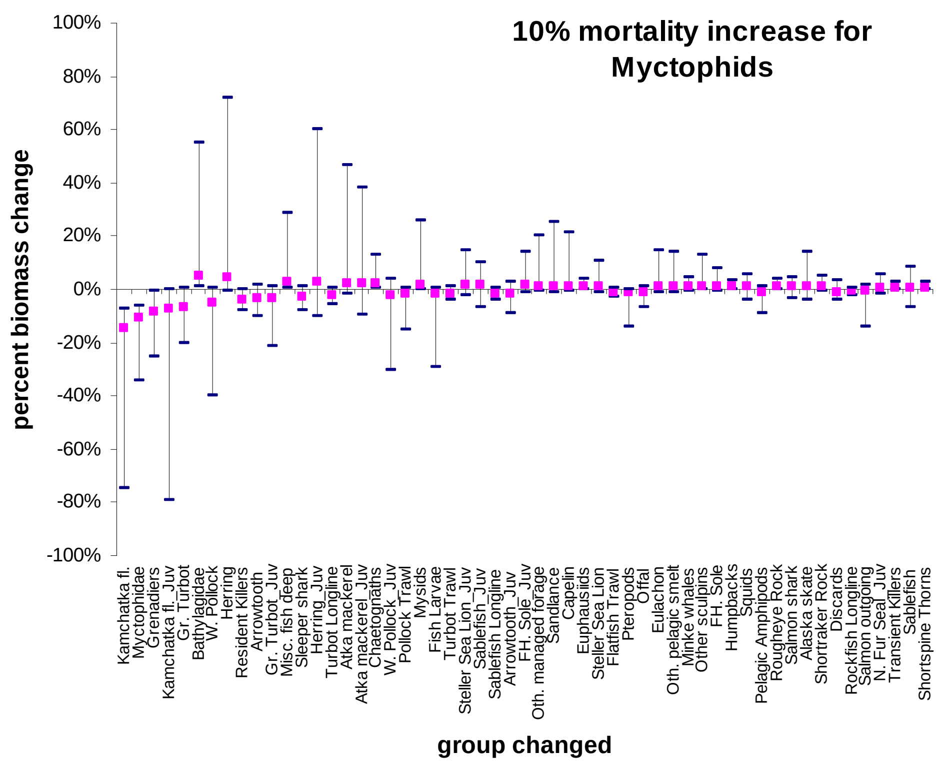


Figure 3-21 Food web model simulation of a 10% mortality increase for myctophids

The impacts of changing mortality to single species and their transmission through food webs is also complicated in the Aleutian Islands ecosystem by changing biological relationships at local spatial scales. Spatial patterns in food webs are examined in more detail in the next section.

3.3.4 Spatial food web relationships in the Aleutian Islands

Two main spatial patterns determine the structure of the food webs in the Aleutians. First, there is a longitudinal gradient from east to west along which the main prey supporting the food webs changes. Second, groundfish distribute vertically on the shelf at different depths. The longitudinal pattern is the result of large scale oceanographic processes which determine major physical attributes of the habitat and geographical boundaries for fish, playing a critical role in species richness (number of species) and species diversity (proportion of each species available within a unit of area). In contrast, the vertical pattern results from small scale factors: the amount of available shelf at depth and habitat partitioning. The relative position of the predators influences their access to prey. What the individuals eat most (strong links) is then the combination of what is available (through large scale processes) and what they can actually get to (local processes). The available resources are increased by spatial subsidies of myctophids and squids from adjacent pelagic oceanic waters and offal from fisheries. The result of these processes is an observed spatial difference in the diets of Atka mackerel and pollock (Figure 3-22), which demonstrate the longitudinal variability in diet for major species.

The combined effect of large and local scale factors structures the food webs into one of three general types, where Amukta and Amchitka Pass mark the breakpoints where the food web structure changes (Figure 3-23). The first are food webs supported by pollock and various groundfish, with a gradually increasing proportion of myctophids and a decreasing proportion of euphasiids. The second are food webs supported by Atka mackerel, benthic invertebrates, myctophids and euphasiids. The third are food webs primarily supported by Atka mackerel, non decapod benthic invertebrates, copepods and euphasiids. Although all the main prey supporting the food webs are distributed throughout the archipelago, they are not of the same importance in each type of food web. Even greater diversity is observed among the weak links: flatfish and forage fish towards the east, demersal fish, polychaetes and amphipods towards the west. As Berlow et al. (2004) point out, the relevance of any one given species lies in the particular configuration or structural organization of strong and weak links.

Myctophids are common among the three food web structures. They are consumed all along the archipelago. Schools of myctophids and squids overlap the edge of the shelf and shelf break, and extend far off shore (Barbeaux et al 2005). As our food web models only include the shelf down to 500 m depth, it is unlikely that the myctophids and squids consumed come entirely from local communities. At least some level of spatial coupling occurs between these local communities and regional pools. If that is the case, then the archipelago receives a substantial subsidy from adjacent pelagic waters. The relevance of subsidies for local productivity depends on the permeability of the system and the potential for resource utilization. The ratio of perimeter to area, currents and upwelling all increase permeability or openness (Holt 2004, Witman et al. 2004). The islands, and archipelago [and shelf modeled here] as a whole, certainly have a large perimeter compared to its area characterized by tidal currents and passes. More than 20 groundfish have direct trophic connections with myctophids, 18 to squids (Ortiz 2007). This evidence points to the archipelago as a subsidized system where productivity on the shelf down to 500 m highly benefits from this process. A second source of subsidies is fisheries, which in some areas support an important portion of the local consumption. The risk of depending on subsidies is the expected low productivity when these resources are missing (Huxel et al. 2004).

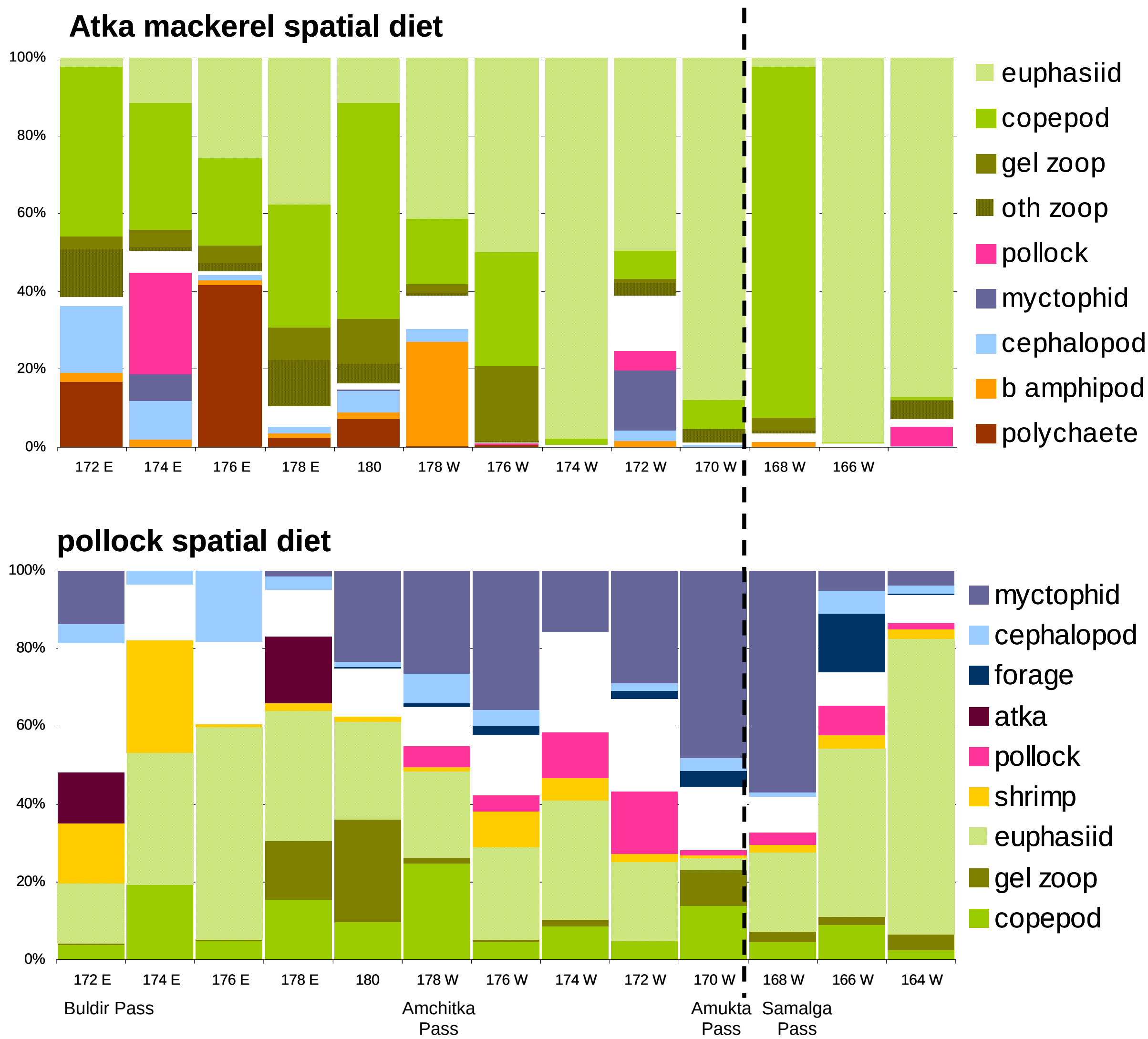


Figure 3-22 Spatial diet composition for Atka mackerel and pollock in the Aleutian Islands, from combined 1981-2001 bottom trawl surveys.

Reprinted from Ortiz (2007).

NOTE: See Appendix E for sample sizes.
Dashed vertical line represents the current management boundary between the AI and the eastern Bering Sea and GOA management areas.

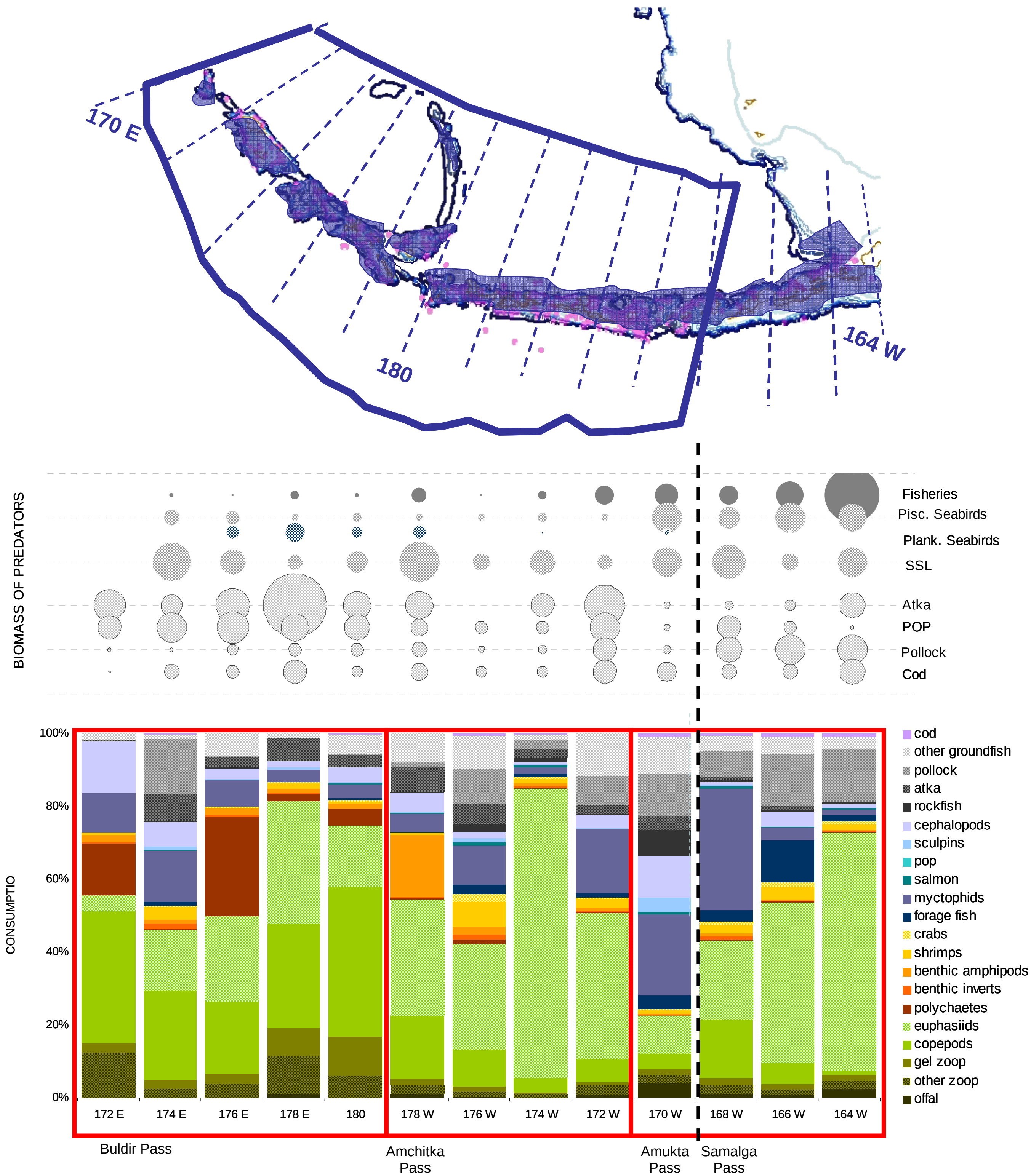


Figure 3-23 Spatial food webs in the Aleutian Islands.

NOTE: Dashed vertical line represents the current management boundary between the AI and EBS, GOA management areas.

3.3.5 Energy flow: leaky ecosystem boundaries

The Fishery Ecosystem Plan defines a boundary for the ecosystem (west from 169°W) based on ecological and management boundaries. However, the actual foraging and distributional ranges of marine species and humans that use and inhabit the ecosystem are neither uniform nor confined to these area, but have a strong relationship with areas outside of the defined boundary.

The primary marine currents that influence the marine waters near the central and western Aleutians originate outside the area. Although the Alaska Coastal current largely moves north into the Bering Sea between Unimak and Samalga Passes, the Alaska Stream continues west along the south side of the islands. The Aleutian North Slope Current apparently originates west of Attu and moves east along the north side of the islands (see Figure 3-8).

The primary atmospheric forcing is from the Aleutian Low Pressure system. Cyclonic storms typically form southwest of the Aleutians and move to the east along the chain affecting not only weather in the Aleutians but also in the EBS and GOA and beyond.

Although the area of interest for this fishery ecosystem plan is the Aleutian Islands, management in this region potentially affects people and animals that are not resident in the area. For instance, several species of seabirds and marine mammals listed as threatened or endangered spend only a portion of the year in this area (Table 3-1). Oceanic seabirds including albatrosses and shearwaters feed near the Aleutians from distant breeding areas (central, eastern, or even south Pacific) or during their non-breeding seasons, but have historically been affected by fisheries in the area of interest (i.e., bycatch during long-lining or drift gill netting). Northern fur seals from breeding areas in the eastern Bering Sea migrate through the Aleutians and several species of whales spend summers in the region, but migrate out to the rest of the Pacific for the remainder of the year.

Table 3-1 Range of seabirds that spend some or all of the year in the Aleutian Islands ecosystem

Species	Seasonality in Aleutian Islands	Estimated population size	Notes
Short-tailed Albatross	Summer and fall foragers	Low hundreds	See Piatt et al. 2006
Laysan Albatrosses	Oceanic, year around	Thousands	
Short-tailed Shearwater	Oceanic in summer	Hundreds of thousands	S. hemisphere breeders, Gibson and Byrd 2007
Mottled Petrels	Oceanic in summer	Thousands	Gibson and Byrd 2007
Marine Waterfowl	Winter	Tens of thousands	Gibson and Byrd 2007
Through migrants birds	Spring and fall	Thousands	Gibson and Byrd 2007

Current protection for marine mammals and recent advances in bycatch mitigation measures have substantially reduced the bycatch of seabirds and high-seas drift gill nets have now been banned from the EEZ. However, all these visiting species still depend upon healthy food webs in Aleutian waters during their seasonal occupancy.

Marine waterfowl (i.e., swans, geese, sea ducks, loons, and grebes) congregate in nearshore waters and intertidal zones of the central and western Aleutians in winter from distant breeding areas. In fact, the Aleutians are the primary wintering area for emperor geese and harlequin ducks, and substantial numbers of species of sea ducks winter in the region (Gibson and Byrd 2007).

For some selected fish species, such as Pacific cod, Atka mackerel, walleye pollock, and various rockfish species, the degree of linkage with areas outside of the Aleutian Islands can be gained from genetic patterns, tagging, recruitment patterns, and other types of data. A common consideration is whether an AI and EBS populations represent distinct stocks, but it is also important to assess whether AI populations are distinct from populations in Russian waters. For example, recent genetic data does not suggest stock structure between the Aleutian Islands and Russia for halibut and Pacific cod.

For cod, significant migration between and within the EBS, AI, and GOA has been demonstrated from tagging studies (Shimada and Kimura 1994), and a study of allozymes failed to show significant stock structure between these areas (Grant et al.1987). However, the decision whether to manage EBS cod separately from AI cod is a current management issue, and additional genetic research use microsatellite DNA is underway at the Alaska Fisheries Science Center (M. Canino, AFSC, pers. comm.). Additionally, length frequencies, age frequencies, size at age, and diet differ between the EBS and AI, but the degree to which these results reflect environmental differences, as opposed to spatial stock separation, between the areas is not clear.

For Atka mackerel, examination of the linkage between the AI and the GOA has been examined with several types of data. Morphological and meristic studies suggests separate populations between these areas (Levanda 1979, Lee 1985), whereas an allozyme study showed no difference between the western GOA and three areas of the AI (Lowe et al. 1998). Ongoing work with microsatellite DNA did not show spatial structure with samples from the AI, GOA, and Japan, and examination of the temporal stability these results is currently being examined. The current genetic data indicates connectivity between the GOA and AI, perhaps due to high dispersal and/or recent population expansion. However, differences in population size, spatial distribution patterns, and recruitment patterns between the GOA and AI has motivated separate management of the AI and GOA populations.

For walleye pollock, three stocks are recognized in the BSAI area: the EBS stock, an AI stock, and the central Bering Sea-Bogoslof Island stock, and it is recognized that these populations likely have interchange between them. Microsatellite data indicates weak differences across samples throughout the north Pacific; however, these weak differences were significant on large geographical scales and conform to an isolation-by-distance pattern (O'Reilly et al. 2004; Canino et al. 2005). Separate stock assessments currently exist for AI and EBS pollock, but the stock assessment authors caution that interaction between AI pollock and EBS pollock does occur although the extent of this interaction is not known.

Tagging information does not exist for Alaskan rockfish, although genetic information is available for several rockfish species in the Aleutian Islands, including POP, northern rockfish, rougheye rockfish, and shortraker rockfish. For POP, microsatellite DNA was analyzed from 10 locations throughout the GOA, EBS, and AI, and the results indicate sub-population structure. Additionally, a pattern of isolation by distance was observed, in which the genetic difference between locations increased with the distance between locations. These results are consistent with research on British Columbia POP (Withler 2001), and suggest limited linkages between adjacent areas. Ongoing genetic research with POP is focusing on increasing the sample sizes and collection sites for the microsatellite analysis in order to further refine our perception of stock structure.

For northern rockfish, a preliminary study revealed no evidence of population structure from either mtDNA or microsatellite analysis (Gharrett 2003). However, the sample sizes were small (20 fish from each of three locations), and only a portion of the mtDNA genome and a handful of microsatellite loci were examined. If subtle differences occur, much larger sample sizes would be required in order to identify stock structure. Additional northern rockfish genetic samples were collected from each of the four major areas in the 2004 Aleutian Islands survey (100 samples each), as well as 100 samples from the

2004 EBS slope survey, and a genetic analysis of these samples by Dr. Anthony Gharrett and his colleagues at the University of Alaska is currently in progress.

Population structure has also been observed for shortraker rockfish, based upon microsatellite data, with the geographic scale roughly consistent with current management regions (i.e., GOA, AI, and EBS) (Matala et al. 2004). The most efficient partitioning of the genetic variation into nonoverlapping sets of populations identified three groups: a southeast Alaska group, a group extending from southeast Alaska to Kodiak Island, and a group extending from Kodiak Island to the central Aleutians (the western limit of the samples). The available data are consistent with a neighborhood genetic model, suggesting that the expected dispersal of a particular specimen is much smaller than the species range. A parallel study with mitochondrial DNA revealed weaker stock structure than that observed with the microsatellite data. This study suggest some linkage between shortraker rockfish in the central and eastern AI and the GOA, although it is not known how shortrakers in the eastern Bering Sea or western Aleutians relate to the large population groups identified by Matala et al. (2004) due to a lack of samples in these areas.

Genetic analyses have revealed two species of rougheye rockfish, with the central and western Aleutian Islands consisting predominately of the “type I” species, later recognized as blackspotted rockfish (Orr and Hawkins 2006). For these fish, four partitioning schemes were examined in which the samples were assigned to non-overlapping populations. Each of these four schemes indicates that significant divergence occurred between the Gulf of Alaska and either the central Aleutian Islands or eastern Bering Sea. However, each of these four partitioning schemes show a linkage between GOA type I rougheye and either AI rougheye or EBS rougheye, thus suggesting some connectivity between rougheye rockfish in the BSAI area and the GOA.

3.3.6 How is the Aleutian Islands ecosystem different from the surrounding ecosystems?

The Aleutian Islands food web is dominated by oceanic processes, and is characterized by substantially higher pelagic energy flow than the Eastern Bering Sea or Gulf of Alaska ecosystems. Much of this pelagic energy could be considered an external “subsidy” for continental shelf and land based species inhabiting the Aleutian Islands (including humans). The gradient of depth defined habitats, species biomass, richness, and diversity across the Aleutian chain drives different food web interactions across space, where both regional and local scale interactions are combined to support ecosystem energy flow.

Groundfish relationships differ greatly between the Aleutian Islands and the Eastern Bering Sea, although the two ecosystems are often combined for management purposes. Atka mackerel dominate the Aleutian Islands food web, where they support economically important fish species, marine mammals, and directed fisheries simultaneously; however, Atka mackerel are only minor components of other Alaskan ecosystems. Commercially important groundfish species have different food web roles in the Aleutians than they do elsewhere in Alaska. Sablefish are zooplankton feeders here, whereas they feed on fish in the EBS and GOA; conversely, pollock rely on myctophids for a substantial portion of their diet in the AI, but are nearly exclusively zooplankton feeders in the other systems. Pacific cod interact strongly with Atka mackerel and sablefish in the Aleutians, whereas they interact mostly with crab species in the Eastern Bering Sea. Myctophids, squids, and grenadiers are prominent players in Aleutian Islands energy flow, but minor components of the Eastern Bering Sea and Gulf of Alaska food webs. This is primarily attributable to the proximity of pelagic oceanic habitats to shelf and nearshore habitats in the Aleutian Islands, which is nearly opposite in configuration to the Eastern Bering Sea shelf which has few connections to the open ocean.

3.4 Socioeconomic relationships in the Aleutian Islands ecosystem

3.4.1 Unangam Tunuu

Language is one of the primary ways in which humans interact with and form concepts of the environment. Unangam Tunuu is the Aleut language, spoken for thousands of years in the Aleutian Islands Ecosystem. The language is very detailed in identification of marine species, reflecting the kind of meticulous environmental knowledge indigenous groups develop over many generations of observations in a particular ecosystem. Each term for a species or resource group is a linguistic marker for a much wider repository of traditional ecological knowledge about natural history, animal behavior, seasonal variation, cultural values, and spiritual interrelations.[6]

In Atka, the fish that bears the community's name in common English, the Atka mackerel (*Pleurogrammus monopterygius*) is called *tmadgi{* (*tavyi{* in Attuan). Some names are the same across the island chain, such as *haanu{* for the sockeye salmon (*Oncorhyncus nerka*). Others terms are distinct to each island, or reflect broader groupings of eastern and western, such as the Steller sea lion, known as *qawa{* from Atka east and *qava{* in Attu and the Commander Islands. Some words hint at the broader system of environmental knowledge of which they are a part, such as aligdusi-{, used in the eastern islands for jaegers (*Stercorarius parasiticus* and *S. longicaudus*). The name literally means "making vomit," a reference to the behavioral trait of forcing other birds to spit out fish they have just caught. Other words retain traces of the region's colonial history, such as herring (*Clupea herengus*), which is called ungla-{, but may also be called sildi-{ from the Russian word *sel'd'* for herring.

There are also a huge number of Unangam names for places and geographic features in the islands. The terms on any contemporary map of the islands reflect Aleut, Russian, American, and scientific interests and influences in the islands. Understanding that the biotic, geographic, and oceanographic resources of the Aleutian Islands ecosystem are discursive objects in many different systems of meaning is a key to understanding that human history, along with a variety of human interpretations, human conflict, and human interests are an integral part of the ecosystem.

According to the US Census 2000, Unangam Tunuu, the Aleut language, is spoken in about a quarter of households in Atka and a much smaller percentage of households in Adak. The language is also taught in area schools and at summer cultural camps. Although English is the predominate language of everyday discourse, Unangam names for places and common animals are more widely known and understood.

3.4.2 Communities in the ecosystem today

The Aleutian Island Fishery Ecosystem Plan boundaries contain four inhabited communities. Until recently, three of these (Adak, Attu and Shemya) were military locations, while only Atka was a civilian settlement. Atka is a Native village that has persisted for thousands of years, though its population is declining. When the base closed in Adak in 1997 the settlement lost almost all of its population of military personnel and civilian support personnel. However, there are still several hundred people there and it appears the location will remain a civilian population center. Both civilian communities (Atka and

[6] The examples of Unangam names for marine animals require the Unangam Tunuu font in order to see all the letters in the words correctly. The font is free and is easy to download at http://www.alaskool.org/LANGUAGE/fonts/unangam/unangam_font.htm. All examples are given in Atkan or Attuan dialects unless otherwise noted. A detailed pronunciation guide for the Atkan dialect may be found at http://www.ankn.uaf.edu:591/Atkan/Pronunciation.html.

Adak) are highly dependent on commercial and subsistence fisheries in the Aleutian Islands ecosystem, though Adak has other economic development as well (see below).

Shemya and Attu

Shemya is the site of Eareckson Air Station, a U. S. Air Force base, which grew from an airfield first constructed during World War II. During the cold war the population of Air Force personnel at Shemya was about 1500 people but most active duty military personnel have left the island. Currently about 300 people (mostly contractor personnel) occupy Shemya, which is being used as an important site for the Missile Defense System, and has an enormous radar installation. Faclities include a 10,000 ft. runway, a relatively unsheltered barge dock, and housing and other facilities to support the contractors. Only Military Airlift Command flights are available and security clearances are required to go to Shemya. The air base is used as a refueling stop for military aircraft.

Attu hosts a Coast Guard Loran station manned by about twenty active duty personnel that rotate yearly. The station is served by Coast Guard aircraft from Kodiak Air station. Housing and other support for the personnel is provided in a single building.

Atka and Adak demography

Populations in these communities have varied over time. The population of Atka has fallen consistently from the maximum of 132 listed for the 1880s and 1890s when Census records were first calculated, to 92 in the 2000 Census, and 90 in the state demographer’s 2005 estimate. The population of Adak has fluctuated extensively over the years due to changing military activities. In 1944, there were more than 30,000 people in Adak, because of WWII action in the Aleutian Islands. A population was first recorded by the Census in 1970 at which time there were 2,249 inhabitants and the population grew to approximately 6,000 people, mostly active duty navy, by 1990. The Navy base closed in 1997 and a civilian community was established after land transfers to the Aleutian Islands Regional Corporation. The 2000 Census recorded 316 people. By 2002, the population had reduced to 149 people, according to a state demographer, but has increased to 167 in 2005, largely due to efforts on the part of the Aleut Corporation to develop economic opportunities there.

Table 3-2 Demographic data for Adak and Atka

US Census 2000 Data	Adak	Atka
Population in year 2000	316	92
% Alaska Native	35.1%	80.4%
% White	49.7%	6.5%
% Asian	9.8%	1.1%
%Hawaiian Native or Pacific Islander	1.9%	1.1%
% Black	1.3%	0.0%
%Two or more races	2.2%	10.9%
% Hispanic ethnicity (supplementary to race)	5.1%	1.1%
Male/female ratio	65/35	50/50
Median age	35.2	35.5

The distribution of population by age and gender in Adak and Atka (Figure 3-24) shows two distinct patterns found frequently in Alaskan communities. Atka’s structure is most similar to the pyramidical “family shape” (Package and Sepez 2007), displaying a relatively even distribution between genders and a general decline by age. This structure is commonly found in Native villages, and often shows a reduction of 20-29 year olds out-migrating for educational opportunities. Adak’s structure resembles the "labor shape" (Package and Sepez 2007), dominated by a bulge of working-age males, as is commonly observed for industrial towns, such as fish processing centers. The population structure of Adak is likely to change over time as the Aleut Corporation continues to actively seek to move Native families into the area.

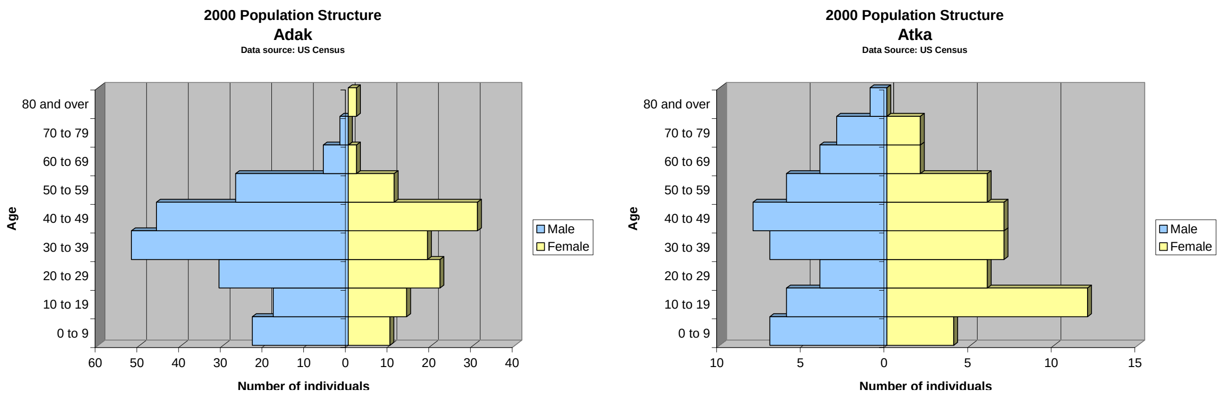


Figure 3-24 Distribution by age and gender of the 2000 Census populations in Adak and Atka.

Atka economy and infrastructure

The economy of Atka is predominantly based on subsistence living and commercial fishing. The median household income in 2000 was $30,938 and the per capita income was just over $17,000. There are limited year-round income opportunities in the village in education and government related work. Some residents work off-island part of the year in order to make enough income to get by. Marine resources are abundant, and about 2,500 reindeer on the island and provide a source of fresh meat to local residents.

Atka was incorporated as an Alaska city in 1988. The city provides water, sanitation, and electricity (diesel powered). The Aleutian Pribilof Islands Association, Inc., a federally recognized, nonprofit, tribal organization provides public safety (Atka Village Public Safety Officers) and health programs (Atka Health Clinic). Atka is a member of the for-profit regional Aleut Corporation chartered under the Alaska Natives Claims Settlement Act. Atxam Corporation is the Native village corporation. The Native Village of Atka is the federally-recognized tribe. Each of these governmental and quasi-governmental organizations plays a role in administering the community. Atka is within the Aleutian Region school district and one school on the island, with two teachers, serves 19 pupils ranging from grades K-12. The school gym is used widely for community gatherings including bingo nights. The St. Nicholas Russian Orthodox Church, rebuilt with reparation funds after being burned by the Navy in WWII, also serves as a focal point of village life.

Atka has a state-owned 3,200 foot lighted paved runway. Scheduled air services are available four times weekly from Unalaska and can also be chartered from Cold Bay. The cost of a roundtrip plane ticket from Atka to Anchorage is about 7% of the per capita income, based on fares searched for in January 2007 (about $1,200). Poor visibility and bad weather make the flight schedule very uncertain. This relative isolation from transportation and supply systems structures many aspects of life in Atka, from retail purchasing to participation in public processes. Coastal Transportation provides freight services during the peak fishing season from May to October. A new dock and port facility, operated by the City, were recently completed 5 miles from town.

Adak economy and infrastructure

The economy of Adak is more varied than that of Atka, with shipping, military, and local commercial establishments as well as commercial and subsistence fishing. Its residents also have higher income levels than Atka. The median household income was $52,727 and the per capita income in 2000 for Adak was $31,747, nearly twice that of Atka.

The City of Adak incorporated in 2001 and provides police and fire services, electricity (from diesel fuel), water, and a sewer system. Adak Medical Clinic is operated by Eastern Aleutian Tribes. Although Adak was an Aleut village in earlier times, it was a military base during the latter half of the twentieth century. For that reason, it was not included in the Alaska Native Claims Settlement Act and is not federally recognized as a Native village. Aleut Corporation has taken a very active role in the development of the city after the base closure, taking over responsibility for some services to the community, such as the landfill. Adak School, the only school present, teaches K-12th grade, and had 18 students in 2000 and 3 teachers. The pool in the former high school, which is currently unmaintained, is scheduled to be refurbished by the military. St. Innocent Chapel of the Russian Orthodox Church was founded in 1996.

In 2004, the Aleut Corporation took over 46,000 acres on Adak, including the former naval base, in a land exchange with the US Fish and Wildlife Service. Adak Fisheries, LLC, is the seafood processing plant managed by Aleut Enterprise Corporation, subsidiary of the Aleut Corporation. The seafood processor is attempting to develop into a year round operation. The Aleut Corporation received from Congress in 2004 a quota of Aleutian Island pollock set aside from the Bering Sea total allowable catch (TAC) for the purposes of economic development in Adak. To support a local fleet, 50% of the allocation is required by 2013 to be taken by vessels under 60 feet in length.

Adak has two 7,800 foot paved runways and Alaska Airlines operates passenger and cargo airline service to Adak on Thursdays and Sundays. A roundtrip flight from Adak to Anchorage represents approximately 4% of per capita income ($1,302, based on dates for January 2007). This relative isolation from transportation and supply systems structures many aspects of life in Adak, from retail purchasing to participation in public processes. There are three deep water docks and fueling facilities in Adak, originally built to handle naval ships. The city has about 16 miles of paved roads and also has other dirt and gravel roads.

3.4.3 Commercial fisheries

The Aleutian Island Ecosystem provides fish that are eaten all over the world, and commercial fishing opportunities to residents of the ecosystem (in Atka and Adak) as well as to communities throughout the west coast. This section will examine commercial fisheries in two ways: commercial fisheries production in the FEP area (for processors and vessels from anywhere) and commercial fisheries pursued by the communities (processors and resident-owned vessels) located in the ecosystem. Confidentiality requirements prevent a full disclosure of much of this information.

Commercial fisheries production in the Aleutian Islands ecosystem

In 2005, the Aleutian Islands Fishery Ecosystem (defined for the purpose of this analysis as statistical areas 541, 542 and 543 combined, see Figure 3-25) produced 216 million pounds of fish, with an estimated ex-vessel value of 60 million dollars. [7] In 2005, AI Ecosystem fish was processed in 10 ports in the following rank order (based on ex-vessel value of fish delivered): floating processors, Dutch Harbor, Adak, Akutan, Atka, King Cove, Homer, Sand Point, Kodiak, Ninilchik, Saint Paul. Further discussion by community is difficult to provide because so many of these locations only have a single processor, making the information confidential. Thirty-two off shore processors (including catcher-processors,

[7] Areas for halibut and salmon fisheries do not exactly correspond to areas 541, 542 and 543. For these fisheries, reasonable approximations have been made to the Aleutian Islands Fishery Ecosystem Plan boundaries, but the associated data may not be as reliable as other fisheries.

motherships and other off shore sector participants) account for 89% of the total landings from the ecosystem, comprising 56% of ex-vessel value. The majority of off shore processing volume is devoted to Atka mackerel, often by twice as much as the highest volume speicies, Pacific cod.

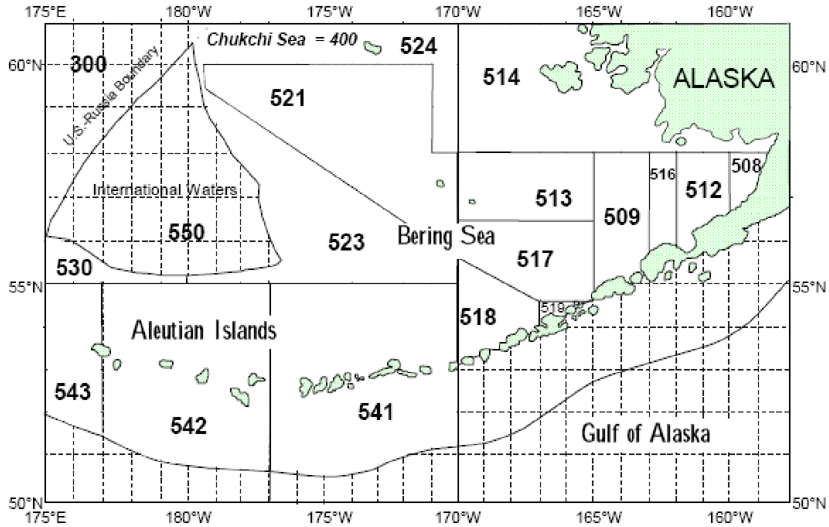


Figure 3-25 Management areas near the Aleutian Island ecosystem.

NOTE: Includes AI areas 541, 542, and 543 (which extends further west to the limits of the EEZ). AI halibut areas 4A and 4B are not shown.

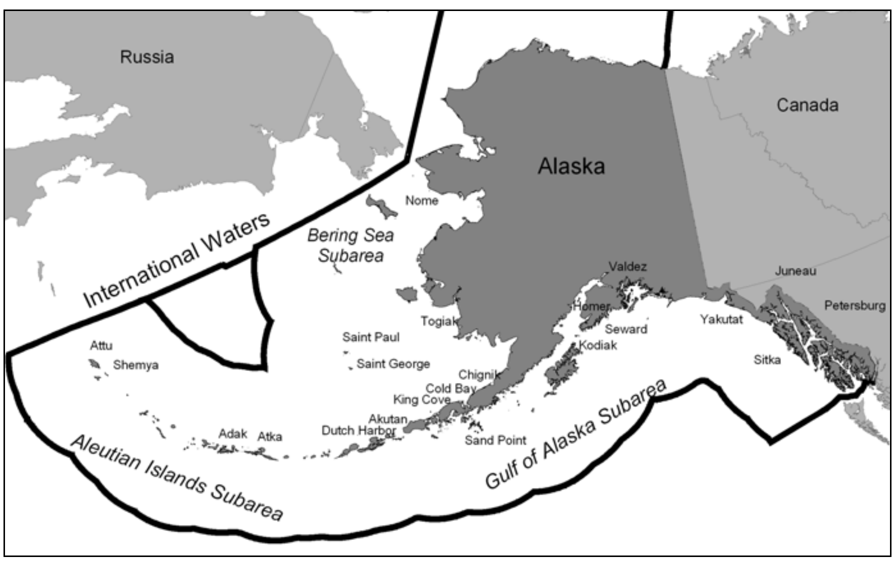


Figure 3-26 Major fishing communities in Alaska.

The majority (by volume) of fishery resources harvested in the Aleutian Islands ecosystem in 2005 consisted of Atka mackerel (Figure 3-27). By value, Atka mackerel, Pacific cod, crab, and halibut together in similar proportions make up the majority of the value of fishery resources removed from the ecosystem (Figure 3-27). These proportions have been relatively stable over the last five years.

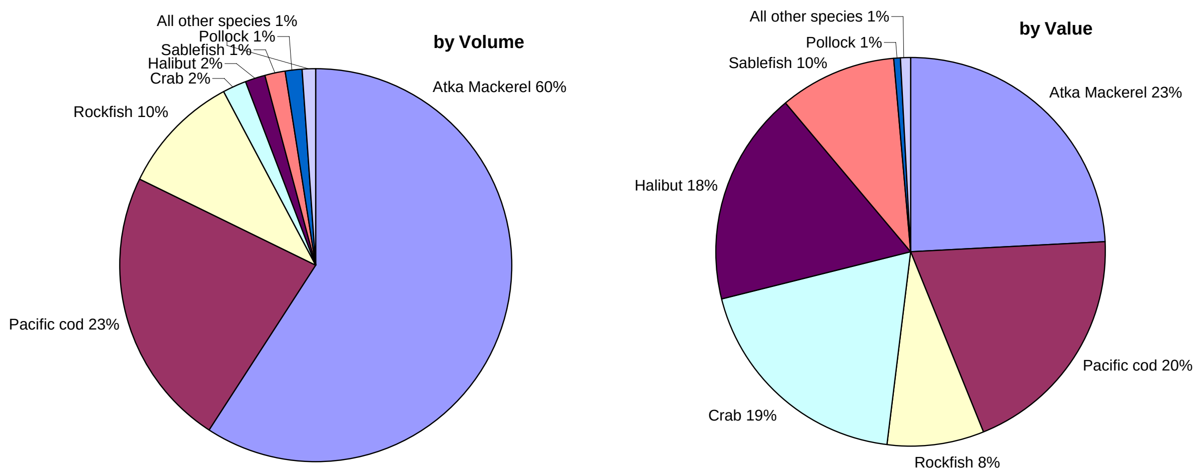


Figure 3-27 Fishery resources harvested in the Aleutian Islands Ecosystem (areas 541, 542, and 543, and halibut areas 4A and 4B) by volume and by value, in 2005.

Over the last five years, the volume of Atka mackerel extracted from the AI ecosystem has ranged between 37,000 and 56,000 metric tons, Pacific cod between 22,000 and 38,000 metric tons, rockfish between 8,000 and 10,000 metric tons, halibut between 2,000 and 3,000 metric tons, crab between 2,000 and 3,000 metric tons, sablefish at 1,000 metric tons (plus or minus about 400), flatfish at 1,000 metric tons (plus or minus about 300), pollock at 1,000 metric tons (plus or minus 600) and other grounfish and other species ranging between 2 and 300 metric tons. Table 3-3 shows by species the number of plants processing and vessels harvesting AI ecosystem fish in 2005.

Table 3-3 Number of vessels harvesting and plants (onshore or offshore) processing AI fish, by species in 2005.

Species	Number of vessels harvesting	Number of processors
Atka Mackerel	12	12
Crab	9	6
Flatfish	30	27
Halibut	97	16
Other groundfish	18	16
Pacific cod	45	27
Pollock	22	23
Rockfish	47	29
Sablefish	41	23

Fish harvested over the last 5 years (2001-2005) in the AI ecosystem was landed in 22 different ports in Alaska. Fifteen of these ports received AI ecosystem fish in at least four of the last five years, indicating a stable pattern of receiving AI fish. The 14 onshore ports are Adak, Akutan, Atka, Dutch Harbor, Homer, King Cove, Kipnuk, Kodiak, Ninilchik, Nome, Saint Paul, Sand Point, Seward, and Togiak (Figure 3-26). Some ports received only a single type of fish from the AI ecosystem, such as halibut, which had a wide distribution. Others, especially those in or closest to the ecosystem, received many different kinds. The 15th "port" consists of all floating processors, catcher processors, motherships, and other off-shore sector participants, which consistently received twice or more as much Atka mackerel than anything else. Only rarely and in very small amounts in the last five years has Atka mackerel been processed on shore.

A detailed description of the management of the fisheries is provided in Section 3.5.

Commercial fishing in Atka

Commercial fishing is of great significance to the economy of Atka. According to the Aleutian Pribilof Island Association, the local fleet consists of 45 vessels. With the help of Atka's CDQ group, Aleutian Pribilof Island Community Development Association, the development of several facilities in the 1990s associated with the fishing industry has resulted in significant economic enhancement in the community (Obeso 1994). The City of Atka collects a 2% raw fish tax on fish landed in the community. A small on-shore fish processor, Atka Pride Seafoods, services the local fleet. Because there is only one processor in the community, landings information must be kept confidential by law.

According to the Alaska Department of Fish and Game (ADF&G) and reported by Alaska Commercial Fisheries Entry Commission, 17 Commercial Fisheries Gear Operator Permits were held by 9 individuals in Atka in 2000. 10 of these were actively fished that year. There were 3 vessel owners in the federal fisheries, no vessel owners in the salmon fishery, and 19 licensed crew members with residence in Atka. A number of offshore fish processors carry out crew changes through Atka.

Permits for halibut issued in Atka for 2000 pertained to one hand troll (not fished), 7 longline vessels under 60 feet (6 fished), and one longline vessel over 60 feet. All permits designated for halibut were for statewide waters. Permits for sablefish issued in 2000 pertained to four longline vessels under 60 feet for statewide waters (three fished). Additionally, one permit for a salmon set gillnet limited to the Atka/Amlia Islands and three permits for miscellaneous salt water finfish longline vessels under 60 feet for statewide waters were issued but not fished. In 2006, there were 9 halibut IFQ holders residing in Atka, holding 16 separate blocks of halibut quota.

Commercial fishing in Adak

Aleut Corporation has been working to establish Adak as a commercial fishing hub for the area. There were 49 vessels that delivered 'Other Groundfish' landings to the plant in Adak, 24 for sablefish, 32 for halibut, and 12 vessels that delivered Bering Sea and Aleutian Islands crab landings to the community. In accordance with confidentiality regulations, data for volume and value of fish landings in the community cannot be revealed. Adak Fisheries provides processing and cold storage capacity in Adak.

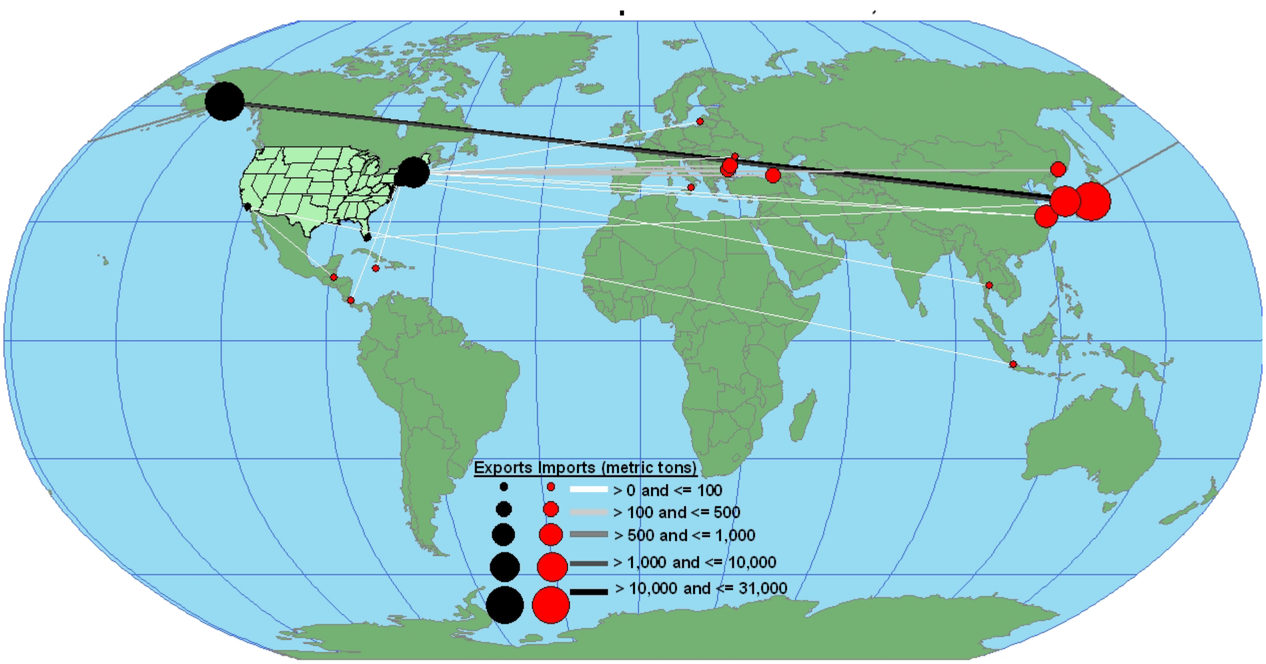
In 2000, there were four commercial fishing permits issued. There was one community member who owned a vessel participating in federal commercial fisheries who was a resident of Adak, and according to the Alaska Commercial Fisheries Entry Commission there were two licensed crew members from Adak in 2000. By 2005, there were 20 licensed crew members in Adak. Adak Fisheries Development Council is operating the local seafood processor in Adak which processes cod, crab, halibut and bottomfish. An allocation of pollock in 2005 to the Aleut Corporation and the implementation of state-waters Pacific cod and pollock fisheries in the central Aleutian Islands may contribute additional growth to this facility.

All four commercial fishing permits issued in 2000 to residents of the community were issued for the harvesting of groundfish. Specifically, one was issued for miscellaneous salt water finfish using a hand troll, one for miscellaneous salt water finfish using a mechanical jig, one for demersal shelf rockfish with a longline vessel under 60 feet in the southeast, and one permit was for demersal shelf rockfish using a mechanical jig in the southeast (not fished). In 2006, there were no halibut or sablefish IFQ holders residing in Adak.

Globalization of product and labor markets

Labor inputs in commercial fisheries, including crew and processing workers have a significant transnational component. Workers in the fisheries in Alaska come from all over the world. In the Aleutian Islands Ecosystem, transnational migratory laborers may be found in the processing plant in Adak, the off shore processor and catcher-processor fleet, and elsewhere. Laborers have come from the Philippines, Vietnam, and elsewhere in Asia, as well as Latin America and Africa. US residents come from all 50 states to participate in Alaska fisheries as commercial fishing vessel crew and processing workers.

The processed fishery products of the Aleutian Islands are exported to countries around the globe. It is not possible to disentangle Aleutian harvests from other United States harvest locations in export records, but an examination of all Atka mackerel exported from the US demonstrates just how globalized the market place is for fisheries products. Atka mackerel has been exported to 28 different countries over the last 7 years (1999-2005). Japan and Korea have consistently been the largest recipients of Atka mackerel (see Figure 3-28 for 2005 exports), but a geographically diverse group of nations are beginning to import the fish, including Bulgaria, Guatemala, Jamaica, Thailand, and Mexico. Records show this global market is continuing to develop, with just 2 nations importing $17 million worth of product in 1999 growing to 15 nations importing Atka mackerel worth an average of $52 million in 2005. It is likely that all of this product came from within the Aleutian Islands Fishery Ecosystem Plan boundaries.



Source: U.S. Merchandise Trade Statistics, GIS: Alaska Fisheries Science Center (michael.dalton@noaa.gov)

Figure 3-28 US Atka mackerel exports to the world, 2005.

NOTE: The black dots indicate the US port from which Atka mackerel was exported; however, all Atka mackerel in the US is harvested in Alaska, almost all in the AI ecosystem.

3.4.4 Subsistence fisheries

Subsistence harvests and related practices continue to be very important to Aleutian communities, providing nutritional, economic, social, cultural, and spiritual value. The following information focuses on quantitative data, which may be used to track change over time in the ecosystem and its inhabitant's practices. However, the importance of subsistence goods in the social, cultural, and spiritual life of a community is repeatedly expressed by participants in many Alaska locations as core motivation and reward for engaging in subsistence harvesting and consumption. There are typically strong connections between commercial and subsistence fisheries with commercial vessels provisioning subsistence consumers with fish or opportunities to fish, and earnings from commercial fishing supporting subsistence gear and other expenses.

Subsistence management of marine mammals in the Aleutians is shared between the US Fish and Wildlife Service, National Marine Fisheries Service, and several Alaska Native Organizations including the Alaska Sea Otter and Sea Lion Commission, the Alaska Native Harbor Seal Commission, and the Aleut Marine Mammal Commission. Management of subsistence fish and shellfish harvesting is conducted by the Alaska Department of Fish and Game in waters under state jurisdiction and by the federal Office of Subsistence Management in waters under federal jurisdiction. Management of the subsistence halibut fishery is conducted by the National Marine Fisheries Service

Subsistence fishing in Atka

Every household in Atka participated in the use of subsistence resources in 1994, the year of the most recent ADF&G survey, including harvesting, sharing, and consuming resources.

Sea lions, salmon, and reindeer are the biggest contributors to the subsistence diet. Of the total population, 96.4% used salmon, 92.9% used non-salmon (cod, flounder, greenling, halibut, rockfish, sablefish, sculpin, char, and trout), 92.9% used marine mammals, and 85.7% marine invertebrates.

The total per capita harvest for the year was 439.28 lbs. The composition of the total subsistence harvest can be shown by the percentages of the resources which demonstrate the amount of each resource category used by the community relative to other resource categories. Salmon constituted 21.58% of the total subsistence harvest by weight while non-salmon fish made up 9.03%, land mammals 21%, marine mammals 34.3%, birds and eggs made up 1.81%, marine invertebrates were 1.19%, and vegetation made up 1.09%. The wild food harvest in Atka made up 284% of the recommended dietary allowance of protein in 1994 (corresponding to 49 g of protein per day or .424 lbs of wild food per day).

The importance of marine mammals shown in the 1994 survey continues in more recent accounting. In 2004, 51 sea lions and 74 harbor seals were harvested by community members.

NOAA issued 19 Subsistence Halibut Registration Certificates (13 rural and 6 tribal) to residents of Atka between 2003 and 2005.

State subsistence permits and harvest reports for crab and salmon are not required in Atka. The most recent subsistence survey in Atka was conducted in 1994 and included 28 of 29 households. The 1994 subsistence salmon harvest in Atka was estimated to 2,504 salmon, comprised of 12 chinook, 431 sockeye, 567 coho, 1,387 pink and 107 chum salmon (Shaul and Dinnocenzo 1994). The magnitude of the subsistence king and Tanner crab harvest near Atka is unknown, but is believed to be relatively small.

Subsistence fishing in Adak

Only limited information on subsistence fisheries in Adak is available. This information indicates that both salmon and halibut are important species harvested by local residents. Based on information about the remote environment of Adak, the heritage structure of the current population, and evidence from other Alaska locations, it is reasonable to assume that a host of other subsistence harvests, including other fish, shellfish, and marine mammals, are taking place around Adak.

Caribou, salmon, halibut and marine mammals are among the resources used by Adak residents. Two sea lions were harvested for subsistence by Adak residents in 2004.

The amount of subsistence fishing in Adak has been very variable in the last decade because of the extreme fluctuations in population numbers and composition, the long legal struggle between the state and federal government over subsistence management and the rural preference, and a change in Adak's rural classification.

Prior to 1988, the non-commercial salmon net fishery at Adak was classified as a subsistence fishery. In 1988 it became a personal use fishery, but was reclassified as a subsistence fishery again in 1998. In 1999, all fresh water on Adak Island and all salt water within 100 yards of a stream terminus were closed to subsistence fishing for salmon because of the federal position on non-rural subsistence. In the Adak District in 1999 five subsistence salmon permits were issued in the area by the State and an estimated 164 sockeye and 4 chum salmon were harvested by those permit holders. Harvest increased to nearly 500 sockeye salmon taken by 17 permit holders in 2001, but decreased to 188 sockeye salmon taken by two permit holders in 2005 (Tschersich 2006). NOAA issued 15 Subsistence Halibut Registration Certificate (15 rural and 0 tribal) to residents of Adak between 2003 and 2005, and classified Adak as rural. In late 2006, the Federal Subsistence Board reclassified Adak as rural, which will re-open other federal areas near Adak to subsistence hunting and fishing for the 2007 harvest.

State subsistence permits and harvest reports for crab are not required in Adak and the magnitude of subsistence king and Tanner crab harvest near the island is unknown, but believed to be relatively small.

3.4.5 Recreational fisheries

Recreational fisheries are not a significant factor in the Aleutian Islands ecosystem at this time. No recreational fishing licenses were sold in either Adak or Atka in the year 2000 (Sepez et al. 2005). Data have not yet been analyzed for later years. Recreational licenses can be purchased in any Alaska location (such as Anchorage and since 2005 on the Internet) for use in these areas, but most recreational fishing communities show some license sales activity. The lack of license sales is an indicator of a major reduction in recreational fishing from when the large military population was present at Adak.

A small amount of recreational fishing occurs in Shemya and Attu where military personnel are stationed, however licenses must be purchased elsewhere before deployment. The Coast Guard provides a fish smoker on Attu and notes an abundance of salmon (June through August) and Dolly Varden (year round) [http://www.uscg.mil/D17/loranattu/recreation.htm].

3.4.6 Other human activities in the ecosystem

Tourism

Tourism is extremely limited in the Aleutian Islands ecosystem. Caribou hunting is probably the attraction drawing the most visitors at this time. Birdwatching is a significant tourist activity, as the Aleutians present an opportunity for North American birdwatchers to spot many Asian species that do not otherwise appear in the United States. Ship-based ecotourism is also a developing activity.

The Aleut Corporation is promoting tourism as one of the commercial developments that will benefit Adak. They have already attracted visitors from six cruise vessels. Car rentals are available at in Adak at Adak Car Rentals and Hotel Adak provides lodging. Both are run by Aleut Enterprise Corporation, a firm established by the Aleut Corporation to further commercial development of the island. The attractions promoted on the Adak website include caribou hunting, hiking, bird watching, wildlife watching, sport fishing, WWII installations, and purported nuclear weapons storage compounds. Some of these attractions may be in conflict with each other, such as hiking, which may require staying on established trails and roads to avoid unexploded WWII ordnance. It is expected that tourism will grow in Adak in the next few years. Because of the available facilities, recreational fishing has the potential to increase in Adak.

Tourism is essentially non-existent in Atka. There are short-term accommodations available and the city has a 10% accommodation tax.

Military

Military activities in the Aleutians have had a significant effect on the island ecosystem. Early Aleut history includes periods of war and peace that affected the places and types of resources used (West et al. in press). Russian military action (including massacres and enslavement) deeply changed the structure of Aleut society and local biotic resources.

More recently, World War II had significant local effects on the people (Kohlhoff 1995; Sepez et al. in press) and on the ecosystem wherever military personnel or actions were concentrated (notably Attu and Adak, as well as Unalaska). Gasoline and ammunition were dumped into the ocean, oil spills were numerous, spawning grounds were filled in or exploded, and terrestrial mammals were hunted in great numbers (so much so that the army had to initiate rules to stop it) (Malcolm 2006; Kohlhoff 2002).

The Environmental Protection Agency has been performing Superfund clean-up and restoration of Adak because of the 40-year period that hazardous substances were disposed of on the island, including materials such as transformer oils containing polychlorinated biphenyls, petroleum, chlorinated solvents, and batteries. Clean-up has occurred and continues at a number of other sites in the Aleutians as well.

The military presence in the Aleutians has had additional social and environmental consequences. In 1965, 1969 and 1971, three underground nuclear tests were conducted on Amchitka Island, including the largest underground nuclear test ever conducted by the United States (Kohlhoff 2002). It is also widely believed (but neither confirmed nor denied by the Navy) that Adak was until 1995 the site of nuclear depth charges and torpedoes, as well as nuclear weapons storage.

It was announced in April of 2003 that Adak was chosen as the site for a radar installation for the Missile Defense Agency. It is estimated that this facility will require approximately 75 to 95 people to operate the system. The sea-based X-band radar that identifies and tracks incoming missiles as part of the national missile defense system is scheduled to arrive at Adak in February, 2008.

Shipping

Unimak Pass and the pass between Buldir and the Near Islands are part of the “Great Circle” shipping route between the United States and Asia. As a result, a tremendous number of ships pass through the islands, particularly on the eastern end. Great Circle traffic is estimated to be 1600 container ships per year and 30-40 tankers, as well as smaller commercial traffic including tugs, barges and small commercial freighters for a total of 3000-3500 vessel transits per year through the Pass (APAWSA Workshop Report 2006). The vessels are flagged from all over the world and carry crews from many different countries.

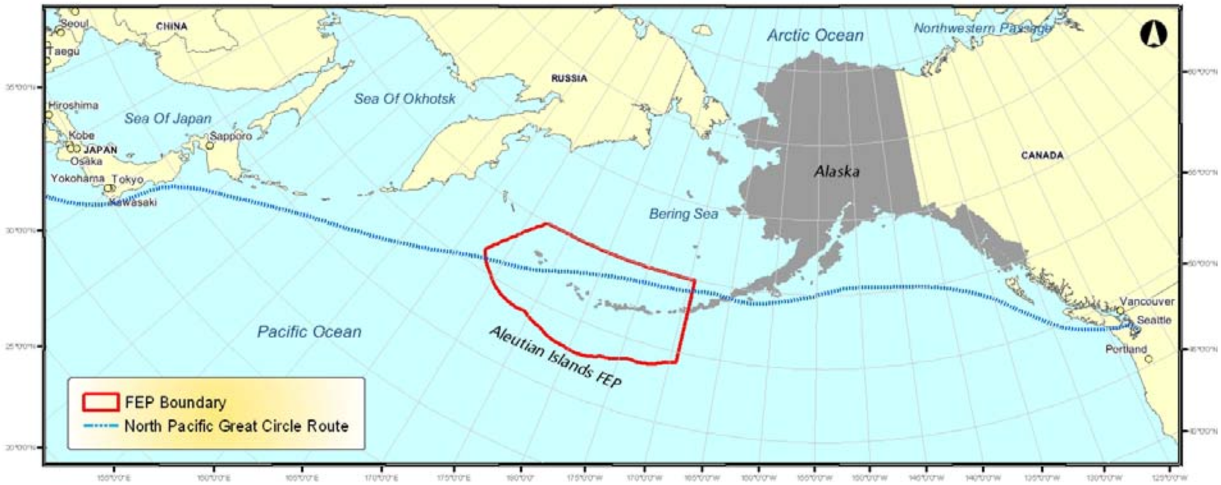


Figure 3-29 One of the routes for the great circle shipping route, through the Aleutians.

The 2004 Selendang Ayu shipping disaster off the coast of Unalaska (though outside of the fishery ecosystem area) brought into sharp relief the vulnerability of the ecosystem, and particularly seabirds, marine mammals, and fishery resources, to impacts from shipping. Very large vessels are required to carry automatic identification system transmitters, but there are few receivers in the islands. Shipping traffic in the region is increasing as trade between Asia and North and South America increases. Oil development in the general area (Bristol Bay, Sakhalin Island) could further increase traffic and vulnerabilities.

A 2006 Aleutian Ports and Waterways Safety Assessment workshop, sponsored by the US Coast Guard and the Alaska Department of Environmental Conservation noted that risk from shipping was concentrated in three areas: Dutch Harbor, Unimak Pass, and North of Akun Island (APAWSA Workshop Report 2006), all of which are outside of the Aleutian Islands fishery ecosystem area. On the western side, the shipping route passes by the Near Islands.

Shipping in the region could increase significantly if global climate change opens a summer shipping route through the Arctic. If opened, this route has the potential to host significant summer traffic directly between Europe and Asia.

Oil and gas development

Oil and gas development in Alaska and elsewhere effects the Aleutian Islands ecosystem mostly through the indirect effect of shipping traffic, as discussed above.

The majority of the Aleutian Islands Ecosystem falls within the Aleutian Arc Planning Area of the Minerals Management Service’s Outer Continental Shelf management system. Depending on the north latitude boundary, some of the ecosystem may be within the Bowers Basin Area. There is currently no oil and gas development in these areas, and none proposed for the upcoming 2007-2012 planning period.

The North Aleutian Basin Planning Area, which is roughly co-extensive with Bristol Bay (outside of but nearby the AI FEP area) is the nearest area with proposed development. It is currently withdrawn by presidential order from oil and gas leasing, however this protection is recently ended and the US Minerals Management Service is preparing for leases in the area known as Sale 92 in 2010 (proposed sale 214) and in 2012 (proposed sale 223).

A large Russian oil terminal is scheduled to open on Sakhalin Island, which could increase eastbound tanker traffic (Anon. 2007).

Research

Research activity accounts for much of the non-fishery travel to the Aleutian Islands area, especially in summer months. A brief synopsis of some fishery research activity ongoing in the AI is included in Appendix F.

In 2006, SeaGrant began a five-year plan to identify the interdisciplinary (ecology, oceanography, fisheries, social, economic, engineering) research and information needs for the Aleutian Islands region. The following methodology will be used:

- Establish a Regional Coordination Group to oversee planning and implementation of the research and information strategy. The Group will work in concert with the Alaska Marine Ecosystem Forum, assisted by Alaska Sea Grant and the State of Alaska Ocean Policy Coordinator.
- Conduct a bottom-up interdisciplinary (ecology, oceanography, fisheries, social, economic, engineering) research and information needs assessment with broad user and stakeholder input.
- Develop an Aleutian Island Ecosystem Research Plan that prioritizes actions according to management critical needs.
- Develop coordination mechanisms to ensure the transfer of technology and information to the appropriate end users.
- Provide an ongoing platform for coordination, collaboration, and resource sharing among governmental and non-governmental coastal and marine resource management and research entities, stakeholders, user groups, coastal residents and other interested parties.

3.4.7 How is the Aleutian Islands ecosystem different from the surrounding ecosystems?

Socioeconomically, the Aleutian Islands differ from the surrounding ecosystem in several ways. First, the population of residents is dramatically lower than elsewhere. With only two civilian communities over thousands of miles, the remoteness and isolation of the islands is unrivaled in the coastal United States. Second, the competition and struggle over natural resources and territorial control among the great powers of North America and Asia and indigenous residents has had a greater influence on local history than other locations in Alaska due to the geographic extension of the archipelago between continents and the abundant resources available. From the modern influence of the Russian Orthodox Church, to the absence of villages refused resettlement after internment during World War II, to the nuclear legacy of Amchitka, these historical influences continue to shape communities in the ecosystem today.

3.5 Management relationships

3.5.1 Regulatory boundaries

Geographically, the Aleutian Islands archipelago ranges from Attu Island to Unimak Island, approximately from 170º E. to 165º W. The Fishery Ecosystem Plan defines the Aleutian Islands ecosystem as ranging from Samalga Pass (approximately 169º W.) to the western boundary of the exclusive economic zone, at 170º E. For fishery management purposes, however, regulatory boundaries differ with respect to the species and agency (Figure 3-30).

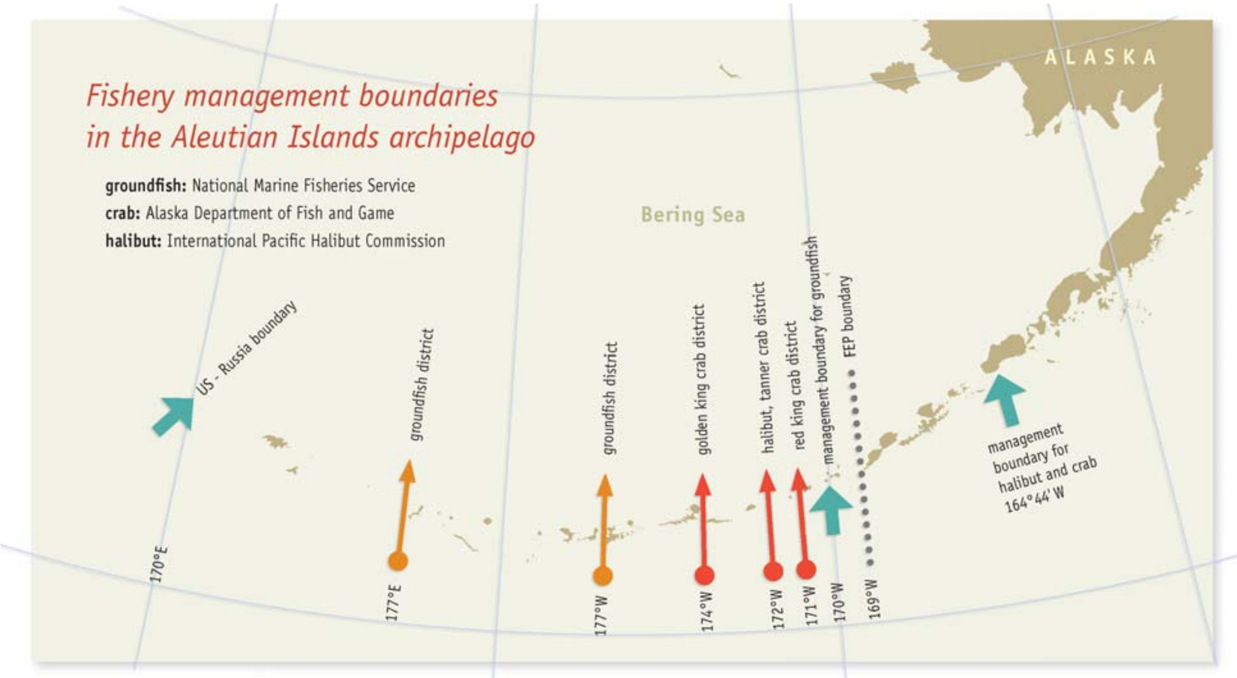


Figure 3-30 Management boundaries in the Aleutian Islands for groundfish, halibut, and crab fisheries.

Groundfish in Federal waters off the Aleutians are managed by the National Marine Fisheries Service and the North Pacific Fishery Management Council under the authority of the Bering Sea/Aleutian Islands fishery management plan. The BSAI FMP defines the Aleutian Islands subarea as that area of the exclusive economic zone (from 3-200 miles offshore) that is west of 170º W. and south of 55º N. (Figure 3-30, above; also see Figure 3-25 for extent of BSAI management area). This is the area that most closely approximates the Aleutian Islands ecosystem as identified in this FEP. The Aleutian Islands subarea represents approximately 44% of the BSAI management area, but accounts for only about 5% of total BSAI groundfish catch.

Some groundfish allocations may be harvested anywhere in the Bering Sea/Aleutian Islands management area; others are spatially restricted to as specific subarea. Allocations for Atka mackerel and Pacific ocean perch are further spatially divided between the three Aleutian Islands statistical areas, due to concerns about localized depletion and to minimize localized effects of Steller sea lion prey depletion resulting from competition from the fisheries.

Certain groundfish species may also be harvested in State of Alaska waters, within 3nm of shore. The State of Alaska is also responsible for day-to-day management of the golden and red king crab fisheries, and small Tanner crab fisheries, that take place in the area (Figure 3-30). These fisheries are managed under the oversight of a Federal fishery management plan, with direct management deferred to the State. Additionally, the State manages herring and salmon fisheries in the areas, which are prosecuted wholly within State waters. The State of Alaska uses its own grid of statistical areas to record catch and manage these fisheries.

The other regulatory areas within the Aleutian Islands are those of the International Pacific Halibut Commission (IPHC). Their areas consider the Aleutians Islands starting roughly at the tip of the Alaskan peninsula (164°W) and extending towards the west, with a split at 172°W (Figure 3-30).

Inseason data are collected at many spatial levels, including Federal statistical areas, State of Alaska statistical areas and precise global positioning system haul locations for some directed fisheries.

Table 3-4 describes the regulatory responsibility of various international, Federal, State, and municipal agencies over the resources and people of the Aleutian Islands ecosystem.

Table 3-4 Regulatory responsibility in Aleutian Islands

Resource, Population	Agency	Responsibility
groundfish	NPFMC/NMFS ADF&G	3-200nm; population abundance; setting harvest levels, fishery management, monitoring, and enforcement 0-3nm
halibut	IPHC NPMFC/NMFS	population abundance, setting harvest levels management of fishery
crab	NPFMC/NMFS ADF&G	monitor overfishing levels, allocations harvest levels; fishery management, monitoring, enforcement
scallop	NPMFC/NMFS ADF&G	monitor overfishing levels harvest levels, fishery management, monitoring, enforcement
salmon	ADF&G NPFMC/NMFS	population abundance, harvest levels, fishery management retention prohibited 3-200nm
herring	ADF&G	population abundance, harvest levels, fishery management
other fish	NMFS	advisory authority for habitat for all fish incl nearshore watersheds
marine mammals (except walrus and otters)	NMFS	population abundance, advisory authority, protection under MMPA and ESA
walrus and otters	USFWS	population abundance, advisory authority, protection under MMPA and ESA
birds	USFWS	population abundance, advisory authority, protection under MBTA
citizens of Adak	City of Adak	municipal responsibility
citizens of Atka	City of Atka	municipal responsibility
land	USFWS BLM, DNR DOD	protection of Alaska Maritime National Wildlife Refuge, including marine responsibility extending offshore own some small parcels Shemya, others
shipping	DEC USCG	oversight of spill response ensure safety of vessels in US ports and waterways
oil and gas development	MMS DNR or DEC	3-200nm 0-3nm
military activity	Alaskan Command, Pacific Command	Shemya, sea-based X-band radar
formerly used defense sites	AFCEE	cleanup
nuclear testing	DOE	monitor for radioactivity (Amchitka)

KEY: ADF&G – Alaska Department of Fish and Game; AFCEE – US Air Force Corps of Engineers; DEC – Alaska Department of Environmental Conservation; DNR – Alaska Department of Natural Resources; DOD – Department of Defense, DOE – Department of Energy, EPA – Environmental Protection Agency, MMS – Minerals Management Service, NMFS – National Marine Fisheries Service, NPFMC – North Pacific Fishery Management Council, USFWS – US Fish and Wildlife Service

3.5.2 Federal groundfish fisheries

Management measures for Federal groundfish fisheries are adopted in accordance with the groundfish management policy included in the BSAI Groundfish FMP. The policy was extensively revised in 2004, and the policy is described in Chapter 5.

Table 3-5 lists the species managed under the BSAI Groundfish FMP, and the catch in 2005 for those species in the Aleutian Islands and Bering Sea subareas. Total catches in the AI subarea in recent years have been just over 100,000 mt annually, compared to over 1.8 million mt in the Bering Sea subarea. Total allowable catch for both the BS and AI subareas combined cannot exceed 2 million mt. Given that the sum of single species acceptable biological catches was approximately 3 million mt in 2007, this limit provides a buffer against the uncertainties of single species harvest targets. Other constraints are also built into the management program, including conservative harvest quotas that are spatially (see Table 3-5) and temporally apportioned for some species, bycatch limits, protected species and habitat area closures and restrictions, gear modifications to reduce bycatch, and a prohibition on directed forage fisheries.

Figure 3-31 illustrates year round fishery closures in the Aleutian Islands, which provide protection for Steller sea lions, essential fish habitat and habitat areas of particular concern. There are also partial year closures to protect Steller sea lions, which apply to the directed pollock, Pacific cod, and Atka mackerel trawl fisheries.

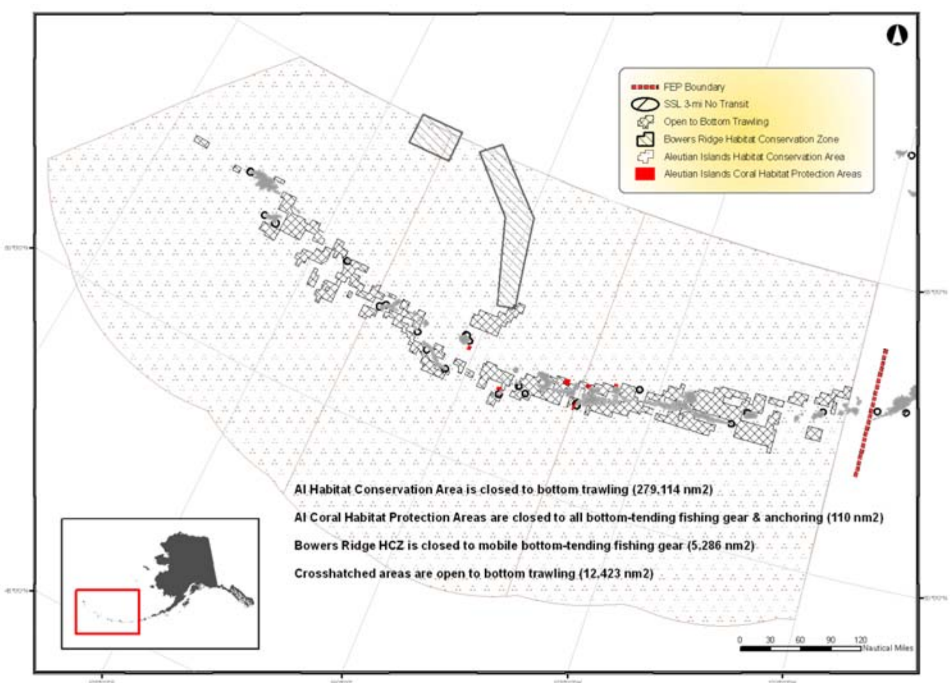


Figure 3-31 Year-round fishery closures in the Aleutian Islands

Information on the relative AI and Bering Sea distribution of biomass of assessed fish stocks can be obtained from comparing the AI trawl survey estimates to the EBS slope and shelf survey biomass estimates, and the degree to which AI trawl survey information is used in stock assessments reflect these distributions. Some flatfish stocks (yellowfin sole, arrowtooth flounder, rock sole, and Alaska plaice) which occur nearly entirely on the EBS shelf and have low biomass levels in the Aleutian Islands do incorporate the AI survey estimates in their stock assessments. Many stock assessments include both

Aleutian Islands and EBS survey information. For example, the EBS Pacific cod is modeled but expanded (based on the ratio of EBS to AI biomass estimates) to include AI cod. Sablefish is an Alaska-wide model, and uses a longline survey that covers the EBS, Gulf of Alaska, and Aleutian Islands. This longline survey is also used in the Greenland turbot assessment, where 31% of the stock is estimated to occur in the Aleutian Islands. For flathead sole, “other flatfish”, and “other rockfish”, both the EBS shelf survey and AI trawl survey are used to estimate the BSAI stock size. Several non-target species or species groups’ (skates, sharks, octopus, and sculpins) assessments are based on mean biomass from the trawl surveys on the EBS shelf, EBS slope, and AI. Finally, some stock assessments use the AI trawl survey exclusively and do not use the EBS surveys due to the stock distribution being predominantly concentrated in the Aleutian Islands (Atka mackerel) or because of the limited time series of EBS slope survey data (Pacific ocean perch, northern rockfish, shortraker rockfish, and rougheye), although the EBS slope survey is used to recommend area apportionments of catch for these rockfish.

Table 3-5 Catch, in mt, of groundfish FMP-managed species in the Aleutian Islands and the eastern Bering Sea, in 2005.

BSAI Groundfish FMP managed species	Aleutian Islands (AI)	Bering Sea (BS)	How total allowable catch is apportioned spatially
Pollock	1,621	1,483,279	separate BS and AI
Pacific cod	22,627	182,807	BSAI-wide
Sablefish	1,476	1,075	separate BS and AI
Atka mackerel	58,474 [4]	3,553 [4]	3 AI statistical areas [4]
Yellowfin sole	2	94,372	BSAI-wide
Greenland turbot	440	2,120	separate BS and AI
Rock sole	548	36,814	BSAI-wide
Arrowtooth flounder	828	13,405	BSAI-wide
Other flatfish [1]	59	20,642	BSAI-wide
Alaska plaice	0	11,175	BSAI-wide
Pacific ocean perch	9,548	879	BS and 3 AI statistical areas
Northern rockfish	3,852	112	BSAI-wide
Shortraker rockfish	61	108	BSAI-wide
Rougheye rockfish	78	12	BSAI-wide
Other rockfish [2]	286	178	separate BS and AI
Squid	17	1,168	BSAI-wide
Other species [3]	1,403	28,034	BSAI-wide

[1] Includes starry flounder, rex sole, longhead dab, butter sole, and all species of flatfish caught in the management area, other than flathead sole, Greenland turbot, rock sole, yellowfin sole, arrowtooth flounder, and Alaska plaice.

[2] Includes light dusky rockfish, shortspine thornyheads, and all species of Sebates and Sebastolobus caught in the management area, other than Pacific ocean perch, northern rockfish, rougheye rockfish, and shortraker rockfish.

[3] Includes sculpins, skates, sharks, and octopus.

[4] Atka mackerel for the combined Eastern Aleutian Islands district and Bering Sea subarea is reported under the Bering Sea.

Groundfish fisheries prosecuted in the AI subarea have included pollock, Pacific cod, Atka mackerel, sablefish, rockfish, and flatfish. Management of these Federal fisheries is complex given the size and geographic extent of the AI subarea, its distance from research and management facilities, and enforcement and safety concerns. The BSAI groundfish fisheries are managed under a single FMP, however Table 3-6 describes those FMP measures that are specific to the Aleutian Islands subarea, and those that apply to the BSAI management area as a whole.

Squid and other species (sculpins, skates, sharks, and octopi) are caught incidentally in other directed fisheries. Squid are caught primarily in the pollock trawl fishery. Skates represent the majority fo the other species catch (over 22,982 mt for the BSAI in 2005), and are caught in the hook and line Pacific cod fishery (Matta et al. 2006).

CDQ fisheries occur in the AI subarea for sablefish, Atka mackerel, Greenland turbot, Pacific ocean perch, northern rockfish, shortraker and rougheye rockfish, and other rockfish. CDQ groups partner with commercial fishing corporations to harvest these allocations. Most of the CDQ groups have ownership interest in the partner corporations.

Table 3-6 Current management measures in Bering Sea/ Aleutian Islands (BSAI) groundfish fisheries that apply across the management area, and those that are AI subarea-specific

Issue	FMP measures that apply BSAI-wide	FMP measures that apply to the Aleutian Islands only
Allocation	Total allowable catch (TAC) for the AI + BS subareas must be ≤ 2 million metric tons AI Fisheries with BSAI TAC: • Directed: Pacific cod • Incidental: Northern, shortaker and rougheye rockfish, flatfish, squid, other species	AI Fisheries with AI subarea TAC: • Directed: Pollock, Pacific ocean perch (by district), Atka mackerel (by district, jig 1% in Eastern AI/BS district), sablefish (trawl 25%, fixed gear 75%), Greenland turbot • Incidental: 'other rockfish'
Permit	BSAI license • certain vessels exempted: vessels fishing only in State waters, vessels less than 32' length overall, or jig gear vessels less than 60' length overall with specific effort restrictions.	Must have AI subarea endorsement
Closures/gear restrictions	Steller sea lions: • 3 nm no-transit zones around rookeries, no trawling for pollock, Pacific cod, or Atka mackerel within 20 nm of rookeries and haulouts during some or all seasons Prohibited species • Attainment of prohibited species catch limits for crab, salmon, and herring closes areas Gear: • Non-pelagic trawl gear prohibited in directed pollock fishery	Steller sea lions • Many of the rookeries and haulouts in the AI Essential Fish Habitat (EFH)and Habitat Areas of Particular Concern (HAPC): • Council has designated various AI EFH and HAPC areas with protections such as no bottom-trawling Prohibited species: • One closure area in the AI: Chinook Salmon Savings Area 1.
Prohibited species and bycatch	Halibut, herring, salmon, king crab, and tanner crab are prohibited species. • BSAI-wide halibut prohibited species catch limit for trawl fisheries (3,675 mt)	• Prohibited species catch limit for Chinook salmon in AI pollock trawl fisheries
Share-based programs	• Fixed-gear sablefish fishery is an individual fishing quota program. • BSAI Pacific cod sector allocations • some community development quota (CDQ) allocations BSAI-wide	• Directed pollock fishery in the AI subarea is fully allocated to the Aleut Corporation. • Sector allocations and cooperative program for POP, Atka mackerel fisheries • AI subarea-specific CDQ fisheries for pollock, POP, Atka mackerel, sablefish, Greenland turbot, rockfish;
Monitoring and Reporting	• 100%/30%/0% on vessels greater than 125'/60-124'/<60' length overall • Fish tickets, catcher/processor and processor reports	• 200% observer coverage on some vessels harvesting AI pollock, and on the head & gut trawl catcher/processor fleet

Pollock

Prior to 1999, pollock were also harvested in this area. Pollock in the Aleutian Islands region is considered to be a separate stock from the eastern Bering Sea pollock, with a tentative boundary identified at 174º W. longitude, although there is some exchange between the stocks (Barbeaux et al. 2004). From 1999 through 2004, the directed pollock fishery was closed, although some are harvested incidentally in other target fisheries (e.g., Atka mackerel, Pacific ocean perch); in 2003 pollock bycatch in other directed fisheries was 1,653 mt.

Beginning in 2005, the Council authorized allocation of pollock quota in a directed pollock fishery in the Aleutian Islands. The allocation is to the Aleut Corporation per recent Congressional action (PL 108-199). The annual quota for this fishery currently is set at no more than 19,000 mt, less the CDQ apportionment and incidental catch allowances for other directed groundfish fisheries. Historically, harvests in the AI subarea pollock fishery have occurred in several areas of concentration, including areas north of Atka Island, northwest of Adak Island, and east of Attu Island and north of Shemya Island.

Pacific cod

The Pacific cod fishery is managed under a quota apportioned to the entire BSAI management area. Pacific cod catch statistics for the AI subarea for the period 2001-2005 showed harvests declining from 34,207 in 2001 to 22,627 mt in 2005 (Thompson et al 2006). This fishery has historically (year to year) occurred around Adak and Atka islands. Since 1999, when the AI subarea was closed to a directed pollock fishery, the Pacific cod fishery has been prosecuted under Steller sea lion protection measures that allow Pacific cod fishing to occur closer to shore than a directed pollock fishery would be allowed. During 2001-2005, the AI subarea accounted for an average of about 15% of the BSAI Pacific cod catch.

Atka mackerel

The Atka mackerel fishery harvested 58,474 mt in 2005. The center of abundance of Atka mackerel is in the Aleutian Islands, although their distribution ranges from the Kamchatka peninsula to the Gulf of Alaska. The harvest quota has been distributed among the AI subarea districts since 1992, to minimize the risk of localized depletion. Although the fishery takes place primarily in the AI subarea, the fishery also occurs north of Akutan Island in the Bering Sea subarea. Areas of harvest concentration in the AI subarea in 2003 were south of Amukta and Tanaga passes, east of Attu Island, and scattered in the Rat Islands area (Lowe et al. 2006).

Sablefish

The sablefish fishery in 2005 harvested 1,476 mt, almost all of which was from longline and pot fisheries (Hanselman et al. 2006). The population is considered to be a single stock throughout Alaska and northern British Columbia. The directed fishery is entirely under an individual fishing quota (IFQ) management system and is prosecuted with fixed gear; a small amount is taken incidentally in some trawl fisheries (35 mt in 2003). The locations of the sablefish harvests from 1995-2003 suggest most of the fishing effort in the AI subarea occurs within 100 nm of Adak and Atka. This fishery is not under special restrictions for SSL protection, and occurs in waters within 20 nm of shore in the AI subarea.

Rockfish

The AI subarea rockfish fisheries include Pacific ocean perch, northern rockfish, shortraker and rougheye rockfish, and other rockfish. Rockfish harvested in the AI subarea in 2005 totaled 13,825 mt. The only directed AI rockfish fishery is for POP. Due to small harvest quotas, the other rockfish species' harvest quotas are taken as bycatch, primarily in the Atka mackerel and POP fisheries. Ninety percent of the BSAI northern rockfish caught are taken incidentally in the Atka mackerel fishery (Spencer and Ianelli

2006). The Pacific ocean perch stock is spatially distributed within the AI subarea, where approximately 84% of the population is concentrated, according to survey data (Spencer and Ianelli 2005). The fishery historically (year to year) has occurred throughout the AI subarea with some concentration of harvests between Kiska and Agattu islands, around Amchitka Island and Petrel Bank, north of Atka Island, and in Amukta Pass. Shortraker and rougheye rockfish are caught incidentally in a variety of target fisheries (such as rockfish and Atka mackerel trawl, and Pacific cod, halibut, and sablefish longline fisheries; Spencer and Reuter 2006). The majority of 'other rockfish' catch is dusky rockfish and shortspine thornyheads. Dusky rockfish are mainly caught incidentally in the Atka mackerel trawl fishery, and shortspine thornyheads are mainly caught in sablefish, grenadier or skate longline hauls or the POP trawl fishery. Dusky rockfish bycatch in recent years has been high near Seguam Pass and Petrel Bank, and in the AI survey they have been caught at the eastern tip of Amchitka Islands. 'Other rockfish' are also distributed in the Bering Sea subarea, north of Unalaska and Akutan Islands and at the southern tip of Zhemchug canyon (Reuter and Spencer 2006).

<u>*Flatfish*</u>

Most flatfish species are concentrated on the continental shelf of the Bering Sea, and have low abundance in the AI subarea. The only target flatfish fishery in the AI subarea is for Greenland turbot. About 25% of the Greenland turbot biomass is located in the area, however, juveniles are absent in the AI, suggesting that the population in the Aleutians originates from the EBS or elsewhere (Ianelli et al. 2006). In 2005, the harvest total was 440 mt, mainly by hook and line gear. The fishery occurs primarily within 100 nm of Adak and Atka islands (Ianelli et al. 2006).

Spatial distribution of Aleutian Island ecosystem fisheries by gear group

The bottom trawl effort in the Aleutian Islands Ecosystem focuses on Atka mackerel, Pacific cod, and rockfish. The highest concentrations of effort occur along the east of Atka, in Tanaga Pass, on the Petrel Bank, northwest of Kiska Island.

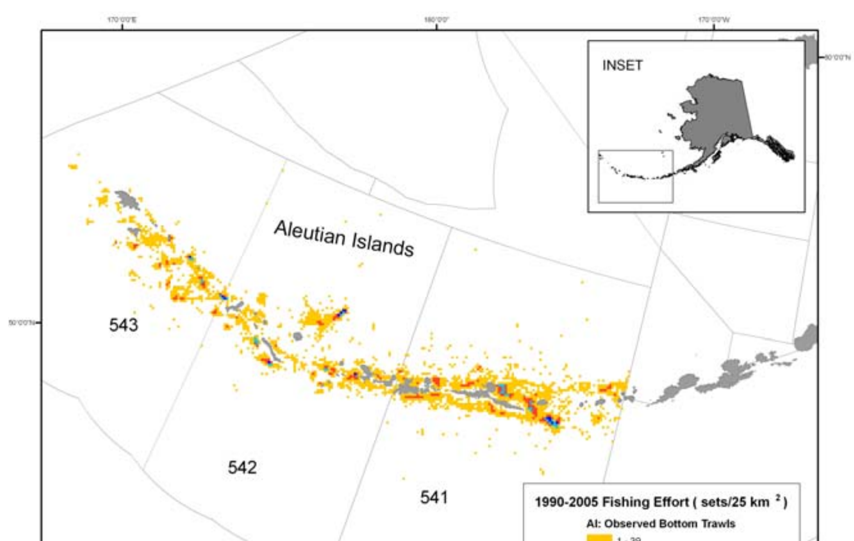


Figure 3-32 Location and density of bottom trawl effort in the Aleutian Islands, 1990-2005.

From Coon 2006b.

The commercial hook and line fishery uses catcher vessels and freezer longliners and harvests mainly Pacific cod, Greenland turbot, and sablefish (Coon 2006). Highest concentrations of effort occur around Atka Island, with pockets around Amchitka, Kiska, and Semichi Islands (Figure 3-33).

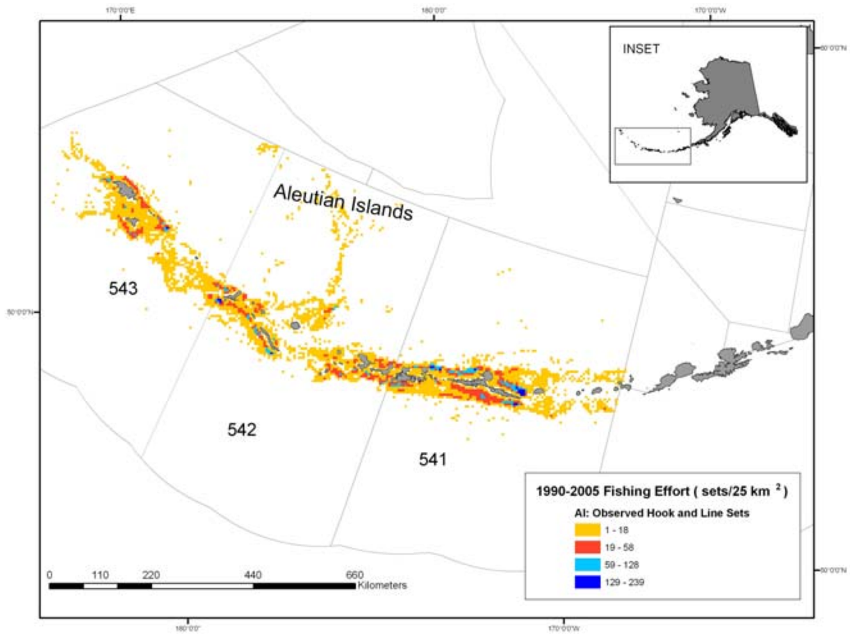


Figure 3-33 Spatial location and density of hook & line effort in the Aleutian Islands, 1990-2005.

From Coon 2006a.

3.5.3 Halibut fishery

The Aleutian Islands halibut fishery is managed by the International Pacific Halibut Commission. Two of the IPHC statistical areas for the halibut fishery encompass portions of the Aleutian Islands, Areas 4A and 4B (Figure 3-30). Over the last five years, approximately 8,028,000 lb annually, or 14% of the Alaska halibut quota, have been allocated to these areas. Halibut allocations in Alaska are managed under an individual fishing quota program and a community development quota program.

3.5.4 Scallop fishery

The Federal weathervane scallop fishery is managed by the State of Alaska under authority of a federal scallop management plan. Management measures are described in Table 3-7. The Aleutian Islands scallop fishery is split into two registration areas at 171° W. longitude. Registration Area O extends from Scotch Cap Light (164º 44' W. longitude) to 171° W. longitude and Registration Area R extends from 171° W. longitude to the Maritime Boundary Agreement Line that separates US and Russian waters, and encompasses both State and Federal waters. Scallop fishing in Area O generally occurs near Umnak Island. Area O was closed in 2000 due to management concerns over localized depletion. In 2002, the area was reopened with a reduced guideline harvest range of 0-10,000 pounds of shucked meats, of which 61% was harvested. Area O represents approximately 1.5% of the statewide guideline harvest range for scallops. The scallop fishery in Area R is opened annually with a guideline harvest range of 0-75,000 pounds of shucked meats. Weathervane scallops have been harvested in Area R only in 1979, 1992 and 1995 (Barnhart 2006). Petrel Bank is closed to commercial fishing for scallops to prevent red king crab bycatch and protect red king crab habitat.

3.5.5 King and tanner crab fishery

The Federal king and Tanner crab fishery is also managed by the State of Alaska under authority of a federal king and Tanner crab fishery management plan. Management measures are described in Table 3-7. In the Aleutian Islands, king crab fisheries are managed within registration Area O (area to the west of the king crab boundaries marked on Figure 3-30). The primary crab fishery that occurs in the region is the Aleutian Islands golden (brown) king crab fishery. Separate total allowable catch levels (TAC), are established for the fishery east and west of 174º W. Stock assessment is performed using relative abundance indicators and other biological indicators of stock health such as size frequency, fecundity and shell age. These data are obtained from both fishery-dependant and independent sources. Harvest limits for this fishery are typically around 3.0 million pounds for the area east of 174° W. and 2.7 million pounds for the area west of 174° W. Compared to other BSAI crab fisheries the Aleutian Islands golden king crab fishery has exhibited less harvest variability and has never closed due to low stock abundance.

Table 3-7 State management measures

Management measure	State-waters groundfish	Parallel groundfish	Crab/scallops	Salmon/herring
Closed waters	Generally follow federal SSL and habitat closures	Federal SSL and habitat closures in effect	Federal SSL and habitat closures in effect	Area specific to protect spawning stocks
Vessel registration/ permitting	State permit and vessel registration with ADF&G	State permit and vessel registration with ADF&G. Potential federal requirements as well.	State permit and vessel registration with ADF&G. Potential federal permits required as well.	State permit and vessel registration with ADF&G
Reporting	Inseason and fish tickets	Fish tickets	Inseason and fish tickets	Inseason and fish tickects
Observer coverage	None	Federal coverage levels	100% for scallops and red king crab, 50% for golden king crab	None
Season dates	Set by Alaska Board of Fish	Based on federal seasons	Set by Alaska Board of Fish around biogically acceptable time periods	Set by Alaska Board of Fish around biogically acceptable time periods
VMS requirement	None	Based on federal requirements	Rationalized crab only	None
Bycatch management	Generally no retainable bycatch or limits	Based on federal requirements	Retainable bycatch limits for certain species, other bycatch prohibited	No bycatch retention or limits

Since the mid-1990s harvests of golden king crab in the area east of 174° W. have averaged 3.07 million pounds with nearly 16 vessels participating annually (Forrest Bowers, pers. comm.). With the implementation of the crab rationalization program in 2005, effort has dropped to about seven vessels per year and 10% of the total allowable catch has been allocated to the community development quota program. Most of the harvest east of 174° W. longitude occurs between the Islands of Four Mountains and Seguam Pass.

In the area west of 174° W. harvests have averaged 2.55 million pounds since the mid-1990s and an average of eight vessels have participated annually. Since 2005, effort has dropped to less than five vessels per year and 10% of the TAC has been allocated to the community of Adak. Harvest in the area west of 174° W. is more geographically dispersed than to the east and occurs primarily between the Delarof Islands and Attu Island.

The Aleutian Islands golden king crab stock is considered to be stable and is above FMP overfishing levels.

There is also an Aleutian Islands red king crab fishery in Area O. The eastern portion of the red king crab fishery has been closed since 1983, and the western portion, which operates primarily in the Petrel Bank area, has opened sporadically in recent years with the most recent harvest occurring in 2002 and 2003. The fishery did not open in 2005 or 2006. Red king crab abundance is believed to be very low in the Aleutian Islands. Future openings in the area will be based on survey results.

Small Tanner crab fisheries in the Aleutian Islands are managed in registration Area J (area to the west of the boundary marked on Figure 3-30). Tanner crab populations in this area are believed to limited by available habitat and have been managed primarily as incidental harvest during the red or golden king crab fisheries. The largest Tanner crab stock in the Aleutian Islands occurs east of 170° W. Directed fisheries for Tanner crabs in the Aleutian Islands west of 170° W. are unlikely to occur in the near future (Forrest Bowers, pers. comm.)

3.5.6 State-managed or parallel fisheries

Within state waters of the Aleutian Islands, groundfish fisheries occur as both actively managed state-waters fisheries and passively managed parallel fisheries.

In February 2006 the commissioner of the Alaska Department of Fish and Game enacted emergency regulations for a state-waters Pacific cod fishery occurring in waters of the Aleutian Islands west of 170° W. longitude. In October 2006 the Alaska Board of Fisheries modified the management plan adopted under emergency regulation and made it permanent in state regulations. The state-waters guideline harvest level is based on 3% of the federal BSAI Pacific cod acceptable biological catch (ABC) and the fishery opens four days after the closure of the federal trawl catcher vessel “A” season (which occurs in the spring). Up to 70% of the state-waters guideline harvest level is available prior to June 10. The remainder of the state-waters guideline harvest level is available after June 10. The Board of Fisheries adopted maximum vessel overall length restrictions of 125 feet for pot vessels, 58 feet for jig and longline vessels and 100 feet for trawl vessels. The management plan specifies trip limits of 150,000 pounds and requires daily catch reporting to the department. Federal Steller sea lion and habitat protection measures are in effect, however vessel monitoring system is not required.

In 2006, 26 vessels participated in the initial state-waters fishery opening and harvested over 90% of the guideline harvest level in nine days. Over half of the participants were trawl vessels and most of the harvest occurred within 75 miles of Adak Island. Very little of the remaining guideline harvest level was taken during the September state-waters opening and the majority of the available guideline harvest level was returned to NMFS for reallocation in the federal/parallel fisheries.

The state of Alaska manages a state-waters sablefish fishery in waters of the Aleutian Islands and waters adjacent to the western portion of the Alaska Peninsula. The fishery began in 1995 and the guideline harvest level is based on approximately five percent of the federal BSAI sablefish total allowable catch. The state-waters fishery occurs from May 15 until November 15 and typically 20 to 40 vessels participate. Both federal IFQ holders and non-IFQ holders participate in the fishery and most of the harvest in the Aleutian Islands occurs on the north side of the Aleutian Islands between the Delarof Islands and Atka Island. Harvest in the state-waters fishery peaked at approximately 477,000 pounds in

2002, but has been less than 300,000 pounds in recent years (Rounds and Milani *in press*). Federal Steller sea lion and habitat protection measures are in effect, however a vessel monitoring system is not required.

In October 2006 the Alaska Board of Fisheries established a pollock fishery in state-waters of the Aleutian Islands between 174° W. and 178° W. The guideline harvest level for the state waters fishery is 3,000 metric tons and is reduced by the amount of pollock authorized for harvest inside Steller sea lion critical habitat under terms of a federal exempted fishing permit. In 2007, the state-waters guideline harvest level was zero pounds. The fishery opens seven days after the beginning of fishing operations allowed by the federal exempted fishing permit and closes on June 10, or earlier if the guideline harvest level is taken. Vessels participating in the state-waters fishery are limited to 58 feet or less in overall length and all state-waters, with the exception of the northwest side of Kanaga Island, within 20 miles of Stellar sea lion rookeries and three miles of Steller sea lion haul outs are closed to commercial fishing. A vessel monitoring system is not required in the state-waters pollock fishery.

Parallel fisheries are passively managed by the State of Alaska and occur concurrently with the Federal groundfish fisheries, mirroring the Federal closures and harvest restrictions. Parallel fisheries are opened annually by emergency order and allow for orderly prosecution of groundfish fisheries in state-waters that are not actively managed by the state. Currently, the major parallel fishery in the Aleutian Islands targets Pacific cod, although other species are taken incidentally (Rounds and Milani *in press*).

Commercial fisheries for salmon and herring are very limited in the Aleutian Islands outside of the immediate vicinity of Unalaska and Akutan Islands. Commercial harvests of salmon occurred in the Atka-Amlia Islands area in 1992, 1993 and 1994. Nearly 90% of the harvest in those years was comprised of pink salmon and total harvest exceeded 1,000 salmon only in 1992. Chum salmon were next most common species in the catch. Permit holders in the Atka-Amlia Islands fishery used set gillnet gear (Tschersich 2006). An experimental commercial food and bait herring fishery near Adak Island was recently established, even though there has been very little fishing effort and no harvest in the fishery.

3.5.7 Fishery bycatch

This FEP utilizes two definitions of bycatch presented below:

> Bycatch: "fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. Such term does not include fish released alive under a recreational catch and release fishery management program" –Magnuson-Stevens Act (MSA) Section 3(2) (1996).
>
> Bycatch: "Discarded catch of any living marine resource plus retained incidental catch and unobserved mortality due to a direct encounter with fishing gear." --Managing the Nation's Bycatch (1998).

The main commercial species (by value) targeted in the AI are Pacific cod, Atka mackerel, golden king crab, halibut, sablefish, and Pacific ocean perch. Bycatch issues in these Aleutian Islands fisheries include regulatory discards, economic discards, prohibited species catches (PSC), non-target species, non-specified species, marine mammals, and seabirds which are discussed below.

Regulatory discards occur when directed fisheries cannot retain catches of species (including the intended target) due to size and sex limits, individual fishing quota amounts, approaching overfishing levels, and reaching maximum retainable amounts (MRA).

Economic discarding (or highgrading) occurs when there is a threshold size, weight, or appearance threshold below which a species is less valuable and these less valuable fish or crab are discarded. In some cases, trends in economic discards are linked to recruitment trends. That is, small fish or crab from good year classes may contribute to increased levels of economic discards in some years and areas.

The Council sets limits on prohibited species catches of halibut, Chinook salmon, non-Chinook salmon, herring, red king crab, snow crab (Chionoecetes opilio), and Tanner crab (C. bairdi) in the BSAI groundfish fisheries. Prohibited species catches are heavily monitored and most of the bycatch occurs in the Bering Sea fisheries. However, PSC limits are set for the Bering Sea-Aleutian area and there are no Aleutian Islands area specific limits.

Crab bycatch occurs in both the targeted crab fisheries and incidentally in groundfish fisheries. Crab bycatch in the targeted crab fisheries is not capped or restricted, and for several crab stocks the largest source of crab bycatch is the targeted crab fishery itself. In the crab fisheries, bycatch takes the form of sublegal males, females, or legal males of lower market value. In the Aleutian Islands golden king crab fishery, up to 65% of the catch has consisted of discarded golden king crabs in some years (Burt and Barnard 2006). Bycatch in the crab fisheries is well documented through the use of onboard observers deployed by ADF&G, however bycatch mortality is less well understood. Alaska Department of Fish and Game regulations require that all non-retained crabs be returned to the sea unharmed, however aerial exposure and injuries incurred during fishing operations may cause at least 20% of discarded king crabs to die (NPFMC 2006). Crab bycatch and associated mortality is accounted for during the stock assessment and TAC setting process.

The halibut fishery does not have an observer program to monitor bycatch. However, logbook data are used by the IPHC to estimate adult halibut mortality due to lost/abandoned gear in the halibut fishery and the IPHC stock assessment surveys collect bycatch data for undersized halibut and for other species. In addition, bycatch data are available for joint groundfish and halibut trips for which a groundfish observer is on board. Although mandatory retention requirements exist for incidental catch of rockfish and Pacific cod, the level of compliance is unknown.

Skates and sharks have been identified as sensitive non-target species and are currently managed as part of the “Other species” category within the BSAI. While skates are caught in the major fisheries in the Aleutians, skate bycatch is relatively low compared to the Bering Sea where most of the skate catch occurs along the shelf break. Most of the skate bycatch in the Aleutians is in the hook and line fishery for Pacific cod followed by the halibut fishery. Fishery observer data indicates that only about 50% of skate catch is identified to the species level. This is largely because most skates are caught in longline fisheries, and if the animal drops off the longline as unretained incidental catch, it cannot be identified to species by the observer (approximately 80% of longline-caught skates are unidentified, and longline catch accounts for the majority of observed skate catch). The species composition of the observed catch in the AI is very different from the EBS with the majority of identified Aleutian and whiteblotched skates caught in AI fisheries. The Alaska skate, *Bathyraja* unidentified, and "skate unidentified” comprise about 85% of the species composition of skate bycatch in the Aleutians (Matta et al. 2006).

There are currently no directed commercial fisheries for shark species in federal or state managed waters of the BSAI, and most incidentally captured sharks are not retained. Shark catches in the Aleutian Islands fisheries are very low; sharks have only been reported to species in the catch since 1997 and have made up from 1% to 5% of the BSAI Other Species catch from 1997-2005 (Courtney et al. 2006). The three shark species most likely to be encountered in BSAI fisheries are the Pacific sleeper shark, *Somniosus pacificus*, the spiny dogfish, *Squalus acanthias*, and the salmon shark, *Lamna ditropis* (Courtney et al. 2006). At present the NMFS Observer Program does not measure the lengths of sharks, and many sharks (22%) are not identified to species.

Two other notable groups caught as bycatch in Aleutian Island fisheries are sculpins and grenadiers. Sculpins are managed as part of the BSAI Other Species Complex, and sculpins along with skates constitute the bulk of the BSAI Other Species catches. Sculpins are caught by a wide variety of fisheries, but the AI fisheries for Pacific cod (both trawl and longline) and Atka mackerel catch the majority. It is likely that the larger sculpin species (Irish lords, *Hemilepidotus spp*., great and plain sculpins, *Myoxocephalus spp*., and bigmouth sculpin *Hemitripterus bolini*), which contribute to the majority of sculpin biomass on surveys, are the species commonly encountered incidentally in groundfish fisheries (Reuter et al. 2006). Until 2004, observers did not regularly identify the sculpin group to species. At least 80% (by weight) of the observed sculpin catch in past years was recorded as "sculpin unidentified", with the remainder of catch identified to the genus level.

Grenadiers are a non-specified species, the majority of which are caught in the sablefish and Greenland turbot longline fisheries. As such, no official catch statistics exist for grenadiers in Alaska and there are no limitations on catch or retention, no reporting requirements, and no official tracking of grenadier catch by management. However, catches for the years 1997-2005 have been estimated based largely on data from the Alaska Fishery Science Center’s Groundfish Observer Program (Clausen 2006). Species breakdown of the grenadier catch is unknown, but is believed to be nearly all giant grenadiers (*Albatrossia pectoralis*). Nearly all catch has been taken as bycatch and discarded. Discard mortality is assumed to be 100%.

One option in the proposed “Other Species” amendment is to add grenadiers to the “Other Species” category. If this option is adopted, the Council would then need to establish levels of overfishing (OFL), acceptable biological catch (ABC), and total allowable catch (TAC) for grenadiers in Federal waters of Alaska. Assessment of grenadiers is difficult as very little is known about the life history and habitat and ecological relationships of giant grenadier. A potential issue of concern based on sablefish longline survey results, is that females were the overwhelming majority of the catch, comprising 94% of the fish sampled in the eastern AI (Clausen 2006). Females especially predominated in depths <800 m. Because these are the depths in which the longline fishery operates, this strongly suggests that most of the commercial catch of giant grenadier is female.

A major regulatory action in regard to bycatch is Amendment 80 to the BSAI FMP which would provide specific groundfish allocations to Non-AFA Trawl Catcher Processor sector and allow the formation of cooperatives. Sector allocations and associated cooperatives would allow participants to focus less on harvest maximization and more on optimizing harvest which would serve to reduce incidental catch, improve retention and utilization, and improve economic efficiency. However, it is noted that that most of the attention is focused on the Bering Sea fisheries where the Non-AFA Trawl Catcher Processor sector had had the highest discard rates.

The bycatch monitoring program for the groundfish fisheries currently consists of extensive self reporting requirements and an observer program designed to quantify total catch, including incidental catch of non-fish species such as seabirds and marine mammals. In addition, the Alaska Region is responsible for monitoring the incidental takes of marine mammals in state managed fisheries that have been designated as Category II fisheries under the Marine Mammal Protection Act (MMPA). The MMPA sets out several goals for which observer data are used: 1) determination whether the potential biological removal level of a (marine mammal) stock is exceeded; 2) categorization of each fishery in the annual List of Fisheries; and 3) determination of whether a fishery has approached a zero mortality rate for marine mammals.

Seabird bycatch interactions occur in the AI longline fisheries for Pacific cod, Greenland turbot and halibut, trawl fisheries, and to a very limited extent in pot fisheries. Seabird bycatch is generally highest in the Bering Sea, lowest in the GOA, with the AI being intermediate. The species composition of seabird bycatch in the Aleutian Islands longline fishery is 54% northern fulmars, 25% albatross species, 11%

unidentified seabirds, 6% gull species, and 4% shearwater species (Fitzgerald et al. 2006). Significant effort has been directed towards research and experimentation with gear configuration and deployment modifications to avoid gear interactions with seabirds. Seabird avoidance regulations in place require, among other things, that longline vessels larger than 55 feet length over all must use paired streamer lines except in certain weather conditions. Beginning in 1998, seabird bycatch in the longline fisheries has trended downward (Fitzgerald et al. 2006). Cooperative efforts by NMFS, Washington Sea Grant, and industry associations to conduct outreach activities and work with vessel owners and operators serve to further reduce bycatch. Efforts by the longline fleet may have contributed substantially to the observed reduction, although no analysis has been completed to ascertain the contribution of various factors.

Discards and offal are used heavily by many seabirds in the North Pacific. Birds are attendant around catcher/processors and can reach high numbers. There have been very large changes from year to year in the availability of discards and offal as a result of changes to fishery management regulations. Another source of mortality for seabirds on trawl vessels are the trawl door cables (warps) and the cable that runs between the net monitoring device and the vessel (trawl sonar cable or third wire). Northern fulmars are the most common species taken in trawl fisheries, constituting about 45% of the overall seabird bycatch in the combined groundfish trawl fleet (Fitzgerald et al. 2006).

4 Ecosystem Assessment

An ecosystem approach to fisheries management should consider the interactions among the fisheries and their target species, their direct (e.g. bycatch) and indirect (e.g. habitat) impact on other species and this influence on other target fisheries, as well as broader ecosystem interactions such as climate, predator-prey relationships and other socio-economic activities. For the purpose of this FEP, an ‘interaction’ is defined as a component (or group of components) that has an impact on another component (or group of components). Interactions important to the FEP area fall within five general categories:

- Climate/Physical Interactions
- Predator-Prey Interactions
- Endangered Species Interactions
- Fishery Interactions
- Socioeconomic Activities Interactions

Below we present a risk assessment (non-quantitative) of the important ecological (biological, chemical and physical), human and institutional interactions occurring within the Aleutian Islands FEP area that could have implications for fisheries management. The risk assessment is intended as an interim step towards developing a comprehensive ecosystem assessment for the Council. Such an assessment is a time-intensive process, particularly given the large data gaps about a variety of ecosystem components and processes are highlighted in the sections that follow. The non-quantitative risk assessment is intended as a tool to help the Council to prioritize potential issues of concern, and to develop a process for a ‘warning system’ for the Aleutian Islands to monitor changes in the ecosystem.

It is important to note that the interactions highlighted in this chapter are those that are considered to be important given the current state of the ecosystem. We recognize that there are many more interactions at work in the ecosystem, and it is expected that the importance of these and contemporary interactions will be re-evaluated as part of the planned, periodic updates to the FEP (for example on a three to five year basis).

4.1 Methodology

The objective of this section is to identify those parameters and ecosystem interactions that the Council may wish to monitor in order to avoid changes to other, potentially undesired, ecosystem states. Most biological processes are not linear and most systems have boundary conditions that determine certain threshold levels that lead to what has been referred to as “regime shifts”. Passing a threshold in one direction may require little extra change close to this boundary, but returning to the previous state may not be as simple as reversing or halting the particular impact that lead to the change (Figure 4-1). For example, the changes in ecosystem structure and function in state 2 that will result in a switch to state 1 may be less than those required to bring the system back up into the second state. Processes of this kind may explain certain fishery collapses and their lack of recovery despite a partial or total reduction of the harvest.

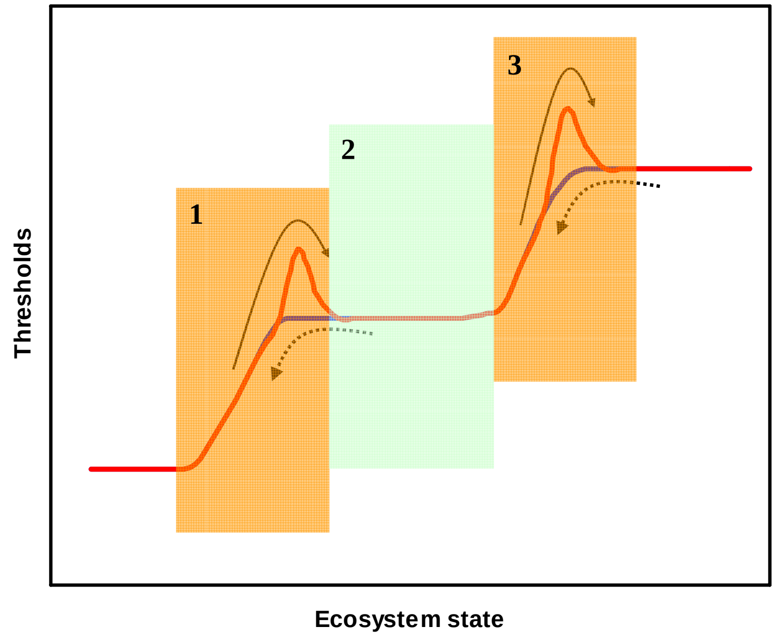


Figure 4-1 Conceptual visualization of non-linear changes between different ecosystem states within the same ecosystem.

Clearly some processes and interactions are more critical in determining or indicating ecosystem status than others, and not all are controllable through management actions. It is therefore of important to first define the relevant ecosystem interactions and then to determine their probability of occurrence, as well as the nature and level of impacts or harm (where harm is defined as a 'cost'; in this case a change in biological structure or function that may or may not lead to economic cost) to the current ecosystem state, measured as the risk of pushing the current system closer to one of the thresholds that lead to a new ecosystem state.

Defining these interactions and their importance aids in the establishment of a risk assessment framework which ultimately identifies preferred actions with respect to one or more management objectives. It is the goal of such an assessment to provide managers with a tool to either make choices between different risks or to take actions to avoid, buffer or mitigate the risk all together through appropriate management actions.

Ecological risk assessment is defined as a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. A risk does not exist unless (1) the stressor has the inherent ability to cause one or more adverse effects and (2) it co-occurs with or contacts an ecological component (i.e., organisms, populations, communities, or ecosystems) long enough and at a sufficient intensity to elicit the identified adverse effect. An ecological risk assessment may evaluate one or many stressors and ecological components (EPA 1992).

4.1.1 Risk assessment

Ecological risk may be expressed in a variety of ways. While some ecological risk assessments may provide true probabilistic estimates of both the adverse effect and exposure elements, others may be deterministic or even qualitative in nature. In these cases, the likelihood of adverse effects is expressed through a semiquantitative or qualitative comparison of effects and exposure (EPA 1992).

For this first version of the FEP, it is not feasible (due to time constraints) to conduct a quantitative risk assessment analysis of the interactions defined in the sections that follow. However, our process still follows the classic risk assessment framework defined elsewhere (NRC 1983, EPA 1992), but is qualitative in nature and relies on expert opinion and the building of consensus. It also makes use of a recent approach to determine critical ecosystem interactions via cognitive maps (Prigent et al. in review). In our approach, each Ecosystem Team member individually rated the interactions. All scoring was based on the personal knowledge of each team member. Criteria for assessing likelihood of occurrence and magnitude of impact were individual to the interactions, but were supported with a written rationale for each rating. Team members abstained from scoring particular interactions if they felt they did not have the expertise to do so. A written summary of the interaction assessment was compiled by the lead author on each interaction topic. The interactions were then circulated and discussed at a Team workshop, consensus on the ratings was achieved.

The use of such an approach is appropriate at this stage of the FEP because the results of the risk assessment are only intended to provide general guidance to the Council about the interactions on which to focus further research or Council attention. This risk assessment is not intended to serve as a decision-making tool for the Council to evaluate management measure tradeoffs. For future versions of the FEP, or in work that stems from the FEP, the Council may wish to utilize an Analytic Hierarchy Process, or a loss function decision tool.

Ratings were defined as follows:

> *Probability/risk,* defined as the probability of an interaction (or result of an interaction) occurring was ranked as high, medium, or low. The Team strived to use these ratings consistency across interactions, but in the face of different standards for the range of physical, biological, and socioeconomic characteristics, each rating is accompanied by a written rationale to interpret the scoring.
>
> *Impact* was defined as the level of impact or importance of this interaction or change. Both ecological and economic impacts were identified, and scored as high, medium, or low. The time scale (annual, decadal, multi-decadal), as well as the geographic scale (local, regional, beyond the AI ecosystem) of the impact was considered.

4.1.2 Implications for management

The risk assessment is used to provide feedback to managers about each interaction. After drining interactions, we provide a synopsis of what the Council is already doing to address the risk identified for this interaction, and we identify actions that the Council may initiate to begin or further address the risk associated with the interaction. Recommended actions include suggestions for needed research to fill data gaps, specific Council analyses, and procedural and process changes.

4.1.3 Tracking critical interactions

Ecosystem indicators, if well understood, may be useful in tracking interactions, and, as determined for this FEP, they have two main objectives: (1) to help assess the status of the ecosystem/interaction, and (2) to monitor how well a fishery is managed in relation to an objective. Ideally, each indicator is associated with reference points and thresholds, the passing of which would indicate a large undesired shift (e.g., Figure 4-1), and consequently might trigger a management action (Link 2005). Ultimately, in a quantitative model, the change in the indicators would trigger management actions in relation to defined reference points, and an audit function model would assess the effectiveness of triggered management actions.

A list of candidate indicators for tracking critical interactions listed below are divided into three categories: (1) currently available as part of the Stock Assessment and Fishery Evaluation report (SAFE) Ecosystem Considerations chapter; (2) those for which data is available but which are not currently monitored by the Council, and (3) those for which data is not currently available (this category is included to guide future research efforts in this field). An essential research topic is to determine critical threshold levels for most of these indicators as well as to determine what the appropriate associated management actions should be. Specific research needs for each interaction are discussed below.

Although a framework of indicators has been identified, the Team has not gone through the processs of describing the time frame and mechanisms for monitoring these indicators. Nevertheless, many of these indicators will continue to be tracked through the SAFE Ecosystem Considerations chapter, and so will feed back into the Council process. Section 8.1 discusses further how the FEP's indicator framework could be used by the Council.

4.2 Climate and physical interactions

Climate and other physical forcing can affect ecosystem processes in numerous ways, oceanic (i.e. ocean temperature, chemistry, mixing, currents, sea level), atmospheric (i.e. storminess, cloudiness, wind speed, precipitation) and terrestrial (i.e. seismic/volcanic activity, freshwater runoff, sediment input). Changes in physical forcing in the Aleutian Islands may occur on a variety of timescales, including interannual (i.e. El Niño; Bailey and Picquelle 2002; Hollowed et al. 2001), decadal (regime shifts; Hare and Mantua 2000; Hollowed et al. 2001; Trites et al. 2007), and longer (global warming trends; IPCC 2001). Changes in mean, extremes, and variability of physical forcing will determine the impacts on the ecosystem (IPCC 2002). Unfortunately, few physical oceanographic data exist in the Aleutian Island region with which to describe the current state of physical forcing or to monitor for change. Thus a fundamental need for research and monitoring in this region is of primary importance.

A. Changes in water temperature may impact ecosystem processes

Temperature regulates all biological rates (growth, feeding, etc.), and has proven direct impacts on primary productivity and thus the forage base. Given this strong direct (exotherms and their habitat) and indirect (shift in distribution and abundance of species) dependency on water temperature, it is clear that changes in water temperature may greatly impact ecosystem processes. In addition, associated changes in sea level due to global warming may impact nearshore habitat and coastal villages.

Examples of ecosystem impacts due to temperature changes include:

- Changes in the timing of biological events (phenology) (Visser and Both 2005), such as growth, reproduction, migrations. The level of response can differ throughout the community and the seasonal cycle, leading to a mismatch between trophic levels and functional groups (Edwards and Richardson 2004).
- Changes in morphology, physiology, and behavior. For example, some animals have been shown to grow larger in warmer conditions (IPCC 2002).
- Changes in species distributions. Differing responses among species can also result in changes in predator/prey relationships. Distribution shifts may result in invasion by non-native species.

The Alaska Fisheries Science Center trawl survey has collected bottom temperature data in the FEP area since 1980 which are summarized in the Stock Assessment and Fishery Evaluation (SAFE) report Ecosystem Considerations chapter. The survey period has ranged from early May to late September and is triennial or biennial (see Figure 3-5). These data show bottom temperatures between 3°C (averaged over bottom depths greater than 700m) and 5.7°C (bottom depths less than 100 m). The coldest mean bottom temperatures of the trawl survey were recorded in 2000 and the warmest in 1983 with no obvious trend.

Bottom temperature data have also been obtained from moorings in a few of the passes, with the longest time series coming from Amukta Pass (2001 through present with a few gaps). Surprisingly, given the depths of the instruments (300 – 450 m), a seasonal cycle in bottom temperature in Amukta Pass is apparent. Maximum temperatures (~5°C) occurred in January with minimum temperatures (~3.5°C) occurring in late April or May (Stabeno et al. 2005). Surface temperatures in the passes have been shown to vary with the diurnal tidal cycle due to vertical mixing caused by the interaction of tidal currents with shallow bathymetry.

Risk assessment

Summary Ratings: Probability – high, Ecosystem impact – high, Economic impact – high, Timescale – annual, Spatial scale – entire region

Probability of occurrence: High. Temperature has been shown to influence ecosystems in the North Pacific on interannual (Hollowed et al. 2001) and decadal timescales (i.e. Hare and Mantua 2000; Miller et al. 2004). In addition to temperature variability due to El Niño and decadal regime shifts (which have already been observed), global warming is projected to influence water temperatures on longer timescales.

Timescale: Annual. Probability of occurrence is high for all timescales (annual, decadal, and multi-decadal).

Spatial scale: AI region wide. Temperature variations in this system are mediated by large-scale atmospheric patterns and ocean currents. Thus the geographic scale of temperature variations that are likely to have ecosystem impacts is the entire Aleutian Island ecosystem.

Ecological impact: High. Temperature regulates all biological rates (growth, feeding, etc.) and has direct proven impacts on primary productivity and thus the forage base. A re-organization of species composition and dominance due to temperature effects has been thoroughly documented (e.g. in relation to the 1976/77 regime shift, recent changes in *Calanus* species composition, etc.), favoring some species and not others. Given this strong direct (exotherms and their habitat) or indirect (shift in distribution and abundance of prey base) dependency on water temperature, the impact of changes in water temperature on ecosystem processes and function is high. Species residing in shallow inshore areas, seabird and marine mammal populations, deepwater corals, and any animals unable to move to stay within a temperature range, are particularly likely to be affected.

Economic impact: High. Economic impacts may be severe if species shifts limit the fisheries. There has already been a northward shift in the center of distributions of several commercial fish species (e.g. pollock, halibut). To the extent this affects AI fisheries or communities, it could result in longer, farther fishing trips entailing higher costs.

Implications for management

The Council needs to understand two elements of this interaction: how water temperature is changing, and how different temperatures favor or disfavor managed species or their prey. To address the latter, the Council needs to understand the relationship between species and preferred temperature ranges.

The ‘Indicators’ section below references available data on water temperature in the AI. The relationship between water temperature and species is currently little understood, but is the subject of research. The AFSC Fisheries and the Environment (FATE) initiative’s purpose is to research the relationship between environmental variables and species, and there are pending FATE proposals for the AI. The groundfish Plan Teams have also stated an objective for stock assessment authors to incorporate environmental variables into the assessments, although to date no AI species assessments include a temperature variable.

The Council has no management control over water temperature change, and can only mitigate potential future effects to the extent of their understanding of this interaction. The Council should continue to monitor temperature trends and encourage further research and data collection specific to temperature linkages in the Aleutian Islands. Such a focus may be of special importance because, as noted in Section 3.2, species in the AI may be less able to adapt to changes in temperature than species in neighboring ecosystems due to its narrow north-south shelf. Additionally, there are some temperature data available not currently used by stock assessment authors. The Council may wish to encourage further discussion at the stock assessment level on the linkages between temperature and species to see whether the existing data can already provide useful insights.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
AI summer bottom temperature from the trawl survey. – good spatial coverage, poor temporal coverage – would be better if it was more frequent (annual).	Moored bottom temperature in Amukta Pass – good temporal coverage, poor spatial coverage – would be better if more locations and multiple depths were measured.	Temperature measured in the entire water column, throughout the seasons, throughout the region – looking for change in mean, extremes, and/or variability.
Biological indices to compare with temperature indices: – i.e. seabird breeding chronology, biodiversity, recruitment and survival – specific to AI region		

Data gaps / research needed

Few temperature data exist for the Aleutian Island region. However, retrospective analysis of temperature from trawl surveys, specific research projects, and ambient temperatures from military bases, could provide indices to describe recent historic patterns. Moorings provide year-round temperature data at specific locations (moorings providing bottom temperature in Amukta Pass have been maintained since 2001). Few other moorings have been used in the FEP area, and the number of locations monitored needs to be increased. Also, to be effective as an indicator, temperatures need to be monitoring long-term. Where possible, temperature should be monitored throughout the water column. This is not currently possible in the high currents of the passes but would be possible outside of the passes. In addition, research on the effects of temperature on biological indices specific to the AI region needs to be pursued. These include research both on the relationship of temperature to managed species, as well as linkages between lower tropic level species and temperature.

B. Increased acidification of the ocean may impact ecosystem processes

The surface ocean is saturated with respect to calcium carbonate, but increasing atmospheric carbon dioxide concentrations are reducing ocean pH and carbonate ion concentrations. This “ocean acidification” is likely to continue and increase given current trends in anthropogenic carbon emissions and projected release of deep water methane (Feely et al. 2004; The Royal Society 2005; Kleypas et al. 2006). Experimental evidence suggests that, if these trends continue, some calcareous species will have difficulty maintaining their external calcium carbonate skeletons. Species groups such as crabs, lobsters, pteropods, corals, foraminifera, and coccolithophorids would be especially affected (Orr et al. 2005; Kleypas et al. 2006) and this could lead to strong impacts throughout the ecosystem. For example, shelled pteropods contribute to the diets of many fish, including salmon (Boldt and Haldorson 2003). Increased acidification may also cause the dissolution of corals in the Aleutians which would have habitat implications for many species including commercial fish species. This interaction could impact primary production and the carrying capacity of the AI ecosystem.

Risk assessment

Summary Ratings: Probability – high, Ecosystem impact – high, Economic impact – high, Timescale – multi-decadal, Spatial scale – entire region

Probability: Ocean acidification is documented to be occurring, and is likely to continue and increase given current trends in anthropogenic carbon emissions and projected release of deep water methane.

Timescale: Multi-decadal. It is projected that some subpolar surface waters will become undersaturated within the next 100 years (Orr et al. 2005). Shoaling of the calcite saturation horizon, where deep waters are undersaturated with calcium, thus more acidic, while shallow waters are supersaturated, implies that deep-water species, including corals, may be influenced sooner.

Spatial scale: AI region-wide. Ocean acidification is occurring globally.

Ecological Impact: High. The AI is an oceanic food web in which oceanic/planktonic energy is very important. Consequences of small changes in pH can be severe for calcifying organisms, such as shelled pteropods, corals, foraminifera, coccolithophors. We cannot predict which species will become extinct and which will adapt, but the impacts to the food web could be severe if many species of plankton (or a few key species) are affected. The dissolution of corals in the Aleutians would have habitat implications for many species, and shelled pteropods contribute to the diets of many fish, including salmon, herring, cod, and pollock. Effects could include significant declines in primary production and carrying capacity of the AI ecosystem.

Economic Impact: High, depending on whether commercial fish and shellfish species, have difficulty adapting to higher acidity, and how thin or depleted shellfish shells affect population growth and abundance. In general, economic impacts will be greater in fisheries for which there are few alternative, new activities into which they can spill over. For example, some crab fishermen are just licensed for crab, but others participate in other fisheries (such as Pacific cod) extensively.

Implications for management

In order to mitigate this interaction, the Council needs to know how acidification will affect managed species, and how quickly it will happen. Acidification is very difficult to measure, and is not currently being monitored. The issue is becoming more prominent, however. The Council may wish to track national developments, and encourage NOAA to integrate the Aleutian Islands ecosystem in any monitoring program that may be developed.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
None. At this point, there are no indicators of ocean acidification.		– aragonite and calcite saturation horizon depths – pH, pCO^2, DIC, TALK – coral calcification rates

Data gaps / research needed

It is important to monitor the ecosystem for the effects of ocean acidification, but basic research is needed to develop monitoring indices and to determine acidity threshold levels for key species and their linkages to managed species.

C. Changes in nutrient transport through the passes and changes in the predominant current patterns that drive primary production impact ecosystem processes

Water movement through Aleutian passes can affect the transport of biota (eggs, larvae, plankton), heat, and nutrients through the AI system. Changes in transport of larvae toward or away from favorable nursery habitat, for example, could influence recruitment (there is evidence for this kind of interaction in the Bering Sea (Stockhausen and Herman *in press*) but no specific information exists for the AI).

The transport of heat into the southern Bering Sea can affect the habitat available to the ecosystem. A subsurface temperature maximum greater than 4°C in the depth range ~150 – 400m has been associated with inflow of Alaskan Stream water through Amukta Pass (Reed 1995). Thus, changes in transport through the passes can interact with Interaction.A (changes in water temperature impact ecosystem processes). In addition, the heat advected through the passes limits the sea ice extent over the Bering Sea shelf.

The net northward transport of nutrients through the Aleutian Passes to the Bering Sea (Mordy, et al. 2005) is accomplished through vertical mixing driven primarily by tidal currents (which are not likely to change) and their interaction with the steeply varying bathymetry (also not likely to change). Net transport of newly mixed nutrients into the Bering Sea is due to mean northward currents which are dependent on large scale gyres in the North Pacific and Bering Sea. Mixing in the passes (vertical transport of nutrients) is not likely to change, but if the northward horizontal transport of the newly mixed water changes, it could have implications for nutrients north of the passes. Changes in nutrient transport could impact the location and intensity of primary production and pelagic habitat.

The transport of heat into the southern Bering Sea can affect the habitat available to the ecosystem. A subsurface temperature maximum greater than 4°C in the depth range ~150 – 400m has been associated with inflow of Alaskan Stream water through Amukta Pass (Reed 1995). Thus, changes in transport through the passes can interact with Interaction.A (changes in water temperature impact ecosystem processes). In addition, the heat advected through the passes limits the sea ice extent over the Bering Sea shelf.

Moorings in some of the passes have been used to estimate transport. The contribution of each individual pass to nutrient transport is dependent on their size. Passes with depths between 120 and 200m (i.e. Seguam Pass) are most efficient at mixing nutrients upward since their sills are deeper than the nutricline but they are shallow enough that tidal currents can completely mix the water column vertically. These passes provide moderate transport (~0.4 X 10^6 m^3 s^{-1}) and large amounts of nutrients in the upper water column. Shallow passes (less than 100 m) primarily occur east of the AI region. The sills of these passes are shallower than the nutricline and high concentrations of nutrients are unavailable for mixing. The deep passes (i.e., Amukta Pass) are too deep to mix completely in the vertical. Thus, although they contribute most of the water transport into the Bering Sea (transport in Amukta has been estimated at ~4.0 X 10^6 m^3 s^{-1}), they contribute fewer nutrients to the euphotic zone (Stabeno, et al., 2005).

Risk assessment

Summary Ratings: Probability – unknown, Ecosystem impact – medium, Economic impact – medium
Timescale – annual to multi-decadal, Spatial scale – regional

Probability: Highly uncertain. Variability in the transport through the passes is virtually unknown, as is the probability that the transport could change enough to affect ecosystem processes. In addition, it is unknown whether transport (direction or magnitude) of biota is important to survival or recruitment.

Timescale: Annual to multi-decadal. Given the high uncertainty, transport (of heat, biota, or nutrients) could change on any timescale from annual to multi-decadal.

Spatial scale: Regional. Eddies in the Alaskan Stream can influence the flow through individual passes (Okkonen 1996). Thus, the presence of an eddy would influence transport locally. On the other hand, gyre scale changes in the Alaskan Gyre could influence transport through the passes on an Aleutian wide scale. Even if transport changed on a large spatial scale, biological impacts may be local.

Ecological impact: Medium. If there were a change in nutrient transport, the impact could be substantial. There could be substantial change of primary production and pelagic habitat if current directions or magnitudes change. Change in the net transport from the Pacific into the Bering could change the locations and intensity of blooms, the survival of larvae, the input of nutrients to the Bering Slope Current, and possibly the winter sea ice extent in the Bering Sea.

Economic impact: Medium. If transport changes result in spatial relocation of species with net biomass remaining fairly constant, fishermen will likely adapt. However, if transport changes drive a change in primary productivity or recruitment, which affects total system biomass, the economic impact could be significant. Higher value and colume of affected species implies higher impact.

Implications for management

The Council needs to understand whether transport and current mechanisms are changing, and what the relationship is between nutrient transport, primary production, and recruitment of managed species. Understanding the physical transport mechanisms is difficult, as there are insufficient AI data to create physical models. Given the potential importance of this transport, the Council should encourage the implementation of a monitoring system, as well as analysis of existing data. The Council may wish to encourage further AI data collection through the auspices of the Alaska Ocean Observing System as the appropriate program to provide this system.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
none	water transport in Amukta Pass from moorings	nutrient transport in Amukta Pass – add nutrient sensors to moorings?
	heat transport in Amukta Pass from moorings	Increase the number of sites that are monitored for transport (passes, Alaskan Stream, and Aleutian North Slope Current): moorings and drifters
	monitor occurrence of eddies (with altimetry) that might deflect or contribute to transport through the passes	

Data gaps / research needed

Monitoring of transports in the passes is needed. Moorings in Amukta Pass have monitored physical transport for multiple years so an estimate of the mean transport is available. Nutrient measurements on the moorings would be valuable to estimate the mean and variability of nutrient transport. Extending these measurements to other locations (within and outside passes) would be useful. Continued research on the forces influencing transport in the passes, their variability, and possible change in the face of climate change, would also be useful. Further research is also warranted on the relationship of larval transport patterns and recruitment in the AI, particularly for rockfish.

D. Changing weather patterns impact ecosystem processes

Evidence of changing weather patterns in this region include: indices such as a mean shift in the strength or location of the Aleutian Low, as changes in variability of wind direction and velocity related to pressure, or as shifts in the timing of the spring and fall transitions. Changes in the Aleutian Low could result in changing the location of the dominant storm track (Rodionov et al. 2005) and/or in changes in stratification. Changes in the strength of the Aleutian Low are related to the position of mature cyclones with more cyclones occurring west of 180° during strong Aleutian Low years (Zhu et al. 2007). The weather of the Aleutian Islands is highly variable and the AI ecosystem is likely resilient to high variability. In addition, stratification in the passes is determined by tidal processes, not storms. Away from the passes, variations in storminess could affect stratification and thus production at low trophic levels. Local shifts in abundance and species composition could occur as a response to changing weather patterns. Impacts to the human component include the ability of the fisheries to operate safely and efficiently in response to changing weather patterns.

Risk assessment

Summary Ratings: Probability – medium, Timescale – Decadal, Spatial scale – Regional, Ecosystem impact – medium, Economic impact – medium

Probability: Medium. Changing weather patterns are likely. For example, increased storm intensity globally is one mechanism the planet has for distributing heat from equator to poles. But climate change predictions in general are uncertain, and are unknown for the Aleutian Islands specifically. The probability that the magnitude of change is large enough to affect the AI ecosystem significantly is medium.

Timescale: Decadal. Given the high variability of weather in the region and the uncertainty, changing weather patterns of a magnitude that will affect the AI ecosystem are most likely on decadal or longer timescales.

Spatial Scale: Regional to AI wide. Weather patterns will most likely change on a large scale. Changes in the dominant storm track could shift resulting in higher storminess in one part of the AI region and lower storminess in another.

Ecological impact: Medium. Increased storminess could affect productivity at lower trophic levels.

Economic impact: Medium. If productivity of lower trophic levels changed, it could have effects up through the food web. Changes in the recruitment or distributions of commercial fish species could have large economic impacts. Changes may alter the ability of fisheries to operate the way they have before, in terms of seasonality, or safety, and there is cost associated with change.

Implications for Management

To understand this interaction, the Council needs to understand what are the weather patterns in the Aleutians Islands ecosystem, how might they be changing, and what is the relationship between weather patterns and productivity, recruitment, or fishing patterns. AI-specific weather data at a fine resolution would help with this understanding. But as with Interaction C above, the Council's first action might be to monitor for changes in weather patterns based on available information. If a large change occurs, it probably warrants investigation.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
none	Annual map of magnitude and position of Aleutian Low	
	Storminess indicator: Map of number of days per season (or month?), per location, with winds over some magnitude? Could use NOAA National Center for Environmental Prediction reanalysis winds to get an index for 50+ years. This would have relatively low spatial resolution (2.5° latitude and longitude)	Better accuracy and higher spatial resolution would be available with winds measured on the islands.

Data gaps / research needed

Few weather data have been collected over any length of time in the AI region making it difficult to analyze trends. Weather stations on a couple of islands would provide important information for monitoring for changes in weather. Research on ecosystem impacts of weather events or trends is also important.

4.3 Predator-prey Interactions

This section discusses ecosystem interactions mediated by trophic processes. Predator-prey interactions affect all groups in the ecosystem, including forage species, commercial groundfish, non-target species, marine mammals and seabirds. However, due to space limitations, we highlight what are currently considered to be among the most important predator-prey interactions in the Aleutian Islands. As the ecosystem changes over time, different predator-prey interactions may become important, and the Council should be able to remain apprised of these changes using indicators developed here. In each interaction below, we focus on three different aspects of predator-prey interactions: managed species interactions, bottom-up, and top-down effects in the Aleutian Islands. We recognize that all three general interaction types overlap considerably and operate simultaneously in the ecosystem. Separating the interactions here is intended to ensure that each perspective receives adequate management attention, but an integrated analysis to provide management advice would consider all interactions together along with physical and socioeconomic interactions identified in other sections.

E. Fishing mortality and predation mortality both impact managed species

Fishing and predation mortality interact in the AI ecosystem, because commercially fished species are also predators and prey within the ecosystem. The interaction happens in two basic ways. In the first case, management actions by the Council (and other agencies) change fishing mortality for certain species; this in turn may change the predation mortality exerted by those fished species on other species in the ecosystem. In the second case, changes in fishing mortality for managed species may change the amount of those species available in the ecosystem for predators of those species. Of course, these interactions do not occur separately; the multispecies fisheries managed by the Council affect the mortality for many species simultaneously, many of which feed on each other. For example, different fishing mortality rates applied to competing predators might unintentionally give one predator a competitive advantage for common prey, changing both the prey’s mortality rate and possibly the productivity of both predators. To analyze the effects of such changes, we use the food web model to assess which fished species are both substantial diet components and substantial predators of other Aleutian Islands biota, with an especial focus on the key species identified in chapter 3 (see Figure 3-14).

Diet and mortality information for key species from the Aleutian Islands food web model is provided in Table 1 in Appendix D. We identified strong interactions both by examining diet and mortality rates between key species (Appendix D, Table 1) and by simulating changes in mortality within a food web model of the Aleutian Islands (for methods, see Appendix D, and Aydin et al in press). We ranked the resulting simulated impacts from highest to lowest in terms of both significant directional change in median biomass and potential range of change even if direction is uncertain. Clear directional change in biomass is an important impact for management to consider, but an uncertain, wide range of potential change is just as important as it suggests that the impact of the interaction may cross potentially irreversible ecosystem level thresholds.

Model simulations show that a relatively small change (10%) in either Atka mackerel or pollock mortality results in the highest range of potential outcomes. Considerable uncertainty is apparent both in the direction and the magnitude of impacts from the Atka mackerel-pollock predator-prey interaction (Figure 3-19, page 36). Pollock and Atka mackerel are both estimated to cause high mortality on each other, despite being a small proportion of each other's diet. The high mortality is a result of the relatively large biomass of each species estimated to be in the ecosystem, combined with their consumption rates. Therefore, small changes in the biomass of either species could result in large changes in the amount of mortality caused by predation (assuming the diet and consumption rates remain the same). For example, if fishing reduces the biomass of Atka mackerel, they will cause less mortality on pollock, potentially releasing pollock to cause even more mortality on Atka, which is a positive feedback reducing Atka mackerel biomass further. The feedback could be even stronger if fishing reduces the biomass of pollock; however, Atka mackerel and pollock are distributed differently across the AI, so spatial interactions complicate this picture. Given spatial differences in food webs across the AI and the importance of both these species as prey to fish, mammal, and bird predators, this potentially high impact interaction should be monitored as fishing for each species continues.

A different impact is the combined effect of Pacific cod and halibut predation on sablefish. Sablefish are less than 1% of each of these species’ diets in the AI, but halibut are estimated to cause 17% and cod 18% of sablefish mortality; their combined effect is equivalent to the longline fishery (31% of total mortality in this analysis). Changes in the combined cod and halibut biomass might impact sablefish populations, and increased sablefish fishing mortality might have stronger population effects than estimated due to this predation mortality. However, a change in sablefish biomass may not affect cod or halibut as sablefish is a small portion of their overall diet.

The interaction between Pacific cod and Atka mackerel is discussed in the annual Atka mackerel stock assessment. No adjustments are made to either the Pacific cod or Atka mackerel TACs in consideration of this interaction. Model simulations do not suggest that this interaction is high impact relative to those identified above.

Risk assessment

Summary Ratings: Probability – high, Ecosystem impact – medium, Economic impact – medium
Geographic scale – AI-wide and smaller, Time scale – 5-10 years

Probability: Diet information from the Aleutian Islands shows that many commercially important species feed on each other, and at least two are also important prey for apex predators in the ecosystem; therefore the probability of this interaction affecting commercial fisheries is high (and has already happened in the context of Steller sea lion management measures applying to pollock, cod, and Atka mackerel fisheries).

Ecological impact: The range in potential impacts across all predator-prey and fishery interactions results in a "medium" impact to reflect the averaging of potentially low to potentially high impacts. Changes in the level of fishing will have the highest impact where predation interactions are strongest. The strongest interactions identified are the pollock and Atka mackerel interaction, the Atka mackerel and Steller sea lion interaction, and the halibut and Pacific cod combined impact on sablefish. The interaction of king crabs and Pacific ocean perch with other key species is low (but higher with their prey base, see Interaction F). Strong interactions among non-key species mainly included effects of reduced non-target prey species on commercial rockfish species; these interactions are also discussed under Interaction F below.

Economic impact: The differences in potential impacts across all predator-prey and fishery interactions results in a "medium" impact to reflect the averaging of potentially low to potentially high impacts. A high economic impact results where predation interactions result in tradeoffs between different fisheries, such as the Atka mackerel fishery and the pollock fishery, or between these fisheries and Steller sea lions. The economic impact of interactions which may trigger ecosystem-level thresholds, such as the Atka mackerel-pollock interaction, is unknown but could be higher than the simple tradeoffs between existing fisheries. There is little economic impact expected for weakly interacting species. The Council's ability to directly control fishing mortality, and to reallocate effort and harvest levels to exploit the most abundant species, will allow it to mitigate, to some extent, high impacts from changing predation mortality.

Geographic scale: The food web used in this analysis reflects an Aleutian Islands-wide scale, which is the scale of most current management; however, predator-prey interactions clearly occur at very small local scales, well below those currently used in stock assessment and management. The impacts of changes in populations due to predator-prey interactions can also range from local to regional. There may also be a global scale economic impact, to the extent Atka mackerel and crab are sold to global markets.

Time scale: Like fishing mortality, population changes due to predation mortality are expected to have multi-year impacts, placing this interaction in the 5 to 10 years category. However, disruption of key interactions might have irreversible ecosystem wide impacts on longer timescales.

Implications for management

A commonly held management objective for ecosystems is to maintain the species interactions sustaining energy flow in the ecosystem. Another is to avoid crossing thresholds that might rapidly move the ecosystem into a new, unknown state, if such thresholds can be identified. We can use food web models and updates (from continued diet sampling in the ecosystem) to determine whether key high impact species interactions are changing, and also whether they are likely to change as a result of fishing. Current analyses suggests that the predator-prey interaction between Atka mackerel and pollock might be most likely to cause impacts to fisheries if mortality for either species changes. In addition, the interaction between cod and sablefish might cause impacts to the sablefish fishery. Further, analysis validates that changing mortality for Atka mackerel might have effects on Steller sea lion biomass in this system (although this interaction has had considerable Council attention already). Beyond impacts to individual fisheries, current analysis also suggests that relatively small changes in unexplained mortality for Atka mackerel and/or pollock, results in widely different potential trajectories for these species and many others in the ecosystem, suggesting a potential ecosystem-level threshold effect. The risk of not considering these interactions in management is that populations might change due to unintended fishery-enhanced predator-prey effects, resulting in more severe management constraints in the future to mitigate the unintended effects. Under a worst case scenario, the effects of unintended fishery-predator-prey interactions might push the ecosystem across a threshold, fundamentally changing the species composition, energetic structure, and species interactions into new and perhaps undesirable configurations.

How is the Council addressing risk right now?

At present, the Council addresses this risk on a single species basis for certain species. The risk of fisheries removing Steller sea lion prey was addressed in a Council process resulting in Steller sea lion protection measures, providing the clearest current example of the Council addressing fishery interactions with predator-prey relationships. Also, each individual species stock assessment lists the predator-prey interactions centered on that species, so some of the relevant information is already part of Council decisionmaking. How this information is used in the Council process has been ad hoc, to date. For example, if the Plan Team has a choice between different potential (and equally valid given uncertainty) ABC and overfishing levels (OFLs) for a species, and some predator-prey information suggests that one might be preferable to the other (e.g., a lower, more conservative quota if the species is prey for protected species), then the Plan Team may select that lower quota. The SSC or Council may use the information similarly.

While the Council addressed Steller sea lion interactions with the best tools it had available at the time, the process was difficult because it was litigation-driven, reactive crisis management. Under an FEP framework such as the one presented here, predator-prey relationships and their current and potential interactions with fisheries can be presented to the Council more methodically and can be updated on a regular basis. This should result in the development of proactive, rather than reactive, research and management measures.

While ecosystem considerations are sometimes approached on a species-by-species basis, this is less effective. The individual stock assessment, in isolation, does not seem to be the appropriate place for ecosystem adjustments to be decided upon. To fully consider the interactions among species, integration might be attempted under the current process at the Plan Team or SSC level, with the representation of other agencies (ADF&G and IPHC) included. In the current process, these groups consider interactions as appropriate, between managed species. For example, issues such as whether the pollock and Atka mackerel quotas might affect each other given that these species prey on each other, or whether mitigation measures for sea lions might negatively impact some other protected species by displacing fishing effort into its critical habitat.

What would be ways to consider any risk identified, and mitigate this risk?

While interactions between managed species are addressed under the current process, the Council may also wish to consider a more formalized process, both for considering ecosystem-level risks and for balancing tradeoffs apparent from an understanding of biological (and other) ecosystem interactions. The decision on what is an acceptable level of risk is a policy decision, which under the Council process means that it is one which only the Council can decide. Such a policy should recognize economic risks and trade-offs associated with these decisions, including the commercial value of species involved in trade-offs. By specifying explicit thresholds or policies on acceptable risk, however, the Council can delegate the ecological assessment of risk to other advisory bodies, such as the Plan Teams or the SSC.

The appropriate time for formally considering and adjusting for ecosystem-level risk would appear to be after the existing single species assessment and review process, but before determining final fishery harvest levels for individual species. Final harvest levels could then be adjusted to mitigate ecosystem-level risks to the desirable extent. During this ecosystem-level review process, the responsible body would review the indicators developed for all Aleutian Islands ecosystem interactions and evaluate them against action thresholds established for each indicator. This would then establish whether individual harvest specifications should be altered from the single species recommendations. By conducting such a review, the Council could also be advised about ecosystem changes that cannot be mitigated through modifications to harvest specifications.

There are at least two ways for the ecosystem-level assessment process to provide advice on mitigating risks from predator-prey-fishery interactions, and these ways may work in concert. One way would be to develop specific mitigation measures for a few of the most important fishery-predator-prey interactions, with importance determined by potential or current economic impact, similar to the approach taken for Steller sea lions. The indicator listing the current most important species interactions would be used to select top candidates for directed research and or mitigation. The initial analysis presented here suggests that the interaction between Atka mackerel and pollock might be most important to consider first, especially if expansion of the pollock fishery is desirable and because both species continue to be important prey to Steller sea lions. The uncertainty in ecosystem outcomes is highest for the interaction of these two species, so studying this interaction (preferably in a spatially-explicit context at scales much smaller than AI-wide) and developing management measures to mitigate potentially large impacts of the interaction might address much of the uncertainty in ecosystem dynamics in the AI. However, this single-interaction focused approach used alone might overlook important interactions either not identified with current data or simply those further down the list.

A second, more integrated approach could be to develop a general framework within the current management process which considers fishing mortality in the context of predator mortality within a complex predator-prey system. A first step might be to use the food web model and other tools to divide species into groups of mainly forage species (more predation mortality than fishing or unexplained, e.g., Atka mackerel) as opposed to mainly predator species (a majority of unexplained mortality, e.g., Pacific cod). Once it is determined which mortality source dominates, then a different ecosystem risk policy could be applied to a “prey” species, needed both as forage and as commercial species, to differentiate it from a “predator” species that is commercially important but not important prey as well. “Predator” species are most likely to benefit from a continuation of the single species assessment and management approach, with the modification that the interactions of all species are considered and updated regularly as part of the overall management process.

One suggestion for balancing the needs of predators and fisheries directed at “prey” (commercially important forage species) would be formally to account for the predator needs on a species, while determining the appropriate allowable harvest for the fishery. This would involve assessing three indicators together: the amount and trend of the prey species observed in each predator’s diet, combined with the biomass trends of the predators and prey species. In the Atka mackerel example, biomass trends of Steller sea lions, Pacific cod, and pollock would be examined along with their diet trends to determine whether a proposed fishery harvest left sufficient Atka mackerel in the system to minimally supply recent predator demands, and whether predator demand might be increasing. The Council, as part of its ecosystem risk policy, could decide to minimally supply predators, or to leave a buffer of arbitrary proportion for uncertainty (as is currently done in maintaining single species TACs below single species OFLs). Or, if the predator is vulnerable, the Council might set fishery harvest low enough to release the a prey population for predators. It is important to understand, however, that leaving fish in the system (on the scale at which we manage, annually and spatially averaged) is no guarantee that a particular predator will benefit from it; at the same time, harvesting it ensures that no other predator will get it. This is why it will be important to consider spatial interactions, much in the manner of the Steller sea lion management measures, in order to address risks posed to fisheries by predator-prey interactions.

Ideally, we would conduct integrated assessments for each commercially important "prey" species using indicators for predators of the species and the current single species data itself, as well as any consideration of "outside" influences such as climate change and many of the other interactions identified in this FEP. To the extent possible, the assessment would include socioeconomic considerations and indicators to address any tradeoffs among fisheries. At this stage, with our current food web models, we can identify critical predator-prey interactions, but the up-to-date collection and processing of appropriate data to monitor these interactions is essential. For example, an Atka mackerel-pollock-Pacific cod model is currently being developed for the Aleutian Islands, and would be useful for helping managers to balance the needs of predators with fishery yield. An improvement to this model would be to develop a time series of Steller sea lion diets, thus completing the set of major predators on Atka mackerel for an integrated fishery-ecosystem assessment.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data is not available
Trophic level catch in AI – captures trophic level and intensity of what we're fishing, over time – include Tim Essington-style survey and fishery trophic level graphs	Monitor the most important predator-prey interactions, currently: – atka and pollock on each other, – Steller sea lion on atka, – cod and halibut on sablefish, – cod on atka Update food web trophic impacts plot every 5 years	
Biomass trends for key interacting species – but focus on comparing trends for key interacting species	Percent of commercial species in each other's diets – monitor for changes at least every 5 years	
	Percent of commercial species in key apex predator's diets (sea lions, birds) – monitor for changes at least every 5 years	

Trophic level of the catch: this is useful as a general aggregate indicator of fishery interaction with ecosystem and perhaps as an indicator of ecosystem shifts if we measure it from the survey. The aggregate indicator is less useful for focusing on specific energy flow pathways (predator-prey interactions).

Most important predator-prey interactions: if they change this indicates a redirection of energy flow in the ecosystem and we may need to balance TACs differently (see above). Mostly this indicator ensures that we are focusing effort on the interactions responsible for much energy flow and or those considered likely to cause the most instability in the ecosystem.

Percent of commercial species in diets of each other, apex predators, and biomass trends for these species: use these indicators in a combined way. If at current fishing quotas we see a commercial prey species have steady biomass trends, but its predators have falling biomass trends and are also eating less of it, a precautionary assumption would be that the fishery is outcompeting the predators and their populations are dropping as a result. The management action could be to lower the quota and see if predators start eating more of the species as a result. This might allow them to recover. The signal might be considerably more mixed of course, so then it would be more of a policy call to decide whether to lower fishing quotas for the prey species to help predator species recover (whether predator species themselves are fished or not complicates the situation as well).

Data gaps / research needed

Diet information from seasons other than summer is needed to assess seasonal changes in predator-prey interactions. Diet information should also be collected at appropriate spatial scales for key predators to determine whether and how spatial food webs are changing in this ecosystem. Continued monitoring of groundfish diets at both the AI-wide and smaller local scales, and expanded or integrated existing databases to coordinate between seabird and marine mammal diet studies as well as lower trophic level studies are needed.

F. Bottom up change in ecosystem productivity impacts predators and fisheries

The overall amount of energy at low trophic levels in any ecosystem ultimately limits the productivity and biomass of higher trophic level predators, as well as fisheries catch. Changes in energy flow originating at low trophic levels are termed “bottom up” effects when viewed from the predator and fishery standpoint. We generally associate bottom up effects with changes in the physical environment, so this interaction is strongly linked to the climate and physical interactions discussed above. Some factors may lead to overall changes in bottom up energy flow in an entire ecosystem (such as nutrient runoff fertilizing freshwater systems), while others factors may favor certain energy flow pathways over others but leave overall ecosystem energy the same, with complex impacts. Reductions in energy flow, whether system-wide or in certain pathways, precipitate competition for the newly scarce resources at higher trophic levels, and could result in changes in species biomass and food web relationships. Conversely, increased energy flow could favor certain higher trophic level species in one pathway, allowing them to outcompete predators relying on another pathway. Here we assess the risks of bottom up effects by examining potential competition for prey resources shared by predators and fisheries in the current Aleutian Islands food web, and by simulating reductions in productivity for low trophic level groups in the food web.

Risk assessment

Summary Ratings: Probability – unknown, Ecosystem impact – medium to high, Economic impact – medium to high, Geographic scale – AI-wide, Time scale – 5-10 years

Probability: According to model simulations, sustained changes in bottom up production on the order of 10% are guaranteed to change biomass trajectories for multiple fished species and apex predators, but both the probability of the bottom up changes themselves occurring and the specific impacts are extremely difficult to predict. Direct competition is for prey resources in the current food web is similarly difficult to evaluate. This assessment identifies species with greater than 10% of prey overlap in their diet, as well as exhibiting a dependence on that prey (i.e., it represents greater than 10% of their diet), as probable competitors, However, competition implies that the prey resource is limited, and prey overlap may just be a reflection of the high prevalence of the prey. Several fishery species, and many other species clearly share a prey base. Table 2 in Appendix D illustrates prey groupings for AI species.

Ecological impact: The degree of bottom up change and whether it is sustained over time determines the degree of ecological impact. The uncertainty in whether a sustained production change will occur combined with the complexity of potential impacts depending on which pathway a change affects led us to rate this impact “medium-high” to reflect the combination of fairly clear model impacts with the uncertainty and the averaging of potentially low to potentially high impacts. Simulation analysis ranked the three strongest single prey bottom up interactions for commercial species as the importance of (1) Pandalid shrimp to rougheye rockfish, (2) benthic amphipods to dusky rockfish, and (3) non-Pandalid shrimps to shortraker rockfish. These interactions all occur through benthic energy pathways. However, the highest aggregate negative ecological impact would result from decreased productivity in the pelagic energy pathway of the AI food web, which potentially affects the prey for most key species. Specifically, these are the euphausiid prey base (shared by all forage fish, myctophids, baleen whales, squids, sablefish, Atka mackerel, seabirds, pollock, rockfish and POP); the copepod prey base (shared by the above species and euphausiids, and particularly important to POP and right whales); the squid prey base (shared by toothed whales, grenadiers, seabirds, halibut, and atka); and the myctophid prey base (shared by flatfish, grenadiers, and pollock). King crab and sea otters are the exception, as they compete for benthic invertebrates with other fish, crabs and shrimp.

Commercially important and protected species share the pollock and Atka mackerel prey base, which rely on the pelagic energy pathway. Pollock are the shared major prey of the Federal trawl fishery (in the early 1990s), as well as skates, pinnipeds, and Steller sea lions. Atka mackerel are shared major prey of Steller sea lions, skates, the fishery, halibut and Pacific cod. Much attention has already been focused on the potential competition between Steller sea lions and the Federal trawl fisheries with respect to Atka mackerel, Pacific cod and pollock. It is important to note that the potential competition between grenadiers and pollock for myctophid prey is not observed in any other Alaskan ecosystem, and the classification of sablefish with other zooplankton feeders is also unique to the AI. If competition for a prey base and/or overall ecosystem productivity is of concern, the importance of euphausiids and copepods as prey for a wide range of commercial and protected species in the AI suggests that production of these important zooplankton groups might be monitored, especially under future climate change. Direct exploitation of euphausiids has been prohibited since 1998.

Economic impact: The uncertainty in whether bottom up changes will happen and the differences in potential impacts across all predators and fisheries led us to rate this impact “medium-high” to reflect the combination of clear model impacts under certain circumstances with our uncertainty and the averaging of potentially low to potentially high impacts. The highest negative economic impacts would result from the depletion of euphausiids; pollock and Atka mackerel, as they are prey shared by both high valued commercial fisheries (halibut, cod) and protected predators; and shrimp which are shared by cod, skate, rockfish, other fish, pinnipeds, and flatfish. Disruptions in benthic energy flow would have negative impacts to the high-valued king crab fishery. Conversely, a general increase in bottom up productivity might result in increased fishery productivity and positive economic impacts.

Geographic scale: The food web used in this analysis reflects an Aleutian Islands-wide scale, which is the scale of most current management; however, competitive interactions clearly occur at very small local scales, well below those currently used in stock assessment and management. The impacts of changes in populations due to competitive interactions triggered by bottom up changes can also range from local to regional. A sustained regional change in productivity would be expected to have regional impacts on most species. There may also be a global scale economic impact, to the extent Atka mackerel and crab are sold to global markets.

Time scale: Ecosystem effects of bottom up changes due to competition or limited energy flow might be observed as groundfish population changes within 5 to 10 years of a sustained change, but could happen more quickly for high-turnover species. However, altered energy flow pathways might have irreversible ecosystem wide impacts on longer timescales.

Implications for management

Another commonly held management objective for ecosystems is to ensure that cumulative exploitation rates do not exceed the productive capacity of the system. This is analogous to the single species management objective limiting fishing mortality to ensure that it does not exceed the productive capacity of individual stocks, considered in isolation. While substantial attention is paid to the productivity of commercially important stocks in current fisheries management, their productivity is inextricably linked to the productive capacity of the ecosystem, starting with low trophic level organisms that currently receive much less research attention, especially in the Aleutian Islands. Current models show that commercially important stocks and apex predators are extremely sensitive to simulated bottom up changes in ecosystem productivity, especially in the pelagic energy pathway. However, we have little capacity at present to measure low trophic level productivity in the Aleutian Islands or to understand the factors that drive changes in this productivity. To successfully address the implications of this interaction, additional monitoring of the ecosystem is required. Bottom up change in ecosystem productivity is likely to occur in response to changing physical conditions, so examining physical interaction indicators concurrently with indicators developed for this interaction will be important to determining mechanistic linkages and will contribute to understanding of ecosystem dynamics.

What is the risk?

A general drop in ecosystem production is predicted to negatively affect multiple commercial species negatively, which might result in unintentional overfishing of stocks before the signal appears at the groundfish level as decreased productivity. Alternatively, increased production in the ecosystem might increase groundfish production such that management measures were unintentionally excessively restrictive before the signal appeared, resulting in unnecessary economic losses. More complex impacts are predicted when production changes in specific energy pathways, but not ecosystem wide. These bottom up changes are likely to favor some species over others in competition for shared prey resources, potentially resulting in economic fishery tradeoffs, but the outcomes of competitive interactions are extremely difficult to predict as they occur at smaller spatial and temporal scales than we currently measure.

How is the Council addressing risk right now?

There is no formal process for addressing this risk at the ecosystem level. Some indices of low trophic level and forage fish production are presented annually as part of the Ecosystem Considerations SAFE, but these indices are not incorporated into management advice at this time, and only two (forage fish and non-target species trends from bottom trawl surveys not designed to sample these groups) are appropriate for the Aleutian Islands area. Seabird production is presented for the Aleutians (under the heading Southwestern Bering Sea) and could be used as a general indicator of low trophic level and forage species production, especially if more detail on Aleutian foraging ranges and timing were included.

Current single species stock assessments address the effects of bottom up ecosystem change on individual stocks by excluding productivity (recruitment) estimates from prior climate regimes (e.g. before 1977). Time series of combined groundfish recruitment and survival rates derived from single species assessments are also presented in the Ecosystem Considerations SAFE, indicating whether multiple species had synchronous changes in productivity in response to climate regime shifts (BSAI wide). Unfortunately, this is not a leading indicator; using current statistical analyses of ocean state combined with fished species recruitment estimates, climate regime shifts are not identifiable until well after they have happened. If bottom up productivity changed in the Aleutian Islands today, we would likely see it as fished species dropping unexpectedly in five years or more (in other words, too late to mitigate the economic effects). Additionally, we are not measuring biological interactions at the appropriate scales to get insight into potential outcomes of competitive interactions for shared prey resources when physical changes drive bottom up changes in specific energy flow pathways without changing overall production.

What would be ways to consider any risk identified, and mitigate this risk?

The Council may wish to add a formal process for considering ecosystem-level risks and for balancing tradeoffs arising from biological (and other) ecosystem interactions. This process might happen after the current single species assessment and review process has been completed, but before TACs are determined for individual species. Final TACs would be set to mitigate ecosystem level risks to the extent possible. During this process, the responsible body would review the indicators developed for all interactions and evaluate them against the action thresholds established for each indicator, which would then determine whether TACs needed to be altered from the single species recommendations. This process would also advise the Council on any ecosystem changes that cannot be addressed through TAC modifications.

Obviously, the Council will most likely be unable to control the physical processes contributing to changes in bottom up production, whether it is ecosystem wide or in certain energy pathways. However, there are two ways the risk of bottom up changes might be mitigated within the fisheries management system. First, the Council can adjust aggregate fishing mortality rates to ensure that overall exploitation is in line with current ecosystem level productivity. Second, the Council can evaluate whether the mix of proposed fishing mortality rates across species might interact with any changes in competitive interactions precipitated by bottom up changes, and attempt to avoid interactions which hamper fishery sustainability.

The first goal might be achieved by establishing a separate OY cap for the Aleutian Islands, based on analyses of commercial stock productivity within this ecosystem combined with any low trophic level information available. (A similar re-analysis of stock productivity and low trophic level production on the eastern Bering Sea shelf would establish an appropriate OY level for that ecosystem, which would most likely be similar to the current BSAI OY cap as that is based primarily on EBS data.) However, indices in low trophic level production should be monitored continuously once established and combined with groundfish productivity analyses to periodically re-evaluate and update the AI OY cap. Periodic updates would ensure that if bottom up productivity changed in this ecosystem, the OY cap would be appropriate to current productivity. The new OY cap would therefore be more analogous to a single species OFL which is updated as stock productivity changes, although the AI OY cap would update on a longer timescale to ensure that adjustments are based on sustained productivity changes. Because we do not understand the range of variability in bottom up production in this ecosystem at present, we suggest conducting ecosystem OY analyses initially on a five year timescale. This timescale should be changed as more information about Aleutian Islands ecosystem variability becomes available through monitoring of low trophic level indices combined with groundfish, bird, and marine mammal production indices.

Within any given OY cap, the Council still makes decisions about the distribution of fishing mortality across commercial species (and the distribution of economic impacts between fishery sectors). To avoid negative impacts of interactions with competitive predator-prey relationships within the ecosystem, the same general approaches developed above to mitigate risk associated with predator-prey interactions between commercial species might be applied. First, the Council might develop specific policy to address the highest impact bottom up interactions detected in the food web perturbation analysis. In this case, the sensitivity of commercial rockfish (rougheye, dusky, and shortraker) to changes in benthic invertebrate groups (shrimps and amphipods) suggests that once monitoring systems are in place, observed changes in benthic productivity might proportionally change recommended fishing mortality rates for these rockfish species (but like overall OY, at longer timescales). Since these rockfish are generally not important as prey for other species in the Aleutians, fishing mortality rates could scale in both directions, up with sustained higher production and down with lower production. With continued diet sampling contributing to food web model updates, these relationships can be periodically re-evaluated to ensure that the highest impact bottom up interactions are considered in fishery management for the impacted species.

Second, to address bottom up changes in major energy pathways, commercial and protected species might be classified by shared prey fields and observed sustained changes in the shared prey fields might translate into altered management for the aggregated commercial species. (Again, since the range of productive variability in this ecosystem is unknown, we suggest that changes be evaluated and management alterations made on a 5 year basis initially.) The next step would be to classify the managed species within the feeding group as “prey” or “predators” (described above under Interaction E), and to estimate any potential competitive interactions for the managed species to determine appropriate fishing mortality when bottom up production changes. In the simplest case, “predator” species which are not important as prey to higher trophic levels and which have only minor competitive interactions might have fishing mortality adjust directly with sustained observed changes in productivity in their energy pathways, as described for rockfish above. When major competitive interactions between fished predators and/or other predators are likely based on current food web model analysis, assessors should simulate the relative risks of different combined fishing mortality levels under the new productivity regime favoring specific competitive interactions which might be counterproductive to sustainability of commercial or protected species. Suites of fishing mortality rates which avoid counterproductive competitive interactions would then be identified and implemented for these species. “Prey” species require more careful balancing of predator and fishery needs, as well as attention to competitive interactions. In general, a change in bottom up production in a major energy pathway may precipitate competitive interactions between these prey species and further competitive interactions among their predators in response. Until there is substantial understanding of these interactions at appropriate spatial scales, the best policy for mitigating risk of negative fishing interactions with bottom up changes to competing prey species might be conservative management which establishes a much lower OY for the prey species in low productivity regimes and partitions this OY among predators and fisheries as described above under Implication F. In high productivity regimes, the Council should continue partitioning OY for the prey species among predators and fisheries to ensure that increased energy is available to higher trophic levels as well as contributing to increased fishing yields.

For example, the zooplankton feeding group identified in Section 3.3 includes Atka mackerel, POP, myctophids, pollock, squids, other forage fish, sablefish, other rockfish, baleen whales, and planktonic seabirds. The shared prey base would include euphausiids and copepods. We can also define more specific groupings based on separate euphausiid and copepod prey bases. Within this group, “prey” species would include Atka mackerel, sablefish, pollock, squids, myctophids, and other forage fish, because they have much higher predation mortality than either fishing or unexplained mortality in the regional Aleutian Islands food web model. Baleen whales, planktonic seabirds, POP, and other rockfish have much higher unexplained or fishing mortality than predation mortality, so these zooplankton feeders are “predator” species for management purposes. The extent of competition for zooplankton feeding species can be estimated from current prey overlap combined with model simulations. Table 3 in Appendix D shows that all groups have euphausiids as more than 10% of diet, and nine of ten have copepods as more than 10% of diet, meeting our basic requirement for potential competition. Model simulations decreasing euphausiid production by 10% show strongest effects on the “prey” species in this group (sablefish, Atka mackerel and other forage), and also significant negative effects on baleen whale biomass (minke, humpback, and fin whales), but not on POP, other rockfish or seabirds, suggesting that among the competing predators, baleen whales would be most sensitive to this change with no changes in fishing. Model simulations decreasing copepod production by 10% show the highest significant negative impacts on POP biomass, followed by right whales, with more uncertain negative impacts to sei whales and northern rockfish. Results are more uncertain for the prey species in this group with respect to a drop in copepod production, likely due to complex competitive interactions. This preliminary analysis shows that different competing predators are favored by different bottom up changes within this energy pathway. A full analysis would decrease both copepod and euphausiid production simultaneously and examine the effects of changing fishing mortality on target species, preferably in a spatial context.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
	Forage estimates from diets - clarify what we mean by forage, one type is Council's 'forage fish' category, also zooplankton, also juveniles of commercial fish (Atka mackerel, cod, pollock)	- surveys of forage fish species - need diet data over time (only have snapshot right now) - need to coordinate between seabird, fish, mammal food habits databases - need biomass estimates (or index) for each prey species of commercial species
	Combine above with physical indicators to assess mechanisms	Primary productivity index - primary production measured at multiple locations and seasons
		Pelagic zooplankton biomass or productivity index (high priority) - euphausiid index measured at multiple locations and seasons - copepod index measured at multiple locations and seasons
		Benthic biomass or productivity index - shrimp index? Benthic amphipods? At multiple locations and seasons.

Forage biomass trends from the AI survey are currently of limited use as this survey is not designed to sample forage species appropriately. However, if direct surveys of forage fish species can be developed (either direct sampling or using time series of diet compositions of groundfish, seabirds, and marine mammal predators), as well as the new indices of primary productivity, zooplankton productivity, and benthic productivity, these would all be translated into action thresholds in a similar manner. In general, stability in the index indicates status quo management is appropriate, while rapid change in the indices suggests that management changes might be considered. Since baseline values for many of these indices do not exist, monitoring the new indices and analyzing whether they correlate (with time lags) to the few existing indices of groundfish production (recruitment), seabird production, and marine mammal production in the AI would help establish potential action thresholds in the immediate future. We note that direct measurements of low trophic level production will be preferable once indices are established, as they will provide leading indicators of the trajectory of higher trophic level stocks. Even without a baseline, however, indices of low trophic level production would indicate whether production is generally stable or whether it is changing rapidly between years.

Data gaps / research needed

To provide early warning of changes in bottom up production in the Aleutian Islands, surveys providing an index of low trophic level production in multiple energy pathways must be developed. Particularly because the Aleutians are an oceanic dominated ecosystem with many fisheries dependent on the pelagic energy pathway, a zooplankton monitoring system at a minimum would be a vital part of assessing ecosystem productivity and potential impacts to fisheries. The spatial complexity of the Aleutians ecosystem further requires that monitoring happen at multiple locations and local scales to assess whether bottom up production is changing or simply redistributing. Further, with predicted changes in climate and ocean acidification, monitoring zooplankton production seasonally throughout the Aleutians will be important as a leading indicator of potential climate effects on fisheries in this system. The FATE (Fisheries And The Environment) research initiative may provide funding for directed research on how to incorporate bottom up factors from monitoring into fisheries stock assessments in the Aleutians.

G. Top down changes in predation and fishing impact ecosystem structure and function

High trophic level predators, including fisheries, affect ecosystem structure (species composition and food web topology) in space and time through both competitive interactions with each other and through their combined impacts on prey at mid and lower trophic levels. Basic ecosystem functions include nutrient cycling and energy transformation, which are linked processes affected by both bottom up changes in energy flow (described above in Interaction F) and the type of top down forcing applied by apex predators and fisheries. Here, we used to regional Aleutian Islands food web model to provide both mortality estimates and simulation analyses for unexploited apex predators in the ecosystem.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – medium to low, Economic impact – medium to low, Geographic scale – AI-wide to smaller, Time scale – 5-10 years

Probability: Unexploited apex predators in the Aleutian Islands include seabirds, marine mammals, sharks, and skates. Fisheries currently directly impact sharks, skates, and birds through bycatch mortality, although the interaction with sharks and skates is much stronger than with birds. There is a negligible direct fishing mortality impact on marine mammals at present in the Aleutian Islands. Between apex predators, marine mammal predation is estimated to have a moderate impact on baleen whales, pinnipeds, sea otters, toothed whales, Steller sea lions, sharks, skates, and seabirds (fulmars) have a moderate predation impact on other seabird groups. Sharks and skates appear to have few direct interactions with other apex predators. These direct interactions do change predation rates and therefore energy flow at lower trophic levels. Therefore, the probability of fisheries and apex predators interacting with each other to impact ecosystem structure and function ranges from high to low, which we expressed as “medium” probability for the interaction as a whole.

Ecological impact: While bottom up impacts and key predator-prey interactions have clear ecosystem wide impacts in food web simulation analyses, top down impacts due to unexploited apex predator interactions with fisheries appear to have few ecosystem wide effects. However, this result is based on the current ecosystem modeled with existing fishing effects already in place, which may contribute to this result. Therefore, to reflect both current model results and the range of impacts as well as our uncertainty, we rated this impact “medium-low” risk for Aleutian Islands ecosystem structure and function. This rating does not apply to the potentially large impacts fisheries may have on individual apex predators through direct mortality and competition effects (separate issues discussed under Interactions E, F, and L).

Fisheries cause more mortality for non-target sharks (79%) and skates (56%) than for any target species aside from king crabs. These species are not intended to be exploited, but effective exploitation rates as bycatch are high. While this may have large population consequences for sharks and skates, it is unclear whether this bycatch mortality has an ecosystem-level effect. Model simulations increasing mortality rates by 10% for sharks and skates showed limited positive effects to primary prey groups of less than 2%, and always less than 10% in even extreme cases. However, these results already incorporate the high fishing mortality rates implied for sharks and skates; at unfished biomass levels these predators might have larger ecosystem effects. Fisheries were estimated to cause 3-6% of bird group mortality in the early 1990s, again potentially with some consequences to bird populations but unclear ecosystem consequences; a simulated 10% increase in bird mortality had no effects beyond those to bird populations themselves using the regional AI food web model. Fisheries cause negligible direct mortality on marine mammals (other than subsistence on pinnipeds).

Toothed whales are estimated to cause predation mortality (10-24%) on baleen whales, pinnipeds, sea otters, and lower estimated amounts (4-8%) on other toothed whales sharks, skates, and Steller sea lions. While some theorize that toothed whale (transient killer whale) predation might account for declines in pinniped and sea otter populations (and thus changes in community composition of apex predators), it is unclear what their diet preferences and even population size are to make credible quantitative estimates of their impacts to other mammal populations. To clarify this, directed research on transient killer whale population size, movements, and food habits should be continued, and this apex predator population monitored to the extent possible. Piscivorous birds cause some mortality on themselves (25%) and planktivorous birds (13%), which is the majority of explained bird mortality in the models, but a minority of total mortality (most is unexplained). This predation may have seabird population impacts, but has unclear ecosystem impacts.

Economic impact: Economic impacts of population changes in unexploited apex predators may result from their increased competition for fishery species as prey when population levels are high. Current simulations suggest that 10% changes in mortality for apex predators are not expected to have large impacts to economically important species or their fisheries, unlike similarly small changes for bottom up effects or for the commercially important species themselves. However, we have not simulated larger population changes for apex predators, and there is considerable uncertainty in this result, so we rated this “medium-low” economic impact. Population changes of listed species such as the Steller sea lion have an economic impact due to regulatory constraints on the fisheries, as described below.

Geographic scale: The food web used in this analysis reflects an Aleutian Islands-wide scale, which is the scale of most current management; however, competitive interactions between apex predators and fisheries clearly occur at local scales, well below those currently used in stock assessment and most management (Steller sea lion mitigation measures being the exception). The impacts of changes in community structure and energy flow due to apex predator changes can also range from local to regional, with strongest effects expected locally.

Time scale: Ecosystem effects of top down changes due to apex predator and fishery interactions might be observed as groundfish population changes within 5 to 10 years of a sustained change, but could happen more quickly for high-turnover species. However, altered energy flow pathways might have irreversible ecosystem wide impacts on longer timescales.

Implications for management

An objective of ecosystem based fishery management is to ensure that healthy ecosystem structure and function is maintained, including a full suite of energy flow pathways terminating in both natural apex predators and fisheries. To some extent, healthy apex predator populations may compete with fisheries for commercially important prey, so some tradeoffs between this ecosystem based objective and objectives maximizing economic fishery yields will be necessary. Energy flow pathways and competition at high trophic levels represent some of the most complex interactions in food webs, but models of the current food web suggest that few natural predators have large top-down effects throughout the ecosystem at present. Fisheries do remove a substantial proportion of energy from the Aleutian Islands ecosystem, which is not surprising given single species objectives to maximize yield. To successfully address the implications of this interaction, considerable policy analysis on the appropriate balance of apex predators and fisheries in what we define to be a “healthy” ecosystem will be necessary.

What is the risk?

The risk of not considering these interactions in fishery management is twofold. First, if fisheries outcompete predators for shared prey there may be population impacts to those apex predators, which in the extreme may eventually severely constrain fisheries through ESA regulatory interactions (see Interaction N). Conversely, if apex predators outcompete fisheries by consuming commercial species and we do not consider this in fishery management, the commercial species may experience more mortality than we are accounting for, such that fishing mortality would have a greater than expected effect on them. Second, the top down effects of natural apex predators differs from those of fisheries (Aydin et al in press footprint analysis shows this), so they play different structuring roles in the ecosystem. Greatly reduced apex predator populations may no longer serve this function, causing changes in ecosystem structure which may lead to unknown and perhaps undesirable configurations.

How is the Council addressing risk right now?

The Council addresses apex predator interactions with fisheries on a single species basis for certain species, with Steller sea lions providing the clearest example (see also discussion under Implication F). The interactions of ESA listed seabirds are also addressed by the Council, but more in a direct take context than in a competitive context. Unexploited apex predators are monitored in marine mammal stock assessments and seabird population studies, as well as stock assessments for sharks and skates. In some single species stock assessments the predators and food web roles of the assessed species is included. However, changing predator consumption is not considered in single species stock assessments for fished species at present, and there is no point in the management process where the integrated effects of fishery interactions with apex predators on ecosystem structure are considered, or the potential tradeoffs between them.

What would be ways to consider any risk identified, and mitigate this risk?

For the purposes of this interaction, combining the mitigation developed under both previous predator-prey interactions above would move towards mitigating this risk. An OY cap could be developed for the AI to constrain the overall fisheries take considered appropriate for the level of productivity in the AI, including maintaining the production of apex predators. Separating species into “prey” and “predator” groups and identifying their key interactions and potential competitors would be appropriate to mitigate risk to apex predators, especially if prey OY for predators was designed to allow “rebuilding” to target population sizes for depleted apex predators. Finally, reduction of fishery bycatch of elasmobranch apex predators might be considered desirable to maintain or restore these apex predators’ function in structuring ecosystem interactions, even though their current impact appears to be relatively small.

To start the policy discussion of how to balance large populations of apex predators and fisheries in this ecosystem, food web models could be used to estimate what level of apex predator biomass would cause substantial conflicts with current fisheries, including potential unintentional overfishing if predation mortality increases substantially. We envision this to be an ongoing policy discussion which would involve both biological interactions and socioeconomic interactions in this ecosystem.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
Alaskan sea lion, western stock, non-pup counts - need specifically for AI subarea - add index for pup counts in AI - SSL mortality by category (fishing, etc.)	Fishery catch of common apex predators’ prey - specifically compare with seabird, marine mammal trends	Develop index of apex predators for seabirds, marine mammals, sharks, skates (show annual anomalies)
Seabird - breeding chronology - productivity - population trends (choose representative species, include resident versus migratory) Shark, skate stock assessments - evaluate fishery removal	Energy sink and fishery footprint analyses from periodic food web model updates - monitor where prey species’ energy leaves the system (marine mammals, birds, groundfish predators, fisheries?) and note changes	

Monitoring apex predator populations together may measure whether trophic structure is changing as a result of fishery management. However, the existing system may already incorporate the long term effects of fishing on apex predator populations, ecosystem structure, and function. These effects are difficult to separate from bottom up effects that have been operating over the same time period; however, monitoring both bottom up indicators and these top down indicators simultaneously may help clarify how fishery management interacts with both bottom up and top down forcing in the Aleutian Islands ecosystem from here forward.

Food web model updates can be used to evaluate ecosystem structure and function with respect to apex predators by evaluating where energy "exits" the ecosystem. By quantifying energy flow throughout the food web we can determine what proportion of energy is converted to marine mammal, bird, or other apex predator biomass versus fishery catch. A full description and comparison of all three Alaskan ecosystems is provided in Aydin et al (in press). Fisheries act as significant energy sinks throughout the food web in all three systems, but that the largest withdrawal of energy proportionally was in the AI during the early 1990s. In each ecosystem, fisheries "reach" all the way to primary producers, with an estimated range of 3.5% (GOA) to 16% (AI) of phytoplankton group production exiting the system via fisheries. In theory, a threshold level for fishery energy withdrawals could be established in an attempt to redirect energy to non-fishery apex predators. However, as noted before, the actual recipients of the redirected energy may not be the intended ones.

Data gaps / research needed

Directed studies at local spatial scales throughout all seasons are most likely to elucidate how fisheries interact with apex predators to shape ecosystem processes from the top down. Funding initiatives are being considered within NOAA that may provide a useful framework for investigating these interactions further. In addition, coordinated monitoring of production indices for apex predators such as birds, marine mammals and elasmobranchs would both provide insight into how these groups interact with fisheries in the ecosystem and also potentially provide integrated indicators of ecosystem productivity.

4.4 Fishing Effects Interactions

Fishing activities comprise some of the largest sources of human influence on the AI ecosystem. They are the basis not only for a thriving industry within the region, but also fill an important nutritional and cultural role in AI communities. Fishing activities have the potential to change the AI ecosystem very quickly through directed harvest and bycatch mortality, gear induced changes to habitat, and interactions with other resource users. Because of the economic and social importance of fisheries and the potential negative impact that unchecked fishing activities may have on the ecosystem, fishing effects interactions are relatively well studied and numerous fishery management programs have been developed to achieve a range of biological, economic and social objectives within AI fisheries. Despite the importance of fisheries in the AI ecosystem and attention that has been focused on them, data gaps still exist, particularly in the areas of stock structure, food web relationships and habitat usage. This FEP addresses the impacts of six fishing effects interactions including total removals, spatial components of stock structure, habitat, bycatch and subsistence.

H. Total removals from the ecosystem due to fishing impact ecosystem productivity

Large total removals of biomass, including both fish and non-groundfish species, from fishing can potentially diminish the productivity of major portions of the ecosystem due to reduced stock sizes. The total BSAI removals are considered to be well managed under the existing 2 million metric ton cap, but this cap is not apportioned between the BS and AI management regions. Twelve of the 18 managed species or species groups do not have their catches apportioned between the AI and BS, and some of the remainder (Greenland turbot, POP, other rockfish, and Atka mackerel) have AI-specific TAC levels which limit retained catch; however, bycatch may occur beyond the TAC level up to the BSAI OFL limit. In addition, there is greater uncertainty associated with the levels of removals of many non-target species (some of which are not subject to any monitoring) relative to target species, contributing uncertainty to the level of total removals. Although the interactions of marine food webs are not fully understood, if the AI ecosystem represents a distinct system then a disproportionate share of the total BSAI harvest within the AI system may impact system productivity.

There is no cap on total crab removals in the AI subarea. Crab TACs are set individually on the basis of both area and species and where a species is present in both the BS and AI, the TACs are established independently. Because of this, the risk of disproportionately harvesting AI crab stocks due to high abundance outside the AI does not exist, however the ecological impacts of large removals of crab biomass remains an important consideration.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – high, Economic impact – high
Geographic scale – regional, Time scale – long-term

Probability: Fishing removals from the ecosystem occur and total removals are considered to be well managed under the current system in an effort to ensure ecosystem productivity. For groundfish removals, however, the Council/NMFS limits total removals from the BSAI as a whole and not specifically from the AI subarea. Although many species have AI-specific TACs, not all do, so there is a potential that total removals from the AI ecosystem may fluctuate. Crab TACs are AI-specific and not subject to impact from harvest occurring outside the AI subarea.

Ecological impact: The interactions of marine food webs are not fully understood, so if total removals in the Aleutian Islands ecosystem increased substantially there could potentially be increased uncertainty about impacts. Also, impacts could potentially be high if total fishery removals occurred in localized areas. There is much greater uncertainty associated with the levels of removals of many non-target species (some of which are not subject to any monitoring) relative to target species, contributing uncertainty to the level of total removals.

Economic impact: In the short term, increasing total removals will be economically beneficial, as more product is made available for sale. However, to the extent that total removals diminish the productivity of the remaining biomass, the longer term impact will be negative.

Geographic scale: Local to regional.

Time scale: Annual to decadal.

Implications for management

The Council currently evaluates only a BSAI-wide cap on total groundfish harvest, and has not considered the need for a groundfish cap specific to the Aleutian Islands. In essence, the establishment of an AI groundfish cap represents an overarching management measure that reflects the evaluation that the Aleutian Islands management area represents system substantially distinct from the EBS system, and thus integrates the numerous biological and physical indicators in this Fishery Ecosystem Plan which aim to illuminate the degree of distinctness between the AI and the EBS. For future research, the Council could evaluate these indicators, particularly in regard to genetic flow and trophic linkages, and the need to establish an AI-specific groundfish cap would likely follow from this evaluation.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
Total groundfish catch in AI and total biomass in EBS/AI – use catch relative to biomass, or catch relative to consumption? – use single species catch/biomass by trophic level	Total crab, halibut catch in AI AI-specific total biomass	Looking for exploitation rate for the ecosystem, maybe catch relative to an ecosystem process would be more relevant; where are the fisheries relative to consumption in the ecosystem?
Trophic level of catch in EBS/AI	AI-specific trophic level of catch	
		food web diversity indices

Data gaps / research needed

The effect of AI total removals upon the fish community depends upon the extent to which the AI ecosystem is distinct from the EBS system. Thus, information on the movement patterns of key fish species (see Interaction I) and linkages between food webs between the AI and EBS systems remain areas for needed research.

I. Differences between spatial stock structure and the spatial scale of fishery management may impact managed species

Fishery management measures are applied to a unit stock, typically defined as a group within a specified spatial area that behaves as a single, cohesive population. For several stocks within the BSAI area, such as Pacific cod, Atka mackerel, walleye pollock, and various rockfish species, genetic patterns, tagging, recruitment patterns, and other types of data have been used to assess the extent to which the AI portion of the population represents a distinct stock separate from the EBS population. In addition, it is also important to assess whether AI and Russian populations represent distinct stocks, as has been suggested by some recent genetic data for halibut and Pacific cod.

A mismatch between the spatial scale of fishery management and the spatial scale of the biological stock can affect fishery management in two ways. First, if the spatial scale used for management is smaller than the spatial scale of the biological population, then management measures would divide a single biological stock into multiple management areas with multiple smaller area-specific harvest quotas, potentially forcing an inefficient and unduly conservative allocation of harvest. Alternatively, if the spatial scale used for management is larger than the spatial scale of the biological population, then multiple stocks would occur within the management area and any single stock may be impacted by disproportionate fishing mortality. Thus, for any given species, a critical question is determining whether the stock is best described as a BSAI-wide stock or an AI stock, and assessing the impact of errors in this definition of stock spatial scale. Perhaps more problematic is the finding of single stock spanning US and Russian waters, as the harvest in Russian waters is outside the control of the FMP.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – high, Economic impact –high
Geographic scale – regional, Time scale – long-term

Probability: The probability that fishery management measures are applied at inappropriate scale, relative to the biological stock, varies by stock. Stocks with extensive movement either from adults or juveniles may show strong linkages between the areas, whereas stock with limited movement may show strong separation between the areas. Averaging over many stocks produces results in a probability rating of medium, although there could be substantial variation between stocks.

Ecological impact: If the spatial management area is too large, the potential impact could be localized overfishing and the loss of productivity and potentially genetic diversity from important local populations; thus, the ecological impact is rated as high.

Economic impact: If the spatial management areas are too small, the potential impact could be unnecessarily small harvest quotas which could impact fisheries from either forcing inefficient harvesting (i.e., higher travel costs) or through more restrictive, area-specific bycatch limits; thus, the economic impact is rated as high.

Geographic scale: Local to regional.

Time scale: Annual to decadal. Potential economic impacts may occur on relatively short time scales, whereas the time scale for ecological impacts may occur at longer time scales depending upon the intensity of localized harvesting and the degree of linkage between local populations.

Implications for management

The Council is currently evaluating spatial management measures based upon the available tagging data, genetic data, age and length composition data, and other data indicating separation of stocks between areas. However, some data types do not exist for some species; for example, rockfish are very difficult to successfully tag. In addition, dispersal between areas may occur in early life-history stages (which would not be revealed by tagging data), and this dispersal would be produced by the ocean currents within the BSAI area. For future research, the Council could encourage research studies that 1) obtain biological data that may reveal separation of stocks between areas (tagging, genetics); 2) examine the early life-history of stocks and the ocean currents in the BSAI region, and the interaction between two items; and 3) use simulation studies to evaluate the biological impact of various spatial management measures. To the extent practicable, data would be also be collected in Russian waters, as stocks may span international boundaries.

Indicators

Indicators from SAFE chapters	Indicators not in chapter for which data is available	Indicators for which data not available
Tagging studies – information exists only for a limited number of species (P cod and Atka mackerel Genetic data Age, length and frequency data – can give indication of separate recruitment patterns Ocean currents, and early life-history information for stock with pelagic larval stages		Would like tagging information for other species, such as pollock and rockfish. Also, we would ideally have to know what degree of linkage between areas is enough to warrant separate management areas (this applies to the other types of information as well)

Data gaps / research needed

A data gap exists in our knowledge of extent of spatial dispersal for many stocks, as tagging studies are problematic for several species groups such as pollock and rockfish. In addition, dispersal may occur during the early life stages for stocks with pelagic larvae, and knowledge regarding the reproductive biology, larval distributions, and larval drift patterns is limited for rockfish. Finally, the process of defining appropriate management areas from information on stock structure is not straightforward and could benefit from modeling studies addressing the level of conservation obtained from various management options.

J. Impact of one fishery on another through fishing impacts on habitat

One process by which fisheries may interact is through the mechanical effects of fishing gear on habitat, or the disturbance and/or destruction of essential fish habitat. Of particular concern are fisheries that disturb spawning habitat, nursery or rearing areas, or juvenile habitat of other fished species, although the effects of this disturbance on those species may be uncertain or undocumented.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – medium, Economic impact – medium
Geographic scale – regional (AI) & local, Time scale – greater than 10 years

Probability: Bottom trawl, longline, and pot fisheries have the potential to detrimentally affect habitat. The bottom trawl fishery is now constrained to historic fishing areas in the Aleutian Islands with the implementation of the Aleutian Islands Habitat Conservation Area in 2006. Approximately 60% of the fishable depths (less than 1000m) are closed to bottom trawling or some bottom-tending gears. Known sensitive areas such as deep coral gardens have been closed to all bottom-contact fishing gear.

Longline & bottom trawl effort has been generally steady or declining since the early 1990s (Coon 2006a,b). The number of vessels participating in fisheries has declined since 1994. This trend in declining participants and effort, when coupled with area closures and the bathymetric features of the Aleutian Islands, results in a probability of “medium”.

Ecological impact: The bathymetric features of the Aleutian Islands limits the amount of area that can be impacted by mobile fishing gear such as bottom trawling at the current level of technology. The footprint of the trawl fishery will not expand after 2006. The majority of bottom trawl tows occur between 50-150m, and the highest coral densities are distributed between 200-300m (Stone 2006), so while bottom trawl gear is presumed to have the greatest effect on living substrate, trawling intensity is not highest where coral densities are greatest. Golden king crab fishing (longline pots) and sablefish/turbot fishing (hook and line/pot) also have the potential to continue disturbing sensitive coral & sponge habitat, but the footprint of these fisheries is relatively small.

Economic impact: Long-term economic effects may be apparent if fishing damage limits available habitat for fish at all life stages, but the effects are uncertain. Corals and sponges may live for hundreds of years (Stone 2006) and are sensitive to fishery effects. 85% of the economically important fish and crab species observed on transects, and 97% of juvenile rockfish observed on transects were associated with corals and other structure-forming habitats.

Geographic scale: Fishing effects occur throughout the AI region but tend to occur in localized areas.

Time scale: Effects are long term, as bottom habitat will likely recover on at least a decadal scale.

Implications for management

Fishing operations in the Aleutian Islands (trawl, longline, pot gears) could change the abundance or availability of certain habitat features (e.g. prey availability or the presence of living or non-living habitat structure) used by managed fish species to accomplish spawning, breeding, feeding, and growth to maturity. These changes can reduce or alter the abundance or productivity of that species, which in turn can affect the species’ ability to “support a sustainable fishery and the managed species’ contribution to a healthy ecosystem,” (50 CFR 600.10). The outcome of this chain of effects depends on characteristics of the fishing activities, the habitat, fish use of the habitat, and fish population dynamics (NMFS 2005: Appendix C).

What is the risk?

An example of the risks of fishing impacts on habitat has recently focused on the conservation of coldwater corals and associated communities. In the Aleutians, corals and sponges, some species of which are believed to live hundreds if not thousands of years, form large ‘groves,’ which are sensitive to human-induced and natural change (Heifetz et al. 2005). These corals and sponges provide important habitat and refuge for a variety of commercially important fish and invertebrates. It has been suggested that corals and sponges may be ‘keystone species’ that by their presence determine benthic fish and invertebrate diversity and abundance (Heifetz et al. 2005).

In the first *in situ* exploration of Aleutian Islands coral habitat, 85% of the economically important fish and crab species observed on transects, and 97% of juvenile rockfish observed on transects were associated with corals and other structure-forming habitats. Corals were observed on 100% of surveyed transects (Stone 2006).

Disturbance to the seafloor from bottom-contact fishing gear was evident on 22 of 25 (88%) transects. Damage associated with bottom trawls was observed at 7 of 25 survey sites while longline impacts were seen at 20 of 25 sites. Approximately 8.5% of all corals on the transects had been damaged to some extent. Plumarella sp., a fanlike colonial coral, was the most frequently observed coral species, representing almost 39% of total observations (Stone 2006).

How is the Council addressing the risk right now?

The Essential Fish Habitat Environmental Impact Statement (EFH EIS) completed in 2005 addressed many of these concerns. EFH regulations (50 CFR 610.815(a)(2)(1) state that each Fishery Management Plan must contain an evaluation of the potential adverse effects of all regulated fishing activities on EFH. As part of this process, a fishery effects model was developed. The Long-term Effect Index (LEI) created an estimate of the proportional reduction in a habitat feature, relative to an unfished state, if a fishery were continued at current intensity and distribution to equilibrium (effects neither increase nor decrease if continued longer).

The LEI model found that none of the fishing activity in the Aleutian Islands is adversely affecting EFH in a manner that is more than minimal and not temporary in nature (NMFS 2005). As part of a suite of precautionary measures enacted in 2006, the Council implemented the Aleutians Islands Habitat Conservation Area in 2006, which froze the footprint of the bottom trawl fishery and closed approximately 60% of the fishable depths in the AI to bottom trawling. Several coral garden sites, Bowers Ridge, and seamounts were also protected from various gear types.

What would be ways to consider any risk identified, and mitigate this risk?

Initial steps have been taken by the Council. Further research and baseline studies are needed to identify bathymetric features, distribution and abundance of living substrate, and effects of fishing on EFH.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
Bottom trawling effort in AI Longline effort in AI	Pot effort in the AI (crab and groundfish)	Habitat diversity - need to know spatial distribution of benthic habitats
Living substrate bycatch in EBS/AI groundfish fisheries		Total area swept, and number of sets, by gear type, over particular habitat type
Living substrate bycatch in the AI bottom trawl survey		Fishing impact rates, recovery rates, frequency of occurrence for living substrates

Data gaps / research needed

Distribution of substrate and habitat type is unknown. The current proxy for habitat type is the AFSC survey depth strata. No actual data exists on relative proportions of habitat types or abundance of habitat-forming living substrate other than relatively few submersible surveys.

The "Coral" category in the observer program database is a conglomeration of hard and soft corals and bryozoans. Better identification of these species would enhance general knowledge of distribution and relative abundance in the Aleutian Islands.

Survey tow locations are limited in the AI due to survey net design and rocky, hard substrates.

Of the AFSC research projects focusing on the effects of fishing on seafloor habitat, only 4 of 31 focus on the Aleutian Islands. This could be due to both the remote location as well as the relative importance of the AI in relation to the BS and GOA. Additional baseline studies in the AI would be beneficial.

K. Impact of a fishery on other biota through fishing impacts on habitat

Fisheries interact with other biota (non-managed species) through gear effects on living substrate, catch and discards of forage, non-target, and miscellaneous species. The effect of these removals is unknown.

Catch of other biota in the groundfish fisheries is tracked in the annual Ecosystem Considerations report, by groups. The non-target species group is composed of forage species, living substrates, non-specified species, and other species. The forage species is composed of groups including gunnels, lanternfish, sandfish, sandlance, smelts, stichaeids, and euphausiids. HAPC biota includes living substrates and organisms such as corals, sponges, sea pens, and sea whips. Miscellaneous species group includes echinoderms, jellyfish, eelpouts, & poachers, among others.

The Pacific cod, Atka mackerel, rockfish, sablefish, halibut and crab fisheries all have varying levels of bycatch of HAPC biota. The bycatch levels of seapens and whips are thought to be low in these fisheries, and the sponge and coral catches are variable. It has been suggested that corals and sponges may be 'keystone species' that by their presence determine benthic fish and invertebrate diversity and abundance (Heifetz et al. 2005). Although the bycatch of corals and sponges in the individual Pacific cod, Atka mackerel and rockfish fisheries is variable, combined, these fisheries account for nearly the total amount of Aleutian Islands coral and sponge catches.

Risk assessment

Summary Ratings: Probability – unknown, Ecosystem impact – unknown, Economic impact – low Geographic scale – regional, Time scale – unknown

Probability: Catch and discards of non-target species (forage, HAPC biota, and non-specified groups) have been roughly stable or declined in the AI since the late 1990s, with the lowest values recorded in 2005. Non-target catch is primarily comprised of non-specified groups, mainly jellyfish, sea stars, grenadiers, and other fish. The AFSC survey is not designed to sample many of the non-target species. While they are occasionally caught in the NMFS trawl surveys, that catch may not represent true population trends.

Ecological impact: The ecological effect of fisheries on "other biota" is largely unknown. A few trends are discernable, however. Sponge catch has been quite high and remarkably stable, as has the frequency of occurrence. Catch rates and frequency of occurrence of Gorgonian corals have decreased since 1994, while stony corals have increased during the same period (Martin 2006a). Echinoderm mean catch rates increased rapidly between 1990 and 1997 and remains consistently high. Jellyfish patterns in terms of both mean catch rate and frequency of occurrence is also consistent across the AI (Martin 2006b). The 2006 bottom trawl survey showed the highest level of jellyfish catch rate for all surveys, with particularly large increase in the Eastern AI. The meaning of these trends is unknown.

Economic impact: Unknown, but direct economic impact is probably minimal as there is no fishery or market for "other biota". The role of these organisms in the ecosystem is largely unknown, however. If some component of the "other biota" groups was classified as a prohibited species or plays an important unknown role in the ecosystem, there could be an economic effect.

Geographic scale: Regional, throughout the Aleutian Islands

Time scale: Unknown

Implications for management

Fishing operations in the Aleutian Islands (trawl, longline, pot gears) could change the abundance or availability of certain habitat features (e.g. prey availability or the presence of living or non-living habitat structure) used by "other biota". These changes can reduce or alter the abundance or productivity of that species, as well as those species' contribution to a healthy ecosystem. The outcome of this chain of effects depends on characteristics of the fishing activities, the habitat, fish use of the habitat, and fish population dynamics (NMFS 2005: Appendix C). The overall effect on "other biota" by fishing activities is unknown.

What is the risk?

Role of "other biota" in the ecosystem is largely unknown. Most of these species are benthic organisms, and there is evidence that bottom-contact fishing gear causes disturbance to the seafloor (see discussion under Interaction J; Stone 2006).

How is the Council addressing the risk right now?

The EFH EIS completed in 2005 (NMFS 2005) included an analysis of the effects of fishing on infaunal prey, epifaunal prey, living structure, and hard corals. As part of a suite of precautionary measures enacted in 2006, the Council implemented the Aleutians Islands Habitat Conservation Area, which froze the footprint of the bottom trawl fishery and closed approximately 60% of the fishable depths in the AI to bottom trawling. Several coral garden sites, Bowers Ridge, and seamounts were also protected.

<u>What would be ways to consider any risk identified, and mitigate this risk?</u>

In the short term, the Council has taken positive steps through the extensive closure areas in the Aleutians. The Council might encourage further research to understand the role of these biota in the ecosystem, and the impact of fishing.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
Bottom trawling effort in AI Longline effort in AI	Pot effort in the AI (crab and groundfish)	Habitat diversity - need to know spatial distribution of benthic habitats
Living substrate bycatch in EBS/AI groundfish fisheries		Total area swept, and number of sets, by gear type, over particular habitat type
Living substrate bycatch in the AI bottom trawl survey		Fishing impact rates, recovery rates, frequency of occurrence for living substrates

Data gaps / research needed

Surveys do not sample "other biota" well. Survey gear also has limitations over rough or hard bottom. Also, the role of these species in the ecosystem is largely unknown.

L. Impact of bycatch on fisheries

Bycatch issues in the Aleutian Islands fisheries (including regulatory discards, economic discards, PSC, non-target species, non-specified species, marine mammals, and seabirds) are discussed in detail in Section 3.5.

Regulatory discards are considered to be relatively well managed within the current inseason management system. However, in some cases, maximum retainable amounts may not be a deterrent to bycatch, rather, they are treated as de facto quota or allocation as in the case of "topping off" behavior. Trends in economic discards are sometimes linked to recruitment trends. That is, small fish or crab from good year classes may contribute to increased levels of economic discards in some years and areas.

Prohibited species catches (PSC) in the BSAI groundfish fisheries (halibut, Chinook salmon, non-Chinook salmon, herring, red king crab, snow crab (*Chionoecetes opilio*), and Tanner crab (*C. bairdi*) are heavily monitored and most of the bycatch occurs in the Bering Sea fisheries. However, PSC limits are set for the Bering Sea-Aleutian Islands area and there are no Aleutian Islands area specific limits. PSC limits are arguably the most closely monitored aspect of this interaction and their implications often have the greatest direct impact on fishing industry.

The halibut fishery does not have an observer program to monitor bycatch. Although mandatory retention requirements exist for incidental catch of rockfish and Pacific cod, the level of compliance is unknown. Therefore, the uncertainty concerning the level of bycatch of some groundfish species, such as Pacific cod is a concern.

Skates and sharks have been identified as sensitive non-target species and are currently managed as part of the "Other species" category within the BSAI. A proposed FMP amendment to split the Other Species complex into groups that can be managed separately has not been implemented. However, the alternatives in the proposed amendment do not include Aleutian Island area specific break outs. Most of the skate bycatch in the Aleutians is in the hook and line fishery for Pacific cod followed by the halibut fishery.

There are currently no directed commercial fisheries for shark species in federal or state managed waters of the BSAI, and most incidentally captured sharks are not retained. Shark catches in the Aleutian Islands fisheries are very low. At present the NMFS Observer Program does not measure the lengths of sharks, and many sharks (22%) are not identified to species.

Two other notable groups caught as bycatch in Aleutian Island fisheries are sculpins and grenadiers. Sculpins are managed as part of the BSAI Other Species Complex, and sculpins along with skates constitute the bulk of the BSAI Other Species catches. Grenadiers are a non-specified species, the majority of which are caught in the sablefish and Greenland turbot longline fisheries. As such, no official catch statistics exist for grenadiers in Alaska and there are no limitations on catch or retention, no reporting requirements, and no official tracking of grenadier catch by management. Nearly all catch has been taken as bycatch and discarded. Discard mortality is assumed to be 100%.

The bycatch monitoring program for the groundfish fisheries currently consists of extensive self reporting requirements and an observer program designed to quantify total catch, including incidental catch of non-fish species such as seabirds and marine mammals. An increasing level of precision and accuracy is needed to estimate the rate of serious injury and mortality to marine mammals. Determination of appropriate observer coverage levels to meet the needs of accuracy and precision is currently the subject of serious interest. The Council should be aware that killer whales and humpback whales have levels of mortality which may cause some federally-managed commercial fisheries to change categories in the list of fisheries (Sinclair et al. 2006).

Seabird bycatch interactions occur in the AI longline fisheries for Pacific cod, Greenland turbot and halibut, trawl fisheries, and to a very limited extent in pot fisheries. Seabird bycatch is generally highest in the Bering Sea, lowest in the GOA, with the AI being intermediate. Significant effort has been directed towards research and experimentation with gear configuration and deployment modifications to avoid gear interactions with seabirds.

Discards and offal are used heavily by many seabirds in the North Pacific. Birds are attendant around catcher/processors and can reach high numbers. The importance of this food source is unknown, as is the risk posed to seabirds from direct mortalities when they are drawn to fishing vessels. Further, there have been very large changes from year to year in the availability of discards and offal as a result of changes to fishery management regulations. Another source of mortality for seabirds on trawl vessels are the trawl door cables (warps) and the cable that runs between the net monitoring device and the vessel (trawl sonar cable or third wire). Currently, there is only one limited program to salvage seabird carcasses recovered during commercial fishing operations. These carcasses represent valuable scientific specimens that could increase the knowledge of trophic level feeding habits, molt patterns, genetic differences between colonies, and other important questions, but also as a means to gain a better understanding of the causes of bycatch in fisheries (Fitzgerald et al. 2006).

Risk assessment

Summary Ratings: Probability – high, Ecosystem impact – medium, Economic impact – medium, Geographic scale – regional, Time scale – annual to long-term

Probability: Management measures are in place to limit fishery bycatch impacts (prohibited species catch limits, required gear modifications, MRAs). Still, incidental species continue to be caught and often discarded in target fisheries.

Ecological impact: Management measures limit the overall bycatch of any species on which there is a directed fishery. Where bycatch mortality is unaccounted for, ecological impacts may occur. Impacts can range from low to high depending on the species, amount of catch, and the species' ecological connections.

Economic impact: Bycatch of some species could impact the ability to harvest other more abundant target fisheries. Bycatch of prohibited species often has the greatest direct impacts on fisheries. Economic impacts could range from low to high depending on the bycatch species and the target fishery being impacted.

Geographic scale: Local to regional. Overriding scale is probably regional given that most management measures are for the BSAI.

Time scale: The effects are long- or short-term depending on the lifespan of the bycatch species, and the nature of the economic impacts.

Implications for management

The bycatch problem is complex, in part, because an action that is taken to reduce the bycatch of one species can increase that of another, or an action that is taken to decrease one type of bycatch mortality can increase another type. It is a contentious issue, and actions to reduce bycatch mortality typically change the distribution of the net benefits from the fisheries. Bycatch mortality can decrease the sustainability of fisheries and the net benefits provided by the fisheries in several ways. First, if bycatch mortality is not monitored adequately, it increases the uncertainty concerning total fishing-related mortality, which in turn makes it more difficult to assess the status of stocks to (1) set the appropriate harvest and overfishing levels and (2) ensure that the harvest levels are attained and that overfishing does not occur. Second, if discards are sufficiently concentrated in time and space, they may result in localized environmental degradation. Third, bycatch mortality precludes some other uses of fishery resources. For example, juvenile fish that are subject to bycatch mortality cannot contribute to the growth of that stock and to future catch. Bycatch is a wasteful use of living marine resources if it precludes a higher valued use of those resources.

What is the risk?

The risk of not appropriately monitoring (or considering) bycatch interactions is an unintended level of fishing mortality and the risk of overfishing, or in the case of marine mammals, the risk of exceeding potential biological removals. The ecological impacts of bycatch interactions can be far reaching depending on the species' life history, connections between species, and the strength of these connections. The economic impacts can be great as well, as bycatch closures may require a fishery to leave valuable commercial species unharvested.

How is the Council addressing the risk right now?

The Fisheries Observer program in the North Pacific is the most developed and comprehensive observer program in the world. Data from the observer program is critical to understanding and quantifying bycatch in North Pacific fisheries, including those in the Aleutian Islands. Because of this program, the Council has excellent bycatch data compared to most other marine fisheries and this data is integrated into fisheries management models.

The Council has taken a variety of actions to address the issue of bycatch. The actions have included research to develop better methods for monitoring and reducing bycatch, outreach programs to explain the bycatch problem and search for solutions, and regulatory actions to monitor and decrease bycatch. Allowinf fishery participants to trade bycatch allowances would allow bycatch to go to its highest valued use. The Alaska Region Current Bycatch Priorities and Implementation Plan lists several explicit objectives to satisfy statutory obligations to monitor and reduce bycatch (http://www.nmfs.noaa.gov/by_catch/AKRfinal_bycatchplan.pdf). To meet these objectives, the Council works cooperatively with NMFS, ADF&G, the IPHC, other international fishery management or scientific organizations, the fishing industry, the environmental community, university or private sector researchers, and other stakeholders. Current action items and recent progress updates of activities listed in the plan can be found at: http://www.nmfs.noaa.gov/by_catch/Alaska%20Region%2007-08.pdf.

What would be ways to consider any risk identified, and mitigate this risk?

Improved accuracy in identification of bycatch species and quantification of removals are of utmost importance. Aleutian Islands area specific information and regulations will serve to mitigate risks. Finer scale spatial and temporal catch information could alert the Council to areas of concern with high concentrations of bycatch in time and space and emerging bycatch issues. Also, the implementation of direct observation and other monitoring options (e.g. electronic logbooks, video monitoring) on smaller groundfish vessels and halibut vessels, continued cooperative research, outreach efforts, application of gear and deployment modifications, improved or implementation of monitoring of non-target species, and stock assessment research for non-target species (i.e., life history, abundance, and assessment information) all serve to mitigate the risks identified in bycatch interactions.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
Time trends in bycatch of groundfish discards – need AI-specific data and information by species for key species Time trends in bycatch of non-target species catch – indicator is for BSAI, and large groups (non-specified, HAPC biota, forage fish). Need AI-specific data and information by species for key species within these groups Time trends in bycatch of PSC – indicator is for all Alaska, need AI-specific data Trends in groundfish (target and non-target species) catches from NMFS bottom trawl survey: anomalous catches, presence/ absence, frequency of occurrence in tows – cross-reference with fishery observer data Marine mammals – Status and trends – Direct take/fishery interactions Seabirds – Trends in abundance and productivity – Fisheries bycatch		Finer scale spatial and temporal information on all bycatch trends (groundfish, non-target species, prohibited species)

Data gaps / research needed

In general, improved accuracy in identification of bycatch species and quantification of removals will continue to be important issues. Improved spatial and temporal information on catches could alert the Council areas of concern with high concentrations of bycatch in time and space and emerging bycatch issues. Also, the implementation of direct observation and other monitoring options (e.g. electronic logbooks, video monitoring) on smaller groundfish vessels and halibut vessels, continued cooperative research, outreach efforts, application of gear and deployment modifications, improved or implementation of monitoring of non-target species, and stock assessment research for non-target species (i.e., life history, abundance, and assessment information) are important ongoing issues for the Council.

M. Commercial fisheries may impact subsistence uses

Subsistence harvests in the Aleutian Islands fishery ecosystem include fish, shellfish, birds and mammals (both marine and terrestrial). These activities in the AI are very important to the participants, providing both nutritional and cultural sustenance. Harvest levels involve much lower quantities compared to the overall commercial harvest. For example, subsistence harvest of halibut in the Western Aleutians accounts for just 1% of the statewide subsistence harvest, which itself is just 1.5% of overall statewide removals (which also include commercial harvest, bycatch, sport fisheries, and wastage) (Fall et al. 2006). The notable interactions through which large-scale commercial harvests may affect subsistence are 1) between subsistence and commercial uses of the same fishery resource, 2) between commercial and subsistence uses of different fishery resources (i.e., interacting through bycatch, habitat, or predator/prey dynamics) and 3) between commercial fisheries and marine mammals.

The interaction is not always negative for subsistence harvesters. Small-scale commercial fisheries in which local residents participate, such as the halibut fishery, can interact synergistically with subsistence activities by providing vessels that are also used for subsistence fishing and earnings which may be spent on support (such as fuel, harvest equipment, processing and storage equipment) for subsistence pursuits. In general, a depression of locally-based commercial fishing activities can alter subsistence practices to favor those harvests which require fewer inputs (such as shellfish collecting) over those which require greater inputs.

Subsistence harvesting in Atka has been affected by commercial fisheries. Halibut has been harder to catch since commercial fishing for species began in the area (Dirks in Ross Oliver 1988: xv), and marine mammal harvests have been affected by sea lion population declines. Changes in subsistence patterns and the potential for increased interaction with commercial fisheries may occur if the community of Adak expands.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – low, Economic impact – medium
Geographic scale – local, Time scale – 1 to 5 years

Probability: The probability of commercial harvests impacting subsistence harvests in the Aleutians ecosystem is medium. The high reliance on marine mammals in the community of Atka is one important potential source for this interaction to have impacts.

Ecological impact: Subsistence uses may be impacted through increased or decreased prey species abundance via direct or indirect interactions. While these ecological changes are likely to be very important to local subsistence users and might affect local species compositions, they are not likely to have a large impact on the overall ecosystem. Species harvested in Atka for subsistence that are also targets of commercial fisheries include: all 5 species of Pacific salmon, Pacific cod, unspecified flounder, greenling, Atka mackerel, rockfish, sablefish, king crab, and tanner crab. Other potentially affected subsistence resources include non-commercial species of fish such as sculpin, char, and rainbow trout, many species of non-commercial shellfish species, and a variety of sea birds.

Economic impact: While the subsistence harvest volume compared to commercial catch is low, the economic importance to those families dependent on subsistence resources is high. The total population of Atka and Adak is a little over 400 people. Consequences of impacts to households in the Aleutians would be distributed differently between the two communities, with Atka currently at much greater risk from impacts. Total per capita annual consumption of subsistence fish and mammals is high in Atka. Residents harvest about 440 lbs per capita annually in Atka with 100 percent of households participating. Reliance on marine mammals is high in Atka, with 51 sea lions and 74 harbor seals harvested in 2004, compared to just 2 sea lions and 0 harbor seals in Adak.

Geographic scale: Subsistence is engaged in by local community members in local places close to Adak and Atka. Some subsistence harvesting takes place farther away in conjunction with commercial harvests (e.g., halibut).

Time scale: Short term to long term.

Implications for management

NMFS and the Council have governed the harvest of subsistence halibut since 2003 through the Subsistence Halibut Program. The program includes the Subsistence Halibut Registration Certificate (SHARC), gear restrictions, and daily bag limits. The Office of Subsistence Management manages subsistence harvesting on federal lands and the Alaska Department of Fish and Game manages subsistence on state lands. The federal government had previously delegated subsistence management on federal lands to the state until a disagreement over rural preferences was determined to be unresolvable and the delegation of management authority was revoked. The resulting patchwork of jurisdictions and regulations has made the situation for subsistence practitioners somewhat confusing.

The State of Alaska has adopted a policy that elevates subsistence uses and concerns over other types of harvesting (commercial, recreational, personal use). Known as the “subsistence priority,” this policy ensures that conservation measures will be enacted on other sectors before they are permitted to affect subsistence harvests. The federal government has no such specifically articulated policy. Subsistence users have had some concerns over federal fishery impacts on subsistence such as through impacts on Steller sea lions (in the AI ecosystem), through salmon bycatch (in the Bering Sea), and through bottom-trawl gear impacts (in many places). Subsistence is a topic where environmental justice concerns over disproportionate impacts on Alaska Natives and low income residents are often raised.

The federal government does assign a preference among subsistence users to those living in rural communities, such as Atka. Adak, long-considered a non-rural community due to its large military population, was recently reclassified as rural. Only rural residents and Alaska Natives are eligible for SHARC cards. Also relevant to subsistence is the federal law under the Endangered Species Act that exempts Alaska Natives engaged in subsistence from the take provisions of the Act. Thus, recovery plans for the Steller sea lion have been designed to accommodate an estimated level of Native subsistence take.

What is the risk?

According to Atkans (Dirks in Ross Oliver 1988), subsistence halibut harvests have already been affected by commercial fisheries. Other effects, such as those mediated by bottom habitat alteration, have already been absorbed into the system. The current risk is that commercial fishing practices are going to further adversely affect subsistence harvesting either through cumulative effects, changes in fishing practices, or changes in ecosystem structure.

How is the Council addressing the risk right now?

The Council hears an annual report on halibut subsistence prepared by the Alaska Office of Subsistence Management. Subsistence uses and concerns relating to Council management actions are described in NEPA analyses.

What would be ways to consider any risk identified, and mitigate this risk?

Species harvested in both subsistence and commercial fisheries should be monitored for direct interactions. Other species with indirect interactions with commercial fisheries should also be identified and monitored. Local and traditional knowledge should be developed in conjunction with ecosystem residents to understand and perhaps attempt to quantify how commercial fisheries have already affected subsistence harvesting and what effects are currently of concern and what could be of concern in the future. Subsistence harvests could be estimated and incorporated into TAC allocations as appropriate. Interactions between species could be considered when adopting regulations. Some Native advocates have proposed creating marine heritage zones around villages and important subsistence sites to help protect key resources.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
	ADF&G household multispecies subsistence harvests in the fishery ecosystem for Atka (not available for Adak)	Houshold multispecies subsistence harvest survey for Adak Annual surveys for both Atka and Adak
	ADF&G household halibut harvests in the fishery ecosystem for Adak and Atka (annual SHARC reports)	Local and traditional knowledge
	ADF&G household sea lion and harbor seal harvest annual surveys and estimates for Adak and Atka	

Data gaps / research needed

Subsistence research is conducted by the Alaska Department of Fish and Game, including halibut harvests (in partnership with NOAA Fisheries) and sea lion and harbor seal harvests. ADF&G multispecies harvest surveys give the best and most complete indicator of subsistence activities in the communities, but these are conducted only rarely, perhaps once in a decade. The only study in Atka was conducted in 1994, and there is no comprehensive harvest survey for Adak.

Community members that participate in subsistence activities are the most knowledgeable persons about the effects of commercial fishing. Local and traditional knowledge from residents of Atka and Adak should be compiled and evaluated as a very valuable indicator of ecosystem effects on subsistence.

4.5 Regulatory Interactions

Regulations define how the fisheries operate, and consequently how they interact with other components as part of the ecosystem. The main legislation for Federal fisheries is the Magnuson-Stevens Act, which authorizes the Council to make recommendations to the Secretary of Commerce, through the National Marine Fisheries Service, about the management of the fisheries. Regulations affecting the Aleutian Islands fisheries are the result of decisions made by the Council, NMFS, and partners the State of Alaska and the International Pacific Halibut Commission. These agencies are filtering national requirements coming from Congress, through changes to the Magnuson-Stevens Act or other Acts, and from NOAA headquarters.

There are myriad regulatory constructs that shape fishery operations and interactions in the AI ecosystem. The purpose of this section is to highlight some particular regulatory interactions that are important and unusual in the AI. The first looks at the interaction between the ESA and fisheries, and subsequent interactions look at characteristics of the Council's fishery management.

N. Changes in the population status of ESA-listed species impact fisheries through specific regulatory constraint

ESA listed species impact fisheries directly through regulatory constraints which can result in closure of areas to fishing (e.g., Steller sea lion Protection Zones), changes in spatial and temporal fishing patterns (e.g., Atka mackerel regulations for sea lion recovery), harvest level reductions (walleye pollock reductions), modification of gear to avoid take of listed species (e.g., tori lines to reduce take of Short-tailed Albatross), and restrictions or other actions that have economic impacts on fisheries (e.g., restrictions on shore-based support facilities to protect Steller's Eiders or sea otters and their habitats).

The two listed species that have had the greatest impacts on fisheries in the Aleutian Islands Ecosystem Plan area through regulatory restraints in the recent past are Short-tailed Albatross and Steller Sea Lion.

A good example of effective reduction of negative interactions has been the introduction of gear modifications to reduce short-tailed albatross and other seabird incidental catch in the BSAI longline fisheries (Melvin et al. 2001). Nevertheless, an increase in albatross populations as a result of international recovery programs, could increase the potential for interactions and increase the importance of mitigative measures to insure "incidental take" limits are not exceeded (currently 2 short-tailed albatrosses before the fishery is shut down).

Although direct mortality to Steller sea lions from fishing activities appears to be minimal, concern about indirect affects through depletion of prey, at least in local areas, has resulted in modifications to fishing patterns and closure of areas that range from complete exclusion of access to prohibitions on certain types of fishing (e.g., trawling). Changes in sea lion populations could result in modifications to regulations in the future, potentially being more or less restrictive based on whether sea lions are recovering from population declines.

Other listed species in the plan area include several species of whales (see Appendix C), sea otters, Steller's Eider, Kittlitz Murrelet (a candidate for listing), and one plant, Aleutian Shield Fern. These species are not expected to directly interact with fishing, but their welfare will need to be evaluated where support operations might affect them or their habitat. Furthermore changes in their populations might bring different levels of restrictions.

Several other species in the region are on lists of concern and could eventually be listed if populations continue to decline. Marine mammals include: N. fur seal (currently depleted under the Marine Mammal Protection Act), and harbor seal (recent declines and potentially greater protective measures). Marine birds listed on the Audubon Alaska "WatchList" that occur in the plan area are: Emperor Goose, Common Eider, King Eider, Black Scoter, Long-tailed Duck, Red-faced Cormorant, Red-legged Kittiwake, Aleutian Tern, Marbled Murrelet, and Whiskered Auklet.

Two species of ESA-listed salmon (Upper Willamette River Chinook and Lower Columbia River Chinook) also occur in the area, and are taken as bycatch in the pollock trawl fishery, although relatively rarely (NMFS 2006). Since 2000, the pollock fishery in the AI has been constrained due to Steller sea lion protection measures, so fishery interaction with salmon in the Aleutian Islands is minimal. Various western Alaska stocks that have also been identified by the Alaska Board of Fisheries as stocks of concern[8], including Yukon River Chinook and chum salmon, Kuskokwim River Chinook and chum salmon, and Norton Sound Chinook.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – medium, Economic impact – high, Geographic scale – regional, Time scale – decadal

Probability: The highest probability that fisheries will be impacted by the incidental take of a marine bird or a marine mammal is for short-tailed albatrosses. Although mitigation measures in the longline fisheries have been very effective (i.e., no short-tailed albatross have been incidentally caught in the BSAI groundfish fisheries since 1998), there is a continuing cost of mitigation and encounter rates may increase as albatross populations recover.

Steller sea lion mitigation measures have already impacted fisheries, and fisheries have at least a medium probability of being further affected by population changes of sea lions (potentially more restrictive with declines and less restrictive with substantial increases in populations).

Most of the other listed species or species of concern have low probability of directly affecting fisheries currently, but if species like red-legged kittiwake or northern fur seal were listed, there is a potential for higher impacts in the future.

Ecological impact: The full ecological impacts of protective measures for the listed species are not fully understood. Certainly reduction of any mortality for very rare species like Short-tailed Albatrosses contributes to recovery potential, and extinction of any of the species would have, largely unpredictable but potentially serious negative consequences on the ecosystems in the plan area. If protective measures are successful and listed species increase substantially, prey fields will need to be adequate to support larger populations. The closure zones for Steller sea lions have created de facto marine protected areas, but the overall impact on the ecosystem is not clear. Ecosystem cascades have been suggested related to declines in marine mammal populations, and increases in marine mammals may cause substantial changes in species composition

Since all the listed species and species of concern have demonstrated a negative response to ecosystem change, they provide a suite of potentially sensitive indicators of broader ecosystem change.

Economic impact: There continues to be a cost for the effective mitigation for incidental catch of short-tailed albatross and other seabirds, but the potential cost of a fishery shut down due to excessive take would be much greater.

The sea lion mitigation measures have already had significant economic impact on the fisheries, changing spatial and temporal fishing patterns and reducing harvest levels. If Steller sea lions recover, there may also be economic impacts as their prey base becomes limited and affects fishery harvest levels.

Other listed species that might have significant economic impact are Steller’s Eiders, Kittlitz’s Murrelets, and sea otters because they occur nearshore and have to be considered, often at considerable expense, during development of shore based fishery support facilities, and for some nearshore fisheries.

Geographic scale: Bycatch of a short-tailed albatross in any BSAI groundfish fishery has regulatory ramifications for all groundfish fisheries, including those occurring in the Aleutian Islands. If fishery closures occur, then the geographical scope of the impacts may be felt globally due to markets, but certainly will have regional impacts.

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[8] The State of Alaska regulations define a “stock of concern” under the Sustainable Salmon Fisheries Policy (5 AAC 39.222) as “a stock of salmon for which there is a yield, management, or conservation conern”.

Time scale: All of the currently listed species are not likely to be delisted from ESA in the short term and thus this is at least a decadal scale consideration. Impacts on the fisheries and mitigative measures may be in the order of a season to several years.

Implications for management

The Council would benefit from knowing the latest information on population trends for ESA-listed species and other species of concern in the region, so that it can have the maximum lead time to plan appropriately for potential impacts of changes in listings or likely intensified regulations based on changes in status of these species. The Council already is actively involved in responses to listings of short-tailed albatross and Steller sea lions, but it would behoove the Council to keep an eye on the other species discussed here, and consider whether additional actions are needed to respond to future changes in the status of these and other species of concern.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
Seabird bycatch – use to measure ESA bycatch and sightings	Otters surveys in the west – indicator of nearshore predator abundance	Indicator of apex predators (show annual anomalies)
Alaskan sea lion western stock non-pup counts – need specifically for AI subarea – add index for pup counts in AI – SSL mortality by category (fishing, etc.)	List of AI marine seabird species on the Alaska WatchList that interact with the AI fisheries – monitor changes in population of these species	

Data gaps / research needed

One of the largest areas of needed research is in the area of ecosystem process change. The difficulty of understanding the relative impact of fisheries compared to other causes of change in various components of the ecosystem, complicates management of fisheries and conservation of marine ecosystems. Examples of the type of information that could help reduce uncertainly include: research to clarify important links within marine food webs, predictive knowledge of how climate change affects marine communities at different trophic levels, and mapping overlaps in fishing effort and sensitive species.

O. Sector allocations can impact the ecosystem and communities

In this interaction, ‘sector’ is intended to refer broadly to different gear groups, vessel types (catcher vessel or catcher processor), or vessel size groups. Allocations have ecosystem effects because each sector may have different effects on the ecosystem through differing bycatch rates or species selection, or habitat (bottom contact) effects. The Council’s sector allocation decisions may explicitly affect ecosystem structure, at least on a local scale. To some extent, this interaction overlaps with issues discussed in Interactions J, K, and L, above.

Allocations also have social effects through the different types of jobs they create. Some sectors employ a lot of transnational migratory labor; others employ more family-owned fishing vessels (e.g., the halibut fishery). Allocations to the CDQ sector also have a significant social effect in the Bering Sea; only Atka in the AI ecosystem is a CDQ village, but the effect there is also important. When the Council makes a specific allocation to a less competitive gear group (e.g., allocation of AI pollock to vessels under 60 ft length overall, or the allocation of Pacific cod to jig gear), it may fundamentally affect the sustained participation of those vessels in the fisheries. Also, allocations to sectors supporting locally-based fleets and onshore processing affect communities in the ecosystem; the crab allocations to processors were intended to help processors with investments in communities.

Over the course of the Council's thirty year history, most of the Council's fisheries have become constrained by some kind of sector allocation. Sector allocations are a useful tool for addressing overcapacity in the fisheries, which is often a cause of environmental strain on the resource, and presents stability and safety issues for participants. Sector allocations are also used to address issues that fall under the heading of environmental justice. However, sector allocations also affect the level of economic efficiency, and thus the cost and prices of seafood harvests. This can have large implications on net benefits derived from fishery resources. Of the six primary target fisheries in the AI, all are subject to some kind of sector allocation.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – low, Economic impact – high
Geographic scale – local to regional, Time scale – 1-5 years to decadal

Probability: Most of the target fisheries that occur in the AI are already rationalized. The only fishery which is not subject to a direct individual or cooperative allocation is the Pacific cod fishery. There is a sector allocation by gear type in place for the Pacific cod fishery on a BSAI-wide scale, and the Council is currently considering the implications on sectors of splitting the TAC between the Bering Sea and the Aleutian Islands. The Council may also choose at any time to adjust the allocation programs in place for the other fisheries. Consequently the probability of further changes to sector allocations is high for the Pacific cod fishery, but averages to a medium in context with the other AI fisheries.

Ecological impact: The ecological impact of future sector allocations is likely to be low. While changes in the allocations may favor one gear type over another, the allocations are unlikely to be significantly different from current allocations, to a point where they might have an ecosystem-level impact.

Economic impact: The impact of any change to sector allocations is high for the participants. Changes that favor small vessels based out of communities may be disproportionately important to the viability of the community. However, these same changes may also result in increases in the cost of seafood harvesting, and decrease the net benefits derived from ocean resources.

Geographic scale: The geographical scale of ecological impacts is fairly local; fishing grounds that favor a particular gear type may be impacted with an increased allocation to that gear type. The allocations are made at an AI-subarea level, and impacts will be felt by fishery participants, many of whom live both in Alaska and the Pacific Northwest.

Time scale: Changes to sector allocations are generally much debated at the Council, and it is unlikely that any change would be implemented in under a year. Sector allocation changes could occur at any time into the future.

Implications for management

The Council considers the social implications of sector allocations thoroughly in the management process, and frequently allocates quota to a less efficient sector in order to benefit communities. The Council also considers an analysis that looks at the differing ecosystem impacts of the various sectors, with respect to bycatch and habitat. As discussed in the Interactions J, K, and L, above, there is more research needed to fully understand the differing impacts of gear types on the ecosystem.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
	% allocation to sectors by bycatch rates	% allocations to sectors by likelihood of gear type's habitat impact
	% of AI fishery participation connected to AI communities by vessel ownership residency, shoreside deliveries, or other measurable connection	

Data gaps / research needed

Research is needed to fully understand the differing impacts of gear types on habitat. Also, unobserved bycatch mortality by differing gear types is a data gap.

P. Fishery participation permit systems (such as limited entry and harvest quotas) impact the flexibility of fishers to react to changing ecosystem conditions

The Council/NMFS have continuously moved from open access harvest systems towards limiting entry and allocating harvest quotas to sectors, cooperatives, and individuals, in pursuit of conservation, safety, and efficiency goals. While options to allow flexibility have been built in to these programs, many (though certainly not all) can limit one particular aspect of flexibility: the ability of fishers to quickly respond to changing ecosystem conditions by switching areas and target species. Area flexibility depends on the degree to which a management regime is area specific. Many fisheries in the Aleutian Islands are grouped together with Bering Sea fisheries, which are managed separately from Gulf of Alaska fisheries. Thus, in contrast with some cases (salmon fisheries, for example, which are state managed) there is a significant amount of area flexibility in the Aleutians. Flexibility of target species depends on how species are grouped together and how allowable catch is distributed between species in a management plan. Limited entry can also make it more difficult or more expensive for new entrants to fisheries (Carothers 2007, Rosvold 2007).

However, factors other than management strategies, primarily economic, may have a greater impact on flexibility and new entry. The expense to purchase new gear or vessels inhibits entry into other fisheries, even if they are open entry fisheries. Investment behavior, profitability, locus of ownership, and patterns of employment may also affect and be affected by flexibility and new entry.

The conservation, safety, market, and management benefits of fishery participation permit systems have benefits that outweigh the increased impediment to flexibility in modern Alaskan fisheries. This approach enables stable and productive fisheries as long as ecosystem productivity remains relatively stable and predictable. The Council has created special programs for entry-level opportunities, and always preserves the ability to reconsider allocation programs. However, sudden and massive ecosystem change (such as might be conceivable under some global warming scenarios) could seriously test the ability of science and management to keep up with the pace of change.

Risk assessment

Summary Ratings: Probability – low, Ecosystem impact – low, Economic impact – high
Geographic scale – AI wide and beyond, Time scale – 5-10 years and beyond

Probability: The probability of limited fishing flexibility having a significant impact on fisheries in the Aleutian Islands fishery ecosystem depends largely on the effects of climate change or other large-scale factors on the ecosystem. The probability that change will be major enough and sudden enough to outpace Council action is low. The Council always preserves the ability to reconsider allocation programs.

Ecological impact: Permit-based systems keep fishing effort steady in proportion to stocks, while open access tends to foster overcapacity and cluster effort in those fisheries which are “hot.” The social impacts of limited entry are largely distributional (winners and losers in initial allocation or market-based redistribution of rights or in event of major prey abundance shifts).

Economic impact: Limited entry restricts the ability of fishers to change fisheries. However, other factors limit those changes as well, primarily economic. The expense of purchasing new gear or vessels inhibits entry into other fisheries, even if they are open entry fisheries. Limited entry adds the expense of a permit or quota to the other expenses of pursuing additional fisheries. Economic benefit accrues to the quota or permit holder. Economic benefits without limited entry would likely be curtailed by overcapacity or overcapitalization. Economic impacts may affect both distribution and net benefits.

Geographic scale: Permitting programs are regional or in some cases statewide.

Time scale: If major ecosystem change occurs, the time scale for an effect from this interaction (following the shift) would be very short, within one year. If no major shift occurs, the effects of this interaction will only be noticed at a longer time scale – 5-10 years or longer.

Implications for management

At one time and in some places in the world, fishermen might respond to poor conditions in one fishery by switching to another. While this provided great flexibility, the open access of these fisheries created many problems as capacity increased. Limiting entry, and in some cases, dedicating access privileges by harvest allocation, solved many of the problems of open access management, but in general decreased fisher flexibility as a response to ecosystem change.

Several factors limit the modern flexibility of fishers to switch fisheries. The two most prominent are appropriate gear and mandatory permits. To the extent that permits are traded on an open market which determines their value, a sudden change in the productivity of a fishery could strand some permit holders with high debt and a valueless permit, while leaving another (newly productive) fishery without adequate harvest capacity.

One implication for management is that conditions could change faster than management and regulation are designed to respond. The Council has very good systems in place for responding to changing conditions by adjusting allowable catch on an annual basis. But anything warranting a change to fishery structure or anything at the FMP level would require a longer process. If social and economic hardship is extreme, there could be significant pressure to act quickly.

What is the risk?

Economic losses to fishermen from a sudden major ecosystem shift that idles vessels in a fishery that is not producing and inhibits new participation in different, suddenly more productive fishery.

How is the Council addressing the risk right now?

The council has entry-level programs in many fisheries. Many loan programs are available to fishermen. In the event of catastrophic change, disaster aid may become available.

What would be ways to consider any risk identified, and mitigate this risk?

The primary thing to consider for this interaction is the time scale at which the Council can react to changing circumstances.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
None	Description of entry level opportunities	Debt load of permit holders, by fishery
	Number and demographic profile off fishery participants	

Data gaps / research needed

Socioeconomic research on the effects of various management regimes is the most effective way of understanding this interaction.

4.6 Other socioeconomic activity interactions

Broad definitions of ecosystems include humans and the activities they conduct, recognizing that they affect both the social environment and the natural environment. The Council's goals for this ecosystem plan include ecosystem health, sustainable fisheries, and vibrant communities. Fisheries are the obvious direct interaction between humans and the ecosystem, as explored above Sections 4.4 and 4.5, but the relationship is more complex than that. This section focuses on communities and economic activities that potentially affect the marine environment, which, in the Aleutian Islands ecosystem, is virtually all economic activities. Somewhat more elusive (in terms of the way this risk assessment is structured) but still very important human concerns such as culture, social structure, and environmental justice are not treated as separate interactions with a designated risk assessment and proposed indicators, but are woven throughout the narratives of the other interactions where they apply, both in this section and in the sections above.

Q. Changes in fishery activities impact the sustainability of AI communities

The Council's ecosystem goal of vibrant communities in the Aleutian Islands region pertains to the civilian communities within the ecosystem boundary (Atka and Adak) as well as to communities that depend on resources from the Aleutian Islands ecosystem. The sustainability of communities and the sustained participation of communities in fisheries (as defined and mandated by congress in National Standard 8 of the MSA) are also affected by ecosystem productivity, management actions, and other socioeconomic activities.

Local fishing harvest activities are particularly important to the economic base of Atka and Adak, which have few other economic base activities or connections to other ecosystems. Atka is particularly involved in the halibut fishery. The Aleut Corporation is actively trying to develop the community of Adak, and expand its economy in order to improve the stability of the community. An allocation of 19,000 metric tons of pollock to the enterprise has not yet been met with an equal harvest as it has been difficult to locate a sufficient biomass of fish in the nearby fishing grounds. Other communities that could be affected by changes in AI fishery harvest activities include Dutch Harbor/Unalaska, Seattle (through the catcher-processor fleet), and others.

Processing is also critical. Both communities inside the boundary of the fishery ecosystem have seafood processing facilities. Onshore processing capacity in the ecosystem affects communities, labor, and fishing behavior. Currently, there is a very small halibut plant in Atka, and a larger commercial processor in Adak. The processor in Adak attracts a labor force from outside the Aleutians, the majority of whom stay only seasonally. Adak is working to develop an onshore processor capable of operating year-round in Adak; an onshore processor is likely a pre-requisite for developing a small boat fishery in Adak, and is part of the Aleut Corporation efforts to develop the community of Adak. The ability to sustain a small vessel fleet would add to the sustainability of the community of Adak. The establishment of an onshore processor not only affects the local community of Adak, but will also impact other Aleutian Island fishers who are able to deliver closer to the fishing grounds. However, processing capacity in Adak may also be in competition with processing activities in other communities

If either processor contracts, the associated community is likely to contract with it, though Adak is more subject to this condition than Atka. The community of Atka has maintained a relatively stable population for the last century, through a number of different resource booms. The community Adak has experienced dramatic population changes based on military activities over the last half a century and it is not clear when or at what level a civilian population may stabilize. The loss of the commercial processor at Adak would mean that virtually all of the commercial fish taken from the ecosystem would be processed in nearby communities that are also connected to the fisheries of the Bering Sea large marine ecosystem (such as in Unalaska) or by the offshore sector.

More than half the fish harvested from the AI fishery ecosystem are processed off shore on catcher-processor vessels. These vessels have little or no contact with shore-based communities in the ecosystem. They are owned by companies located in other places in Alaska, in Seattle and beyond, and they tend to attract labor from other locations as well. Occasional crew changes are carried out in Aleutian communities.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – medium, Economic impact – high
Geographic scale – local communities, Time scale – 1-5 years and beyond

Probability: Fishery activity is an important part of the economic base of Atka and Adak. The Aleut Corporation is actively trying to develop the community of Adak, and expand its economy, and it is likely that these efforts will affect the stability of the community. Communities outside of the AI ecosystem boundaries are also involved in harvesting fish in the ecosystem.

The current situation in Adak cannot be considered stable at this point. The community is still being reshaped and reconfigured after the closure of the military base, a dramatic population loss, and the commitment of the Aleut Corporation to reestablish the location as an Aleut community. The likelihood that the processor at Adak will either increase its size of operations substantially, or decrease them is substantial. Other alterations in processing patterns are not expected at this time, except perhaps those that may come about in response to climate-driven ecosystem change.

Ecological impact: Changes in fishing activities could lead to substantial changes in human populations in the ecosystem. In particular, climate change effects could impact the types and abundances of commercial fish within viable distance of the hub port at Adak, causing the population to expand or contract in response.

An increase in small fishing vessels is not likely to adversely affect the ecosystem, as quotas will continue to be set at sustainable levels. Discharge from shore-based processors may have a localized impact on water quality.

Economic impact: Fishery support at Adak and Atka is important economically both to the people of the communities and to the fisheries they support. Economic effects will be high on those communities which experience instability. Commercial activity in the area is likely to expand or contract with the community at Adak, which will expand or contract largely based on the success of developing commercial fisheries. Because there is very little other economic activity in the ecosystem that affects these communities, the situation in Adak, though small overall, represents the bulk of the economic activity taking place in shore-based communities within the ecosystem.

The economic impact of changes to the onshore commercial processing enterprise would be fairly large to the community of Adak, which currently relies on fish processing as a main economic basis. The economic impact to overall fisheries in the Aleutian Islands fishery ecosystem would be small to medium.

With increases in human populations in the Aleutian Islands that may accompany military, port, and community development, there may be additional participation and expanded harvest opportunity in the existing fisheries and perhaps other, new State fisheries may be developed.

Geographic scale: Local communities.

Time scale: Changes are likely to occur over the short time horizon of 1-5 years and beyond. Changes in commercial seafood processing in Adak are likely to occur in the short term 1-5 years as well as the medium term 5-10 years.

Implications for management

Congress has indicated that the sustained participation of fishing communities in fisheries is one of the National Standards of the Magnuson-Stevens Fishery conservation and Management Act.

A viable seafood processing plant and a sustainable community in Adak will provide opportunities for many vessels to fish in the Aleutian Islands that would not otherwise be able to do so. If the commercial processor in Adak does not continue operations, AI fishery harvests and processing will become even more dominated by the off shore sector. The community would likely lose population.

In Atka, the small processing plant is mostly dependent on halibut. Without the processing plant, many local fishermen would not be able to fish locally.

What is the risk?

The risk is that communities will decline (in population or in economic status) or lose resilience in response to fishery changes.

How is the Council addressing the risk right now?

The Council currently addresses sustainable communities in the AI fishery ecosystem by promoting allowable catch levels that are sustainable, by analyzing social and economic impacts on communities, and by conducting a transparent management process that is open to the public.

The Council has implemented the 19,000 metric ton pollock allocation to the Aleut Corporation (which is developing Adak), and NMFS is conducting stock assessments separate from the Bering Sea stock. The halibut fishery, on which Atka in particular is dependent, is managed by the International Pacific Halibut Commission, with whom the Council interacts closely. The fishery is performing very well.

What would be ways to consider any risk identified, and mitigate this risk?

Support for the sustainability of AI communities could include allocation of TAC in AI fisheries separately from TAC in Bering Sea fisheries for species in addition to pollock, with specification to smaller vessels.

Risk mitigation for AI shoreside processors could include allocation of TAC in AI fisheries separately from TAC in Bering Sea fisheries for species in addition to pollock, with specification to smaller vessels.

Support for the sustainability of the community of Atka could also include prioritization of local subsistence activities in management decisions, perhaps through the recognition of a marine ecoheritage zone.

Support for sustainable communities could also be achieved (and risk mitigated) by increasing proactive solicitation of input into Council processes from community members and stakeholders. This could be achieved by video conferencing, community liaisons, and/or making travel funding available.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
Population size and structure in AI communities – US Census data and Alaska State Demographer's Office	% of AI fishery participation connected to AI communities by vessel ownership residency, shoreside deliveries, or other measurable connection Number of processing jobs (full time equivalent or other measure) in onshore locations and in offshore sector	Need data on people on Shemya and Attu, also seasonal shifts in populations in these areas

Data gaps / research needed

Further development of community sustainability indicators is needed in order to understand the relationship between communities, populations, and ecosystems.

R: Coastal infrastructure and development impact the ecosystem and communities

Coastal development in the Aleutian Islands includes activities in the upland, estuarine, and marine environments. Those activities include creation and expansion of ports and harbor facilities, point and non-point source pollution, seafood processing waste, oil and gas exploration and development, marine mining, placement of utility and telecommunications lines, marine dredging and disposal of fill material, vessel operations, transportation and navigation, road construction, streambank modification and shoreline erosion, waste treatment, and sand and gravel mining. Some coastal development issues that are very significant in other locations are not considered to be significant in the Aleutians. These include increasing density and gentrification of coastal housing and conflicts between tourism and commercial fisheries over waterfront usage (Impact Assessment 2005, Hall-Arber et al. 2001).

Estuaries are the bays and inlets influenced by both the ocean and rivers, and they serve as the transition zone between freshwater and saltwater (Botkin et al. 1995). Estuaries support a community of plants and animals that are adapted to the zone where freshwater and saltwater mix (Zedler et al. 1992). Estuarine habitats fulfill fish and wildlife needs for reproduction, feeding, refuge, and other physiological necessities (Simenstad et al. 1991, Good 1987, Phillips 1984). Estuaries often include eelgrass beds that protect young fish from predators, provide habitat for fish and wildlife, improve water quality, and control sediments (Johnson et al. 2003, Thayer et al. 1984, Hoss and Thayer 1993, Phillips 1984). In addition, mud flats, high salt marsh, and saltmarsh creeks also provide productive shallow-water habitat for epibenthic fishes and decapods (Sogard and Able 1991).

Coastal or marine habitats comprise a variety of broad habitat types for fish species, including sand bottoms, rocky reefs, and submarine canyons. When rock reefs support kelp stands, they become exceptionally productive. Relative to other habitats, including wetlands, shallow and deep sand bottoms, and rock bottom, giant kelp habitats are substantially more productive in the fish communities they support (Bond et al. 1999). The stands provide nurseries, feeding grounds, and/or shelter to a variety of groundfish species and their prey (Feder et al. 1974, Ebeling et al. 1980).

Coastal development can impact estuarine and marine habitats through numerous mechanisms, including direct habitat modification, altered water and sediment flow regimes, water temperature changes, pollution, erosion, and many other direct and indirect alterations of the environment.

Risk Assessment

Summary Ratings: Probability – low, Ecosystem impact – low, Economic impact – medium
Geographic scale – local, Time scale – less than 10 years

Probability: Although many forms of coastal development can have an effect on marine resources, the opportunity for development in an extremely remote environment minimizes the probability of impacts.

Ecological impact: Limited local effects may occur; however, impacts at an ecosystem scale are low.

Economic impact: To the extent that development affects local water quality, estuarine, or marine habitat, communities may be impacted adversely. At the same time, such coastal development may also contribute to the sustainability of such communities.

Geographic scale: Local.

Time scale: Effects of any activities would be longer term, as most development is intended to persist.

Implications for Management

What is the risk?

Coastal development activities have the potential to adversely affect the quantity or quality of estuarine and marine systems. Broad categories of such activities include, but are not limited to, mining, dredging, fill, impoundment, discharge, water diversions, thermal additions, actions that contribute to nonpoint source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of fish habitat.

How is the Council addressing the risk right now?

The Essential Fish Habitat Environmental Impact Statement analyzed non-fishing impacts on the Aleutian Islands (NMFS 2005: Appendix G). Initial steps to address any risk associated with such impacts have been taken by the Council. The Council requested regular updates on coastal development from the Habitat Conservation Division of NMFS. The Magnuson-Stevens Act requires NMFS to recommend conservation measures to federal and state agencies regarding actions that would adversely affect EFH.

These EFH conservation recommendations are advisory, not mandatory, and may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects to EFH. Within 30 days of receiving NMFS' conservation recommendations, federal action agencies must provide a detailed response in writing. The response must include measures proposed for avoiding, mitigating, or offsetting the impact of a proposed activity on EFH. State agencies are not required to respond to EFH conservation recommendations. If a federal action agency chooses not to adopt NMFS' conservation recommendations, it must provide an explanation. Examples of federal action agencies that permit or undertake activities that may trigger EFH consultation include, but are not limited to, the U.S. Army Corps of Engineers, Environmental Protection Agency, Federal Energy Regulatory Commission, and Department of the Navy.

What would be ways to consider any risk identified, and mitigate this risk?

The North Pacific Fishery Management Council may choose to comment on proposed actions that may adversely affect EFH.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
Habitat permit reviews from NMFS-HCD		Habitat impacted by coastal development

Data Gaps / Research Needed

Effects of coastal development on managed and non-managed species.

S. Vessel traffic, and risk of vessel grounding and spillage, may impact ecosystem productivity

Shipping on the great circle route passes through the AI fishery ecosystem on the western end, as vessels transit between North America and Asia. With the potential looming for a Northwest Passage through an ice-free arctic route in the summer, vessel traffic in the area could increase significantly as direct traffic from Europe to Asia and Europe to the American west passes through.

Oil and gas development in adjacent areas, such as the North Aleutian Basin and the western pacific (Russia) has the potential to affect vessel traffic not only by increasing vessels, but by increasing those vessels with cargo most damaging to the marine environment.

Vessel traffic itself has limited potential for ecosystem impacts beyond the issue of ship strikes for endangered whales. However, as vessel traffic increases, so will the occurrence of accidents. There is the potential for significant impacts to the ecosystem if a grounding or spill occurs at key locations within the ecosystem area. Oil spills and the introduction of rats and exotic species are of critical concern. Exotics are introduced from ballast exchange and dumping. Oil spills result from tanker accidents as well as bilgewater dumping and other small volume introductions.

Risk assessment

Summary Ratings: Probability – high, Ecosystem impact – high, Economic impact – high
Geographic scale – AI wide and larger, Time scale – 5 to 10 years and longer

Probability: Shipping between North America and Asia (see Figure 3-29) is likely to increase as is shipping from Europe. As vessel traffic increases, so does the probability of an accident.

Ecological impact: The potential for an adverse ecosystem impact is high if a vessel grounding or oil spill occurs at key locations within ecosystem area. Oil spills and introduction of exotic species are of critical concern.

Economic impact: As above, if the grounding or spill occurred in key areas within the ecosystem, the economic impact could be high. Depending on location on currents, a spill in the Aleutian Isalnd fishery ecosystem could impact other ecosystems such as the Bering Sea.

Geographic scale: Effects could be localized or regional, depending on the location and size of the accident.

Time scale: Shipping is likely to increase over the next 5 to ten years. Impacts from a major incident could be long term.

Implications for management

Although a shipping mishap could have a significant affect on the ecosystem, the Council does not regulate shipping. If a major incident were to occur, the Council might need to effect emergency closures to FMP fisheries. Managing risk, especially that from oil spills or other toxic substances, should involve the following priorities: 1) preventing an accident from occurring, 2) containing or mitigating the effects of an accident should one occur, and 3) effective clean up of areas that have been affected. One of the most important factors for effective execution of these first two priorities, prevention and containment, is rapid access to necessary equipment such as tug boats, absorbent boom, oil skimmers, and other response equipment. In the Aleutian Islands, where nearly every location is remote, rapid response and access to large caches of specialized equipment are particularly problematic. Further more, it can be difficult to maintain resources and vigilance for an event that may not occur.

What is the risk?

The risk is from negative effects to the ecosystem from shipping or other vessel traffic related accidents, ranging from minor marine emissions with potential local and cumulative impacts to major catastrophic oil spills such as occurred with the Exxon Valdez. The highest level of ecological and economic effects comes from the shipment of oil or other toxic products that could contaminate a large areas of the ecosystem. A major spill could cause large-scale in-season closures to commercial fisheries, closures of key subsistence fishing and shellfish collecting spots particularly in estuarine and intertidal areas, and long-term damage to seabirds, marine mammals, fishery resources, and ecosystem productivity. Of greatest concern would be effects on threatened and endangered species, effects on key subsistence resources (marine mammals and intertidal areas) that support families in Atka and Adak, effects of settled oil on bottom-contact fisheries, and long-term hydrocarbon contamination of marine resources.

How is the Council addressing the risk right now?

The Council participates in the Alaska Marine Ecosystem Forum to communicate about activities in the Aleutian Islands.

What would be ways to consider any risk identified, and mitigate this risk?

The Council and NMFS could consider developing a contingency plan for a response specific to the Aleutian Islands fishery ecosystem based on known shipping activities and the likelihood of different accident scenarios. Such a plan should include ways to contain or mitigate contamination of marine resources, ways in which the fishing fleet (as those most likely to be able to reach a spill area quickly) could assist in the initial response to a spill, and plans for accessing the equipment necessary to contain or mitigate the effects of a spill.

In some areas of the United States, double-hulled tankers have been recommended or mandated as a way of reducing the risk of oil spills. Appropriate positioning of rescue tug boats has also been an effective proactive approach to risk reduction. The Council could research whether advocating for these options would be appropriate for the Aleutian Islands fishery ecosystem area.

Finally, the Council should consider and plan ahead for the regulatory mechanisms to bring about emergency in-season closure of fisheries should a major incident occur.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
None	Port and Waterways Assessment – vessel count estimates for great circle shipping route	Count of vessels by type and cargo passing through the area each season
	Count of spills and other shipping accidents in the region by type Coast Guard information	Vulnerability index (see also oil and gas development) – Cross tabulate Habitat Areas of Particular Concern (HAPCs), critical habitat, fishing grounds and other special areas with shipping traffic
	US Coast Guard Safety inspection statistics	
	Monitor aquatic nuisance species – ADF&G data	
	Beach bird monitoring for ocean pollution – US Coast Guard / North Pacific Research Board beach bird monitoring	

Data gaps / research needed

More precise and annual information is needed on shipping traffic through the Aleutian Islands fishery ecosystem. Some information may be available from the Ports and Waterways Assessment or the US Coast Guard. This information should be cross-tabulated with information about critical areas in the Aleutians to form a vulnerability index (see also oil and gas development).

T. Changes in the level of military activity in the area may impact communities

The military has scaled down its AI operations considerably since the Cold War, has closed many installations, and is conducting cleanup of those sites. In a reversal of this trend, however, a sea-based x-band missile defense radar installation has just recently been positioned in Adak aboard an oceangoing platform. Additional x-band radar capabilities are being built in Shemya. These installations are part of the national missile defense program.

Military activities may have mixed effects on communities and ecosystems. Military bases can sometimes provide the only available nearby support for vessel emergencies in remote areasbut the security around the new radar systems means that vessels cannot go to Shemya anymore, and there is a closed area around the system in Adak. Closed areas will not experience any fishing pressures, but may be subject to habitat and other impacts generated by military activity. To the degree that nearshore development related to the installations or other expansions of military activity in the Aleutians involve marine testing or maneuvers that could result in habitat loss or disturbance, there may be localized impacts to habitat and localized effects on recreational and subsistence fisheries. Low and medium frequency sonar use by the military, which may have implications for marine mammal populations, is not known to be an issue in this area.

In Adak, where a civilian community exists alongside military activity, the new installation may add to community stability by diversifying the local economy.and increasing the population. This in turn may contribute to Adak's ability to function as a fishery hub in the Aleutian Islands. A population increase could also affect subsistence and recreational fishing locally.

Although Amchitka Island was the site of three large underground nuclear tests in the 1960's and 1970's, environmental contamination from the site does not appear to be a current problem and is being monitored by the Department of Energy. A recent assessment indicated: "Ongoing monitoring data does not indicate that radionuclides are currently seeping into the marine environment. Additionally, the groundwater modeling results indicate no seepage is expected for tens to thousands of years. If seepage does occur in the future, however, the rich, diverse ecosystems around the island could be at risk, as well as people eating foods from the area (DOE 2006).

The entire Aleutian Islands fishery ecosystem has the potential to be highly impacted by military activity as it was during World War II when tens of thousands of military personnel were active in the islands with hundreds of major construction projects. However, this type of war-time military influx was seen as having a very low probability at this time.

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – medium, Economic impact – medium
Geographic scale – local, Time scale – 1 to 5 years to very long term

Probability: New operations of x-band radar installations may have some local effects and the increase in population is likely to have some local effects. Contamination from the Amchitka site may be a concern over the very long term.

Ecological impact: Ecological impacts from military activities could include effects on habitat and locally harvested species. The impacts could be negative (damage from activities or increased harvest from population) or positive (regeneration of areas closed to vessels and harvest).

Economic impact: This installation may add stability to the community of Adak by diversifying its economy supporting the military presence. This in turn may contribute to its ability to act as a fishery hub in the area.

Geographic scale: Local.

Time scale: Effects are likely to be short-term for development activity, and potentially long-term for the stability of the community and contamination issues.

Implications for management

Military activity has management implications in two major ways. First, the activity can be seen as a form of economic diversification in the area, bringing people and material support to locations in the Aleutian Islands that would not have them otherwise. This has direct effects on fishing communities (population increases, jobs, commerce) and indirect effects on fishing activities (emergency support, closed areas). Second, military activity can be seen as having direct effects on the fishery ecosystem through local habitat or stock impacts at installations.

What is the risk?

At this point, the risk from military activities to the ecosystem are the local direct and indirect implications of current installations, and the regional implications of potential increases in the level of activity or changes in the nature of the activity.

How is the Council addressing the risk right now?

The council is addressing risk from military activites by participating in the Alaska Marine Ecosystem Forum with a representative of the Defense Department.

What would be ways to consider any risk identified, and mitigate this risk?

The Council should continue to pursue communications with the Department of Defense over activities that could affect the fishery ecosystem. The Council should include in their communications those activities which are not significant factors in the ecosystem now, such as low and medium frequency sonar use, but which would be significant if they began.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
None	Department of Energy surveillance and monitoring of radionuclides and other contaminants at Amchitka	Monitor military activity – location of new facilities – uses of low and medium frequency sonar – other testing

Data gaps / research needed

The Alaska Marine Ecosystem Forum in which NOAA can interact with the Alaska military command structure and the Missile Defense Agency is the most important conduit for information about military activities in the Aleutian Islands at this time.

U. Oil and gas development may impact ecosystem productivity

The sale of new oil and gas development leases is being discussed for the North Aleutian Basin, just north of the Alaska Peninsula. There is a probability of oil spills occurring from the development and associated increased vessel traffic through the ecosystem area. The risk of oil spills from the North Aleutian Basin development is less important for the Aleutian Islands ecosystem area because ocean current patterns in that area are likely to disperse oil spills into other parts of the Bering Sea. However, increased vessel traffic has a potential to increase the likelihood of accidents, which may directly affect habitat, fish, marine mammals, and seabird species in the area of the accident. Risks associated with shipping are evaluated under the vessel traffic indicator.

If oil and gas development were to take place in the Aleutian Islands fishery ecosystem, the probability of impacts would be much higher and the intensity of those impacts to the ecosystem and the economy would be much greater. Current information does not indicate such development is planned.

Major oil development in Russia and the new terminal at Sakhalin Island will impact the Aleutian Islands mainly through increased ship traffic.

Risk assessment

Summary Ratings: Probability – low, Ecosystem impact – medium to high, Economic impact – high
Geographic scale –AI wide and larger, Time scale – 5-10 years and longer

Probability: Sales of oil and gas development in the North Aleutian basin (adjacent to the Aleutian Island fishery ecosystem) leases are on track to move forward in 2012. There is a high probability of impacts occurring from the development in the local area. There is a much lesser probability of impacts spilling over into the Aleutian Islands fishery ecosystem. The development will undoubtedly lead to increased vessel traffic through the ecosystem area, as will oil development in Russia. These effects are considered under vessel traffic.

Ecological impact: Impacts from offshore structures or pipelines themselves are generally seen although their footprint is small. The ecological impacts in the AI FEP ecosystem from potential oil spills from the North Aleutian Basin development is likely small because ocean current patterns are likely to disperse oil spills into other parts of the Bering Sea.

Economic impact: Economic impact will be twofold. With the onset of oil and gas development more resources and potential capital will flow into the area close to the development and some may spill over into the FEP area. Such an impact would be positive. On the other hand, oil spills or vessel accidents that might occur due to this development would certainly have negative and potentially high economic implications, especially if subsistence and commercial harvests are affected.

Geographic scale: The scale of impact of the development in the Aleutians is local to regional; the scale of an ecosystem or economic impact, if it occurs due to a North Aleutian Basin oil spill is national and potentially even global if it were to affect commercial values or global trade.

Time scale: Oil and gas activities would be carried out for many years. Local impacts would therefore be on that time scale. Ecosystem impacts from major oil spills are known to be likely to be long-term, lasting for decades.

Implications for management

The Council does not exert authority over oil and gas development. The U.S. Minerals Management Service manages off shore leasing and development. A previous ban on development in the North Aleutian Basin no longer pertains. The Council does have a voice in regional planning through interagency groups. Development of oil and gas in the Aleutian Islands Fishery Ecosystem does not appear to be a concern in the foreseeable future. Mosts of the concerns about oil development in nearby ecosystem areas are addressed under the topic of shipping. There is no indication that there are significant exploitable or economically viable oil and gas resources in the ecosystem by today’s standards. However, oil is in a period of extreme flux as a comodity in the world economy making the long term future quite difficult to predict.

What is the risk?

The risk to the ecosystem from oil and gas development is from oil spills that affect marine life and fisheries. These do not appear to be a significant concern at this time (but see shipping).

How is the Council addressing the risk right now?

The Council and NMFS participate in regional interagency the Alaska Marine Ecosystem Forum.

What would be ways to consider any risk identified, and mitigate this risk?

The Council could consider a proactive stance on securing an exclusion of oil and gas development in the Aleutian Islands Fishery Ecosystem in order to protect fishery resources.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
None	Monitor oil and gas spills – review DEC history of development-related spills	GIS database of all oil and gas development in all adjacent areas
	Monitor oil and gas development in AI and near AI – US Minerals Management Service planned lease sales – information from western pacific nations	Fishing grounds vulnerability index – Cross tabulation of ocean currents (NOAA), likely oil spill sites (?), and fishing grounds (NOAA and ADF&G)

Data gaps / research needed

Given that there is no oil and gas development planned in the Aleutian Islands fishery ecosystem, the information necessary to best assessing the vulnerability of the ecosystem lies in understanding how development in other locations will affect the AI. The critical pieces of information are ocean currents models, likely spill sites, and fishing grounds or other areas of particular concern. Such a model could also incorporate information about vessel traffic.

V. Research activity may impact fisheries

Research activity is an essential part of resource management and economic development in the Aleutian Islands. Periodic and ongoing research activities have been conducted by state and federal government, military, universities and private corporations throughout the AI subarea.

Research vessels represent a considerable proportion of the vessel activity in remote portions of the AI and research activities have the potential to impact commercial fishing. The presence of research vessels, moored research instrumentation, and other data collection equipment may result in gear conflicts between research and fishing vessels. A higher presence of vessels increases the threat of accidents, potentially resulting in oil spills, as discussed in Interaction S, above.

Interactions between fishing gear and research equipment could increase in the future if fishing effort in the AI subarea expands during the summer months, which is also the primary time when research vessels are likely to be present. Most fishery research results in the taking of organisms for scientific sampling or cost-recovery purposes. Typically the amount of take is relatively small, but both state crab surveys and federal Exempted Fishing Permit pollock surveys have resulted in commercial-scale removals.

From a broader perspective, it is hoped that research activity conducted in the AI subarea will benefit the ecosystem and fisheries by elucidating ecosystem processes, thereby allowing managers to more effectively maintain ecologically sustainable fisheries in the long term. There is some overlap between this interaction and the Interaction T (military activity), Interaction S (vessel traffic), and Interaction U (oil and gas development).

Risk assessment

Summary Ratings: Probability – medium, Ecosystem impact – low, Economic impact – low, Geographic scale – local, Time scale – short-term, less than five years.

Probability: Research vessels represent a considerable proportion of the vessel activity in the AI and they often operate with a spatial and temporal overlap of commercial fishing activity resulting in a medium probability score. Most research design considers the spatial and temporal components of commercial fisheries in the area and commercial fishing activities are taken into account during the permit application review process.

Ecological impact: A higher presence of vessels increases the threat of accident, potentially resulting in an oil spill, as discussed above. In remote portions of the AI, research vessels may represent the majority of the human activity taking place in a given year. Seismic and geological data collection may cause habitat impacts and may not be well regulated through current fish resource based permitting process. Research take of sensitive organisms, or populations with low abundance should be closely monitored. Since research vessels in the AI subarea have been relatively accident free and the research take of organisms is relatively small, the ecological impact score is considered low.

Economic impact: The presence of research vessels and/or moored researched instrumentation may result in gear conflicts with fishing vessels causing gear loss or lost fishing time, however such conflicts would be relatively easy to resolve and should be of short duration only. Gear conflicts could increase if commercial fishing activity or research needs change. Potential positive economic impacts may accrue through improved fishery management and additional commerce in AI subarea communities.

Geographic scale: Effects are primarily local and may be more concentrated around communities.

Time scale: Potential impacts due to gear conflict would be of short duration and may be minimized through the permitting process; effects of a vessel accident could be long-term.

Implications for management

In general, research activities pose little risk to fisheries or the ecosystem. Minor, short-term conflicts between research and commercial fishing activities may occasionally occur, but they are likely to be isolated and localized problems that are quickly alleviated. The impact of a research vessel accident, sinking, or grounding is greater, but the probability of such accidents is low. The risk of vessel accidents is ongoing and not unique to research vessels. In the case of very sensitive species such as Steller sea lions, potential mortality from research activities may have a negative impact on the population that could have downstream effects. Use of dredge or other heavy bottom contact sampling gear could cause damage to sensitive benthic habitats.

The Council is generally not involved in the issuance of research permits, or directing research activities, however the Council uses research products in their management decisions and receives frequent briefings on research activities. This interaction is not currently addressed by the Council, but is adequately addressed by individual agencies during the permitting process.

The majority of risk mitigation responsibility lies with the permitting agencies. The Council may wish to encourage efforts to create an inventory or ‘clearing house’ of research activities in the AI, in order to minimize the potential for gear conflicts.

Indicators

Indicators from Ecosystem Considerations chapter	Indicators not in chapter for which data is available	Indicators for which data not available
None	Number of permits: – fish resource permits from ADF&G for research in state waters; – EFH and experimental fishing permits through NMFS, – Corps of Engineers permits. Take of marine resources allowed under permits granted above.	Interactions between commercial fishing and research activity.

Data gaps / research needed

Periodic "clearinghouse" review of research conducted in AI would help to track long-term trends in amount of research activity in AI subarea. Review of permit status reports by permitees may document conflicts with fishing activities.

4.7 Summary of risk assessment findings

The interactions, identified in Sections 4.2 to 4.6, comprise a conceptual model of some of the major interactions in the Aleutian Islands ecosystem. These interactions go beyond a single species approach to management, and should be taken into account during fishery management decisions. The inter-relationship between these interactions is displayed visually below in a cognitive map, in which the direction and strength of the interaction is indicated through arrows (Figure 4-2).

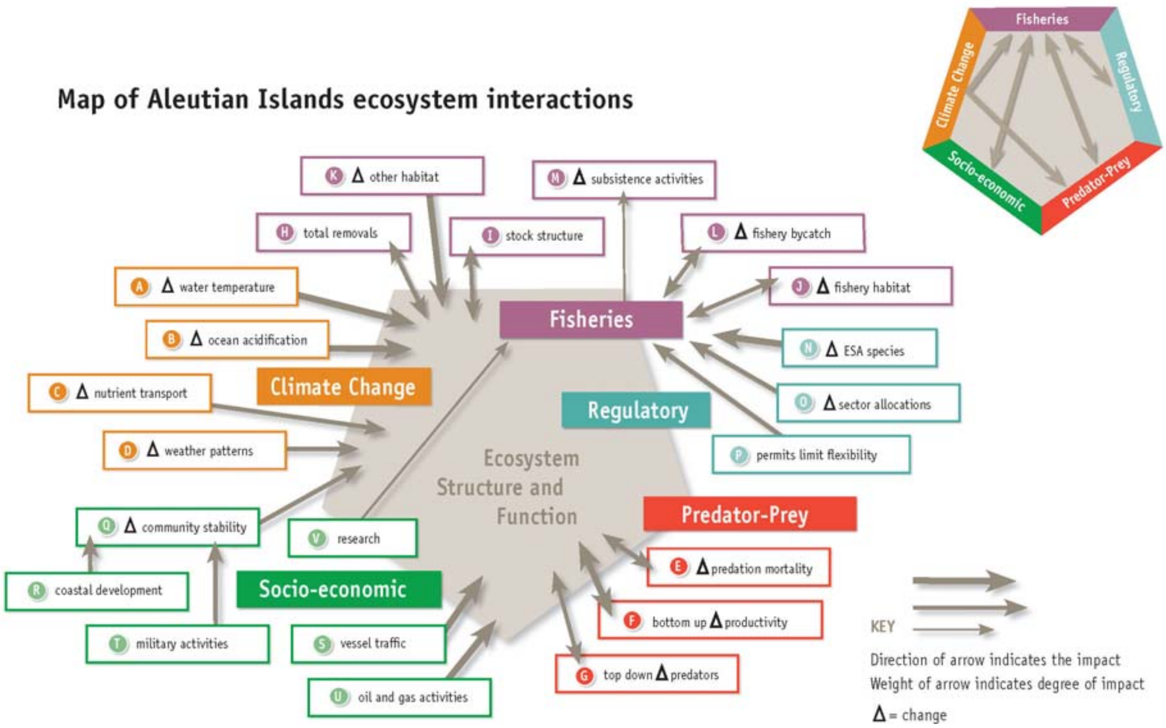

Figure 4-2 Map of ecosystem interactions, and direction and intensity of impacts, summarized from the risk assessment.

The importance of these interactions for the ecosystem and subsequently for management can also be shown as plots of likelihood of occurrence versus impact (Figure 4-3, Figure 4-4). The rankings of each interaction are based on the consensus judgement of the Ecosystem Team members. The Team considers those interactions with an unknown likelihood of occurrence or magnitude of impact to be high priorities for the Council, in terms of allocating further research or analysis to understanding these interactions.

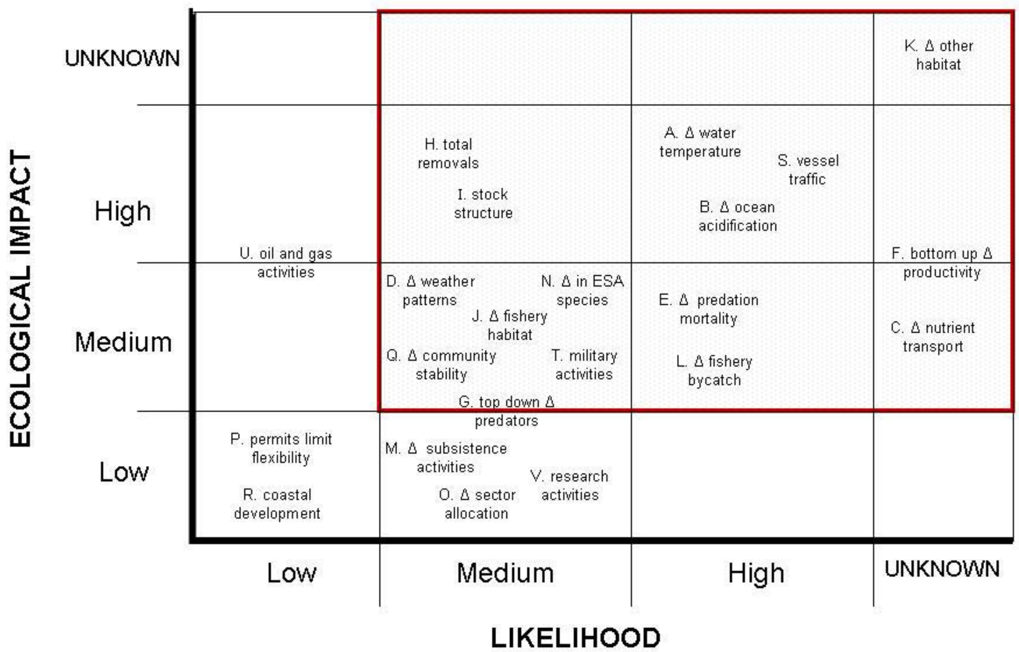

Figure 4-3 Likelihood of occurrence and ecological impact assessment of interactions.

Based on the professional judgement of the Aleutian Islands Ecosystem Team.

NOTE: Red box in upper right quadrant highlights those interactions with a medium to high or unknown likelihood of occurrence and impact.

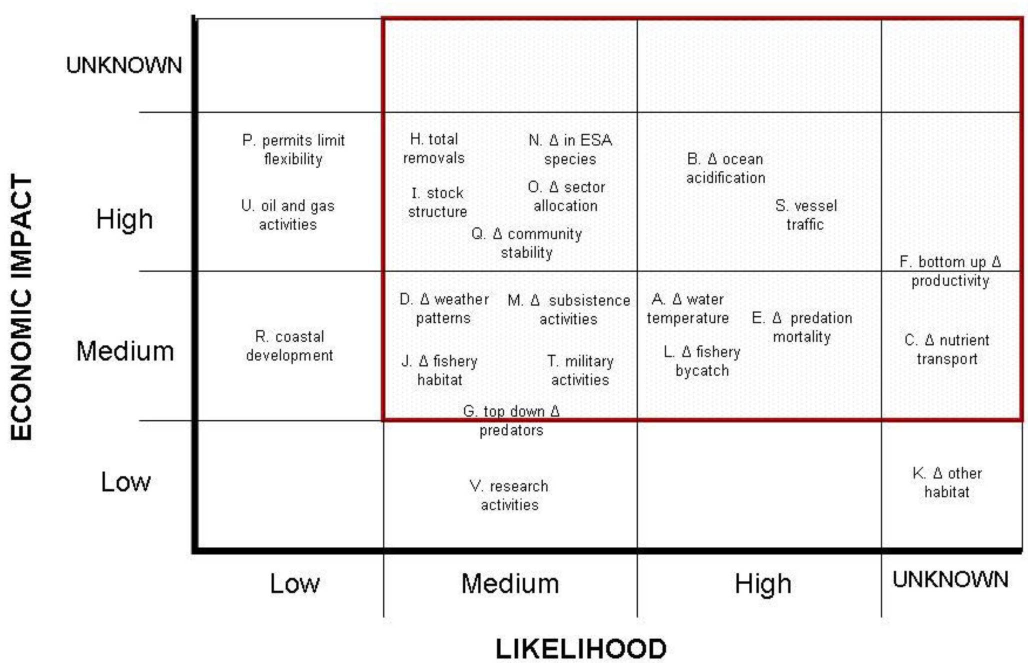

Figure 4-4 Likelihood of occurrence and economic impact assessment of interactions.

Based on the professional judgement of the Aleutian Islands Ecosystem Team.

NOTE: Red box in upper right quadrant highlights those interactions with a medium to high or unknown likelihood of occurrence and impact.

4.8 Cumulative interactions

The cognitive map, Figure 4-2, is a visualization of how the various interactions discussed in this chapter are related. We defend the value of looking at interactions independently, as in the previous sections. In a sense, this FEP is introductory material. These are the fundamental steps to ecosystem planning – these interactions are complex, not simple to understand. It is sometimes easier to parse out individual perspectives, and to understand them before being able to understand the whole.

The FEP has identified a number of ways to monitor and further evaluate these individual interactions, and until some of that work has proceeded, it is difficult to be able to proceed with a true cumulative analysis. One of the difficulties with the cumulative perspective is how to measure the overlaps. That being said, the importance of the connections among interactions and ecosystem components is critical. The discussions above have pointed out some places where interactions are interrelated.

A Council example illustrates the connections among interactions. For example, the Aleut Corporation has been allocated up to 15,000 mt of AI pollock, of which they are currently harvesting less than 3,000 mt. Growing the pollock fishery based out of Adak would involve an influx of people into the community (Interaction Q), and would affect the sustainability of the processing plant at Adak (Interaction R). Growing the fishery also requires developing a small boat fleet out of Adak (Interaction O), which is constrained by Steller sea lion protection measures (Interaction N). The type of vessel involved in the fishery may result in differing bycatch and habitat effects (Interactions L, J, and K). Pollock TAC is already allocated to the AI subarea, but the stock structure boundary does not match perfectly with the subarea boundary (Interaction I).

Anecdotal evidence indicates that a directed pollock fishery may be difficult in the area because it is difficult to catch pollock without catching POP (Dave Fraser, pers. comm.). This again brings up an allocation issue, in that there is a limit to the amount of POP that Adak fishermen can catch due to a recent Council decision allocating the majority of the POP fishery to offshore catcher processors (Interaction O). The changing species composition in the directed AI pollock fishery in the last ten years indicates a change in the ecosystem, specifically in the food web (Interactions E, F, G) as POP have continued to rebound in population after intensive fishing in the 1960s. There may be other environmental changes that have brought about ecosystem change also (Interactions A-D).

Further research on how interactions work together is an area of future work for FEP and Council. These can be explored through management strategy evaluations, and scenario exploration. One avenue for this work is to investigate whether some species are particularly vulnerable, due to multiple risks from multiple interactions. Scenario analysis with the food web model and other tools can help with this task. Another interesting direction might be to identify whether there are ecologically important areas, in the Aleutian Islands ecosystem, due to multiple sensitivities. Audubon has recently completed work on this subject in the Bering Sea, for seabirds, that might provide a useful starting point for such an analysis.

5 Management objectives

Decision makers are faced with uncertainty – uncertainty about the structure and dynamics of integrated physical, biological, economic, and sociocultural systems, uncertainty about how the systems will respond to the actions taken, and uncertainty about the merits of alternative outcomes. Decision making under these conditions entails risk to ecological systems, risk to socioeconomic systems and institutions, and risk that implementation of management actions will lead to unanticipated or undesired consequences. Actions taken to minimize one aspect of risk often increase the level of risk in other dimensions. When the consequences of management actions are uncertain, good decision making involves balancing risks and benefits (NRC 2004).

Multiple objectives may be balanced through political processes or formally examined using multiple criteria decision analysis methods (e.g., Keeney and Raiffa, 1976; Saaty, 1990). These methods have been used to address a variety of fishery management issues (e.g., Hilborn and Walters, 1977; Bain, 1987; Walker et al., 1983; Healey, 1984; Mackett, 1985; Merritt and Criddle, 1993). Solutions that emerge from the application of multiple criteria decision analysis often favor compromises that minimize maximum losses or maximize minimum benefits. Multiple criteria decision analyses that incorporate multiple stakeholders with overlapping objectives often select management options that enjoy broad support and limited objection (NRC 2004).

The Council recommends management measures on the basis of the ten MSA National Standards and the policy statement included in each of its FMPs. The Council's policy and objectives should guide the Council in prioritizing and addressing the risks that have been qualitatively identified through the risk assessment process in the previous chapter. The following section summarizes the management policy for the Council's FMPs and also the State of Alaska's management policy for the crab fishery. Section 5.2 then compares the priorities highlighted in the management policies with the interactions identified in Chapter 4.

5.1 Council and State of Alaska management policies

The Council has developed management policies for each of the Federal fisheries in Alaska. The groundfish and crab management policies are summarized below. As the crab fishery is managed jointly with the State of Alask, the State's crab management policy is also included. The scallop fishery in the AI ecosystem, while technically open on an annual basis, has not been fished for many years, and so is not discussed below. A halibut fishery also occurs in the ecosystem, but the Council does not have a management policy for managing the halibut fishery. Section 2.1 describes the management of the various AI fisheries in detail.

5.1.1 BSAI Groundfish FMP

The BSAI Groundfish FMP was revised by the Council in April 2004 following a programmatic review of the BSAI and GOA groundfish fisheries (NMFS 2004). The new policy captures the Council's ecosystem approach to management, and contains a number of specific objectives that the Council is in the process of fully implementing. The following summarizes the management approach, and the goal statements under which the objectives fall.

> The fishery management goal is to provide sound conservation of the living marine resources; provide socially and economically viable fisheries for the well-being of fishing communities;

minimize human-caused threats to protected species; maintain a healthy marine resource habitat; and incorporate ecosystem-based considerations into management decisions.

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

- Prevent Overfishing
- Promote Sustainable Fisheries and Communities
- Preserve Food Web
- Manage Incidental Catch and Reduce Bycatch and Waste
- Avoid Impacts to Seabirds and Marine Mammals
- Reduce and Avoid Impacts to Habitat
- Promote Equitable and Efficient Use of Fishery Resources
- Increase Alaska Native Consultation
- Improve Data Quality, Monitoring and Enforcement

5.1.2 BSAI King and Tanner Crab FMP

The BSAI King and Tanner Crab FMP includes a management goal and management objectives. The following is a summary of the FMP language:

The management goal is to maximize the overall long-term benefit to the nation of BS/AI stocks of king and Tanner crabs by coordinated Federal and State management, consistent with responsible stewardship for conservation of the crab resources and their habitats.

- Ensure the long-term reproductive viability of king and Tanner crab populations.
- Maximize economic and social benefits to the nation over time.
- Minimize gear conflict among fisheries.
- Preserve the quality and extent of suitable habitat.
- Provide public access to the regulatory process for vessel safety considerations.
- Ensure that access to the regulatory process and opportunity for redress are available to all interested parties.
- Provide fisheries research, data collection, and analysis to ensure a sound information base for management decisions.

5.1.3 State of Alaska King and Tanner Crab Management Policy

In addition to the National Standards specified in the Magnuson-Stevens Fishery Management and Conservation Act, Aleutian Islands king and Tanner crab fisheries managed by the state of Alaska are managed in accordance with the Alaska Board of Fisheries Policy on King and Tanner Crab Resource Management (#90-04-FB, March 23, 1990).

This policy is summarized as follows:

It is the goal of the Alaska Board of Fisheries and Alaska Department of Fish and Game to manage king and Tanner crab stocks in a manner that will protect, maintain, improve, and extend these resources for the greatest overall benefit to Alaska and the nation. Achievement of these

> goals is necessarily constrained by the requirements to minimize: (1) risks of irreversible adverse effects on reproductive potential; (2) harvest during biologically sensitive periods of the life cycle; (3) adverse interactions with other fish and shellfish stocks and fisheries.
>
> Management of these fisheries for the purpose of achieving this goal will result in a variety of benefits which include, but are not limited to the following:
>
> (1) maintaining healthy stocks of king and Tanner crabs of sufficient abundance to insure their continued reproductive viability and maintenance of their role in the ecosystem;
> (2) providing a sustained and reliable supply of high quality product to the industry and consumers which will provide sustainable and stable employment in all sectors of the economy relating to these fisheries; and
> (3) providing opportunities for subsistence and personal use fisheries on these stocks.
>
> The Alaska Board of Fisheries also recognizes the benefits of managing for the highest socio-economic benefit when such action does not conflict with biological constraints.

The state of Alaska does not take the National Standards into consideration when managing parallel or state-waters groundfish fisheries, however the Alaska Board of Fisheries has adopted a set of guiding principles for groundfish fishery management in state-waters. These guiding principles were adopted in 1997 (5 AAC 28.089) and are as follows:

> With state groundfish management expanding to cover the groundfish resources in the waters of Alaska, the Board of Fisheries (board) will be receiving regulatory proposals for these fisheries. The board will, to the extent practicable, consider the following guiding principles when taking actions associated with the adoption, amendment, or repeal of regulations regarding groundfish fisheries:
>
> 1. conservation of the groundfish resource to ensure sustained yield, which requires that the allowable catch in any fishery be based upon the biological abundance of the stock;
> 2. minimization of bycatch of other associated fish and shellfish and prevention of the localized depletion of stocks;
> 3. protection of the habitat and other associated fish and shellfish species from non-sustainable fishing practices;
> 4. maintenance of slower harvest rates by methods and means and time and area restrictions to ensure the adequate reporting and analysis necessary for management of the fishery;
> 5. extension of the length of fishing seasons by methods and means and time and area restrictions to provide for the maximum benefit to the state and to regions and local areas of the state;
> 6. harvest of the resource in a manner that emphasizes the quality and value of the fishery product;
> 7. use of the best available information presented to the board; and
> 8. cooperation with the North Pacific Fisheries Management Council (NPFMC) and other federal agencies associated with groundfish fisheries.

5.1.4 Alaska Board of Fisheries Management Plan for forage fish in the waters of Alaska

The Board of Fisheries has also adopted a regulation similar to that in force in groundfish fisheries in Alaska, prohibiting the direct harvest of certain species of forage fish.

> The board finds that forage fish perform a critical role in the complex marine ecosystem by providing the transfer of energy from the primary and secondary producers to higher trophic levels. The higher trophic levels include many commercially important fish and shellfish species. Forage fish also serve as important prey species for marine mammals and seabirds.
>
> The board finds that abundant populations of forage fish are necessary to sustain healthy populations of commercially important species of salmon, groundfish, halibut, and shellfish.
>
> Except as otherwise provided in regulation forage fish may not be commercially taken. A vessel fishing in a directed groundfish fishery may retain a maximum allowable bycatch of forage fish equal to no more than two percent of the round weight or round weight equivalent of the groundfish on board the vessel.
>
> For the purposes of this management plan, forage fish are defined as the following species of fish: family Osmeridae (capelin, eulachon, and other smelts); family Myctophidae (laternfishes); family Bathylagidae (deep-sea smelt); family Ammodtidea (Pacific sand lance); family Trichodontidae (Pacific sandfish); family Pholidae (gunnels); family Stichaeidae (pricklebacks, warbonnets, eelblennys, cockscombs, and shannys); family Gonostomatidae (bristlemouths, lightfishes, and anglemouths); species of the Order Euphausiacea (krill).

5.2 Matching AI ecosystem interactions to management objectives

Both the groundfish and crab FMPs have an extensive list of management objectives which are intended to guide decisionmakers about policy decisions regarding those fisheries. The FEP approach has been to look holistically at the Aleutian Islands ecosystem, and identify the important interactions that characterize the ecosystem. In Chapter 4, those interactions were evaluated through a qualitative risk assessment, to provide the Council and fishery managers with information about the probability and potential ecological or economic impact associated with changes in those interactions.

In Table 5-1, the interactions are compared against the management objectives that are currently operational in the groundfish and crab fisheries. This comparison is helpful to the Council in two ways. On the one hand, the existing management policies provide a filter for the interactions, which can assist the Council in prioritizing the results of the risk assessment. The comparison, however, also provides information on the different perspectives of the fishery management policy and the FEP. In general, the fishery management policies focus in depth on fishery and some socioeconomic aspects of management. The FEP highlights other important ecosystem interactions that managers may want to consider as part of their fishery management decisionmaking.

It is important to note that although there may not be a specific objective or policy element that addresses an interaction, which does not mean that the Council or fishery managers are oblivious of the interaction in practice. Chapter 4 discusses measures that the Council is currently taking to address the risk elements of each interaction. These are also summarized in Table 6-1.

Table 5-1 Matching interactions to fishery management objectives

AI Interaction	Comparable objectives in BSAI Groundfish FMP policy?	Comparable objectives in BSAI King and Tanner Crab FMP policy?
Climate/physical interactions		
A. water temperature	none	none
B. ocean acidification	none	none
C. changes in currents	none	none
D. weather patterns	none	none
Predator-prey interactions		
E. Fishing and predation mortality on managed species	Yes. • Adopt conservative harvest levels • Account for uncertainty and ecosystem factors in harvest levels	none
F. Bottom up productivity changes	Yes. • Limit harvest of forage species	none
G. Top down predator changes	No specific objectives, but goal to avoid impacts to marine mammals and seabirds.	none
Fishery interactions		
H. Total removals	Yes. • Cap optimum yield for the BSAI groundfish fisheries • Total allowable catch accounting • Account for bycatch mortality and improve the accuracy of mortality assessments	none
I. Stock structure	none	none
J. Effects on fishery habitat	Yes. • Identify EFH and HAPCs and mitigate fishery impacts to continue sustainability of managed species	Yes. • Ensure optimal habitat for juvenile, breeding, and exploitable crab populations • Consider impact of crab fisheries on other fish and shellfish populations
K. Effects on other habitat	Yes. • Implement marine protected areas as appropriate to maintain abundance, diversity, and productivity	Yes. • Consider impact of crab fisheries on other fish and shellfish populations
L. Effects of fishery bycatch	Yes. • Seasonal distribution of harvest and geographical gear restrictions • Prohibited species catch limits • Use gear and fishing techniques to reduce bycatch • Develop incentive programs	none
M. Impacts on subsistence	none	Yes. • Ensure that subsistence use is met

AI Interaction	Comparable objectives in BSAI Groundfish FMP policy?	Comparable objectives in BSAI King and Tanner Crab FMP policy?
Regulatory Interactions		
N. ESA-listed species	Yes. • Protect ESA-listed species, and if appropriate, other seabird and marine mammal species	none
O. Sector allocations	Yes. • Provide economic and community stability through fair and equitable allocations • Extend allocation programs	Yes. • Minimize gear conflict among fisheries through seasons, gear storage, and fishing area arrangements • Provide access to regulatory process to address allocation issues
P. Permits limit flexibility	Yes. • Provide for adative management by periodically evaluating effectiveness of allocation programs	Yes. • Provide access to regulatory process to address allocation issues
Socioeconomic Interactions		
Q. Community sustainability	Yes. • Provide economic and community stability through fair and equitable allocations	Yes. • Consider social and economic impacts of crab fisheries on coastal communities
R. Coastal development	none	none
S. Vessel traffic	Yes. • Cooperate and coordinate management and enforcement programs with various agencies • Promote increased safety at sea	Yes. • Provide public access to the regulatory process for vessel safety
T. Military	none	Yes. • Review any State or Federal actions with potential to adversely affect crab habitat • Promote new and ongoing research
U. Oil and gas	none	Yes.
V. Research	none	Yes.

6 Priorities and considerations for the Council

6.1 Summary of interactions and opportunities for Council action

Table 6-1 summarizes the interactions, the risk assessment on each interaction, and the implications for management of each assessment. For each interaction, the FEP has identified specific actions that the Council may wish to consider, either to obtain a better understanding of the interaction, or to mitigate the risk associated with that interaction.

The table uses the following columns to describe each interaction:

Risk assessment priority – Based on the risk assessment for each interaction evaluated in chapter 4, does the interaction present a low, medium, high, or unknown risk for fishery management? The rankings used in this table are summarized in Figure 4-3 and Figure 4-4.

Fishery management plan priority – Is the interaction addressed in the groundfish or crab FMP policy? More information on this column can be found in Table 5-1.

Within Council control – Do the Council, NMFS, or State of Alaska fishery managers directly influence this interaction?

Does the Council currently address this risk – How do the Council, NMFS, or State of Alaska fishery managers currently address the risk represented by this interaction?

What else might the Council do – What other approaches could the Council, NMFS, or State of Alaska fishery managers pursue to mitigate the risk associated with this interaction?

Table 6-1 Summary of interactions

Interaction	Risk assessment priority?	Fishery management policy priority?	Within Council control?	What is the Council currently doing to address this risk?	What else might the Council do?	
					Short-term	Long-term
A. Change in water temperature	high	no	no	Some Alaska research, not specific to AI.	• Monitor for big changes (need to define 'big')	• Encourage funding for physical data collection in the AI. • Encourage research into biological-physical linkages.
B. ocean acidification	high	no	no	NOAA program is investigating.	• Interact with NOAA program to encourage monitoring and investigation in the AI ecosystem	• Develop an ocean acidity monitoring program in AI • Encourage research into the threshold effects of acidification on different parts of the ecosystem
C. changes in currents	unknown	no	no		• Monitor for big changes (need to define 'big')	• Encourage funding for moorings in AI passes.
D. weather patterns	medium	no	no		• Monitor for big changes (need to define 'big')	• Encourage funding for AI weather stations.
E. Fishing and predation mortality on managed species	high	yes (gfish)	yes	Ad hoc, species by species. SSL protection measures are best example.	• Focus on species with the most important predator-prey interactions • Use food web model and mortality source estimates to characterize commercial species as primarily 'prey' or 'predator', and consider these differently	• Task new or existing management body to provide ecosystem-level advice, rather than species-by-species • Develop framework to 'assign' an amount of a species' productivity to its predators, when setting fishery catch levels • Implement mechanisms which more explicitly integrate ecosystem considerations into the allocation process

Interaction	Risk assessment priority?	Fishery management policy priority?	Within Council control?	What is the Council currently doing to address this risk?	What else might the Council do?	
					Short-term	**Long-term**
F. Bottom up productivity changes	high	yes (gfish)	somewhat	Some indices presented as part of Ecosystem Considerations chapter, but AI not well represented.	• Consider species' roles as prey and predator when assessing harvest levels • Encourage AFSC 'Fisheries Interactions in Local Ecosystems' initiative, and include study for AI.	• Consider estimating a measure of optimum yield for the AI ecosystem, that is updated on a periodic timeframe • Develop framework to adjust management for species with shared prey fields
G. Top down predator changes	medium	no (except for ESA, see below)	somewhat	For ESA-listed species, interactions are managed; other marine mammals and seabird populations are monitored	• Consider species' roles as prey when assessing harvest levels	• Analyze what level of apex predator biomass would cause substantial conflict with current fisheries
H. Total removals	high	yes (gfish)	yes	Total removals are well managed for the BSAI groundfish, but not necessarily specific limits for AI specifically.	• Evaluate AI framework of indicators for evidence of a distinct system, particular with regard to genetic flow and trophic linkages	• Evaluate need to develop an AI-specific groundfish cap
I. Stock structure	high	no	yes	Some research for certain AI species to look at whether AI population is distinct from EBS population.	• Encourage tagging and genetics studies, research into the interaction between physical and biological characteristics	• Modeling studies to determine biological impact of various scales of spatial management
J. Effects on fishery habitat	medium	yes	yes	Bottom trawl fishery constrained to historic fishing areas. Known sensitive areas closed to bottom-tending fishing gear.		• Encourage funding to discover distribution of substrate and habitat type in the AI, other baseline habitat studies in AI.

Interaction	Risk assessment priority?	Fishery management policy priority?	Within Council control?	What is the Council currently doing to address this risk?	What else might the Council do?	
					Short-term	**Long-term**
K. Effects on other habitat	unknown	yes	yes	As above.		• Need better sampling mechanisms for 'other biota'.
L. Impact of bycatch on fisheries	medium	yes (gfish)	yes	Council has myriad bycatch controls in place in the groundfish fisheries, from time/area closures, required gear modifications, seasonal harvest allocations, and a comprehensive observer program.	• Continue to improve accuracy in identification of bycatch species and quantification of removals. • Continue to encourage and promote development of bycatch reduction measures in gear design.	• Consider ways to collect finer scale spatial and temporal catch information. • Consider AI-specific bycatch regulations • Implement direct observation or other monitoring on smaller and halibut vessels • Improve/implement monitoring and stock assessment research of non-target and non-specified species
M. Impacts on subsistence	low to medium	yes (crab)	yes	Commercial fisheries do not pre-empt subsistence use.	• Encourage ADF&G to conduct subsistence surveys in AI communities. • Monitor species harvested in both subsistence and commercial fisheries for direct interactions	• Develop local/ traditional knowledge from the people of Atka and Adak. • Consider need for marine heritage zones around villages and important subsistence sites • Estimate and incorporate subsistence harvests into TAC allocations as appropriate
N. ESA-listed species	medium to high	yes (gfish)	somewhat	Council actively involved in development of protection measures for SSLs. Mitigation measures in effect for seabird bycatch.	• Monitor marine mammal and seabird species that breed and/or seasonally occur in the AI for signs of population decline.	• Consider need for action to mitigate against future changes in species of concern

Interaction	Risk assessment priority?	Fishery management policy priority?	Within Council control?	What is the Council currently doing to address this risk?	What else might the Council do?	
					Short-term	Long-term
O. Sector allocations	low to high	yes	yes	Council thoroughly considers and mitigates differing social impacts of sector allocations.		• Encourage research on differing impacts of sectors on bycatch and habitat
P. Permits limit flexibility	medium to high	yes	yes	Council builds in some options for flexibility into permit programs, in particular, entry-level opportunities.	• Continue to provide entry level opportunities as more constraining allocation programs are put in place	• In developing new programs, consider the timeframe at which the Council can change management measures to adjust to changing conditions
Q. Community sustainability	medium to high	yes	somewhat	Council considers effects on communities in planning management actions, and conducts a transparent management process that is open to the public.	• Encourage and actively solicit more participation in Council processes by community members from the AI by providing travel funds to attend meetings, video conferencing, and community liaisons	• Encourage development of community sustainability indicators to understand the relationship between communities, population, and ecosystems
R. Coastal development	low to medium	no	no	The Council's recently analyzed the effects of all fishery and non-fishery impacts on essential fish habitat, including effects of coastal development.	• Comment on any proposed actions that may adversely affect essential fish habitat	
S. Vessel traffic	high	yes	somewhat	NMFS/Coast Guard require and enforce vessel safety standards for fishing vessels.	• Engage with the State of Alaska/Coast Guard's vessel traffic risk assessment (through Alaska Marine Ecosystem Forum)	• Prepare contingency plan for a response to AI accident scenarios

Interaction	Risk assessment priority?	Fishery management policy priority?	Within Council control?	What is the Council currently doing to address this risk?	What else might the Council do?	
					Short-term	Long-term
T. Military	medium	no	no	Dialogue with Alaskan Command through the Alaska Marine Ecosystem Forum.	• Continue to interact with military through the Alaska Marine Ecosystem Forum, and track future planning	
U. Oil and gas	high	no	no	Dialogue with Minerals Management Service through the Alaska Marine Ecosystem Forum.	• Monitor lease sales and participate in development of analyses and mitigation for potential impacts on fish stocks and fisheries	• Identify sensitive areas where oil and gas development are not compatible with existing uses/habitat needs, and proactively seek to exclude oil and gas development where it might affect these areas
V. Research	low	no	no	Council has opportunity to comment on fishery experimental fishery permits, fishery managers involved through permitting.		• Encourage 'clearing house' of AI research activities

6.2 Area-specific management for the Aleutian Islands ecosystem

An objective of this FEP has been to bring together information about the Aleutian Islands ecosystem and examine it holistically. To achieve this objective, the FEP has synthesized a broad range of information from several sources and has described an ecosystem that functions differently than its neighbors, the eastern Bering Sea and the Gulf of Alaska. The physical environment of the Aleutians, with its narrow shelf and strong current system, creates a food web that is highly influenced by the open ocean. Even when the same species occur in the AI and in neighboring ecosystems, they generally have different feeding and habitat relationships. Socioeconomic interactions, both in terms of existing communities and other users operating in the AI, are affected by the area's remoteness and distinct characteristics.

This reinforced understanding of the area's unique characteristics leads to the conclusion that the AI is distinct and should be recognized as such by fishery managers when considering actions and regulations affecting the ecosystem. With respect to State-managed fisheries, including the Federal crab fishery, fishery managers already operate on a local to regional scale. It is important to note that even in the Federal groundfish fishery, which is managed on a Bering Sea/Aleutian Islands-wide scale, the Aleutian Islands ecosystem is often considered independently. The AI is identified as a subarea within the BSAI FMP that is separated by a major ecological boundary identified in this FEP. Many groundfish stocks are assigned separate harvest levels for the AI (e.g., Atka mackerel and Pacific ocean perch), and there are aspects of spatial management both in terms of groundfish harvest and protective measures for vulnerable species (see Table 3-6 for further detail).

However, chapter 4 highlights many instances where risk and uncertainty about the stability of the AI ecosystem could be reduced if groundfish management took into account the distinct features of the AI ecosystem relative to the Bering Sea. One big obstacle to this is the lack of data specific to the AI. As a result, this FEP highlights a series of data gaps and research needs that if addressed would bring managers closer to the goal of true sustainable ecosystem-based management. By explicitly considering the AI as a distinct ecosystem in environmental analyses, and not relying on a BSAI-wide perspective, the Council can begin to adjust management to take into account the distinctions between the two ecosystems.

The issue of whether the Aleutian Islands should be managed under a separate groundfish FMP was discussed by the Council in the 2005 discussion paper (NPFMC 2005), which eventually prompted this FEP. Reworking the FMP into separate Bering Sea and AI FMPs would be a considerable effort on the part of the Council and NMFS, with likely unintended consequences in the fisheries during the time of transition. Even though this may not be formally resolved in the short term, Chapter 4 of this FEP identifies ways in which the Council could serve to integrate AI ecosystem considerations and mitigate many of the risks within the existing groundfish FMP structure.

6.3 Improve process to account for ecosystem considerations in fishery management

Another conclusion from the FEP is the need to refine the fishery management process to more formally account for ecosystem considerations in management. This conclusion echoes a similar finding of the programmatic groundfish review that was conducted by the Council and NMFS in 2004 (NMFS 2004), and which was brought into the Council's groundfish management policy.

Currently, there is no group in the Council process with the primary task of integrating ecosystem information and providing ecosystem-level advice. Individual groundfish stock assessment authors are provided with ecosystem information (through the SAFE Ecosystem Considerations chapter) to incorporate into their stock assessments, as appropriate. To the extent that ecosystem factors influencing their stock and fishery are understood, the author's recommendations may reflect that influence. However, each author's focus is on their species and it is their decision whether to integrate these broader considerations or not.

Moving up a level, it is the primary role of the BSAI Groundfish Plan Team to recommend sustainable harvest levels for groundfish species. The Plan Team includes representation from non-groundfish disciplines (marine mammal, seabird, economic, ecosystem expertise), and considers ecosystem interactions for individual species as appropriate, but its 'task' is still primarily to recommend biologically acceptable levels of groundfish removals on a species by species basis, and conflicting goals between species are not necessarily explicitly addressed.

The role of the Crab Plan Team is even more limited than that of the Groundfish Plan Team in its consideration of ecosystem-level concerns. The Crab Plan Team does note recommend harvest levels for crab, rather it comments on stock assessments performed by individual agency authors and makes recommendations to them on model input and other variables. The Crab Plan Team generally includes non-crab experts in its discussions, principally in the habitat and economic disciplines.

The Council's Scientific and Stastical Committee (SSC) does take responsibility for attempting to integrate information across an ecosystem, and applying it to all management actions, including setting harvest levels. However, the SSC has many tasks, however, and must also comment on the soundness of the stock assessment analysis and methodology, as well as for groundfish harvest levels, and recommending species-specific acceptable biological catch maximums (ABCs). The difficulty comes into play when there is not necessarily a quantitative, scientific basis on which to adjust actual catch levels, but such an action may be desirable from a policy perspective to mitigate a perceived risk. Policy decisions are the prerogative of the Council, and not the role of the SSC.

The problem with the current process to incorporate ecosystem considerations is two-fold. First, decisions based on our current level of ecosystem understanding are likely to be qualitative or interpretative, because we often do not have enough data to provide reliable knowledge of the ecosystem connections. Even though the Ecosystem Considerations chapter is reviewed annually, and authors incorporate predator prey and environmental variables into their assessments as best they can, there is no formal overall consideration of whether the ecosystem is currently stable or vulnerable, or whether it is likely to cross a critical threshold under current or proposed management (see Figure 4-1). The idea would be to prevent driving over an ecosystem cliff with current fishery management by avoiding fishing-related thresholds that can be identified, as well as to mitigate the economic and social impacts of climate or other things out of Council control that may move the system over a threshold anyway.

The second issue is that the Council, as policy-maker, needs to have a formal role in deciding whether and how harvest levels are adjusted based on ecosystem considerations. In the current process, the Council accepts the SSC's ABC recommendations for each species, and reduces actual harvest levels (TACs) for some individual species to bring the sum of TACs in at 2 million mt for the BSAI (for example, in 2007 the sum of the BSAI ABCs was equal to approximately 2.7 million mt). Generally, some form of industry negotiation guides the Council as to which species' TAC will be reduced from the allowable maximum (often based on the inability of some fisheries to take the full quota based on other constraints such as halibut prohibited species caps). The Council may also, on an ad hoc basis, set a lower TAC due to environmental considerations.

The Council has the ultimate responsibility to balance risk imposed by the fishery and management actions. There are a number of ways the Council could be more involved at the ecosystem level. The ideal would be to develop a process for creating ecosystem 'control rules' to be implemented at the appropriate level (stock assessment, Plan Team, SSC) of the harvest specifications process. The control rules would specify, for example, that if a certain indicator crossed a given threshold, an action would ensue. Developing the process by which such rules would be put into use, rather than the rules themselves, would allow for adaptive management in the face of changing circumstances or understanding.

A first step towards developing indicator thresholds would be for the Council to articulate its desired or undesired state of the ecosystem. What are the characteristics of the ecosystem state that the Council is trying either to preserve or steer away from? This question links back to the discussion of ‘ecosystem health’ from the Council’s FEP goal statement (see Section 1.1). If the Council can define what it perceives to be a healthy ecosystem, it will be easier for its advisory bodies to provide recommendations that help to achieve that goal. It may also be useful, in the context of setting ecosystem objectives, to articulate what kind of ecosystem-level decisions the Council/ advisory bodies believe they have sufficient information to make, and which they do not.

6.4 Dialogue with non-fishery agencies

The FEP highlights activities ongoing in the ecosystem other than fishery activities. The Council actively confers with other fishery management agencies about AI activities, such as NMFS, the International Pacific Halibut Commisssion, and Alaska Department of Fish and Game. Through their participation on the Council, the US Fish and Wildlife Service and the US Coast Guard are also active partners with the Council. With other agencies, however, the Council’s dialogue is more limited. Given that the activities managed or engaged in by these other agencies may have direct impacts on Council resources, it may be important for the Council to engage more directly with these agencies.

A recent step taken by the Council should be very helpful in this regard. The Council was recently instrumental in setting up the Alaska Marine Ecosystem Forum (AMEF). The AMEF is a partnership between the Council, Federal and State agencies, who have signed a memorandum of understanding to create a forum for information exchange on marine ecosystem issues in Alaska. The AMEF is currently focusing on issues relating to the Aleutian Islands ecosystem area.

The Council may also wish to take more active steps to engage with other agencies. Participation in the AMEF increases the Council’s awareness about other activities ongoing in the region, and also provides other agencies with some input as to Council issues and concerns. Following up on those issues by inviting agencies to present information in front of the full Council, and discuss issues in front of Council stakeholders, would be another type of engagement.

6.5 Data gaps and research needs

Research needed to understand the interactions identified in this FEP is described in detail in chapter 4. Many of the interactions highlight a lack of data specific to the Aleutian Islands, particularly for climate and physical data. Although data needs are described individually under the interactions, what is needed is an ecosystem-wide monitoring scheme, under which strategic locations and parameters to be measured are identified.

The following table provides a summary of data gaps, into which the Council may wish to encourage research.

Table 6-2 Data Gaps for the Aleutian Islands ecosystem

AI Ecosystem Interaction		Data Gaps and Research Needs
Climate and Physical Interactions	*A. Interaction: Changes in water temperature may impact ecosystem processes*	• Increased number of moorings (which provide year-round temperature data at specific locations) at various locations. • Where possible, temperature should be monitored throughout the water column. Research on the effects of temperature on biological indices specific to the AI region, including research on the relationship of temperature to managed species as well as linkages between lower tropic level species and temperature
	B. Interaction: Increased acidification of the ocean may impact ecosystem processes	• Research to develop indices in order to monitor the ecosystem for the effects of ocean acidification. At present, there are no indicators of ocean acidification.
	C. Interaction: Changes in nutrient transport through the passes and changes in the predominant current patterns that drive primary production impact ecosystem processes	• Monitoring of transports in the passes • Nutrient measurements on moorings to estimate the mean and variability of nutrient transport • Extending monitoring and measurements to other locations (within and outside passes) • Research on the forces influencing transport in the passes, their variability, and possible change in the face of climate change • Research on the relationship of larval transport patterns and recruitment in the AI, particularly for rockfish.
	D. Interaction: Changing weather patterns impact ecosystem processes	• Weather stations located on a few of islands would provide important information for monitoring for changes in weather. • Research on ecosystem impacts of weather events or trends
Predator-prey Interactions	*E. Interaction: Fishing mortality and predation mortality both impact managed species*	• Diet information from seasons other than summer is needed to assess seasonal changes in predator-prey interactions. • Diet information collected at appropriate spatial scales for key predators to determine whether and how spatial food webs are changing in this ecosystem. • Continue monitoring of groundfish diets at both the AI-wide and smaller local scales • Expand or integrate existing databases to coordinate between seabird and marine mammal diet studies as well as lower trophic level studies.
	F. Interaction: Bottom up change in ecosystem productivity impacts predators and fisheries	• Specifically designed surveys to provide an index of low trophic level production (e.g., a zooplankton monitoring system), at multiple locations, local scales, and seasons
	G. Interaction: Top down changes in predation and fishing impact ecosystem structure and function	• Directed studies to understand how fisheries interact with apex predators at local spatial scales throughout all seasons • Coordinated monitoring of production indices for apex predators such as birds, marine mammals and elasmobranchs
Fishing Effects Interactions	*H. Interaction: Total removals from the ecosystem due to fishing impact ecosystem productivity*	• Information on the movement patterns of key fish species • Research into the linkages between food webs between the AI and EBS systems
	I. Interaction: Differences between spatial stock structure and the spatial scale of fishery management may impact managed species	• Research on the extent of spatial dispersal for many stocks • Studies on the reproductive biology, larval distributions, and larval drift patterns of key species • Research on how to incorporate stock structure information to define appropriate management areas • Modeling studies to address the level of conservation obtained from various management options

AI Ecosystem Interaction		Data Gaps and Research Needs
	J. Interaction: Impact of one fishery on another through fishing impacts on habitat	• Information on the distribution of substrate and habitat type, including relative proportions of habitat types or abundance of habitat-forming living substrate • Improved identification and quantification of removals of species in the broad "coral" category by the Fishery Observer Program • Improved or modified survey net design to enable survey tows to be conducted on rocky, hard substrates • Research focusing on the effects of fishing on seafloor habitat specific to the Aleutian Islands
	K. Interaction: Impact of a fishery on other biota through fishing impacts on habitat	• Specifically designed surveys to sample "other biota" • Improved or modified survey net design to enable survey tows to be conducted on rocky, hard substrates • Research on the role of these species in the ecosystem
Fishing Effects Interactions con't.	*L. Interaction: Impact of bycatch on fisheries*	• Improved accuracy in identification of bycatch species and quantification of removals • Improved spatial and temporal information on catches • Implementation of direct observation and other monitoring options (e.g. electronic logbooks, video monitoring) on smaller groundfish vessels and halibut vessels • Research and experimentation on the application of gear and deployment modifications • Improved or implementation (in some cases) of monitoring of non-target species • Stock assessment research for non-target species (i.e., life history, abundance, and assessment information)
	M. Interaction: Commercial fishery may impact subsistence uses	• Regular ADF&G multispecies harvest surveys in the communities of Atka and Adak • Compilation and evaluation of local and traditional knowledge from residents of Atka and Adak
Regulatory Interactions	*N. Interaction: Changes in the population status of ESA-listed species impact fisheries through specific regulatory constraint*	• What are the important links within marine food webs • How climate change affects marine communities at different trophic levels • Mapping overlaps in fishing effort and sensitive species
	O. Interaction: Sector allocations can impact the ecosystem and communities	• Research on effects of sectors on bycatch and habitat
	P. Interaction: Fishery participation permit systems (such as limited entry and harvest quotas) impact the flexibility of fishers to react to changing ecosystem conditions	• Socioeconomic research on effects of various management regimes
Other Socio-economic Activity Interactions	*Q. Interaction: Changes in fishery activities impact the sustainability of AI communities*	• Further development of community sustainability indicators in order to understand the relationship between communities, populations, and ecosystems
	R. Interaction: Coastal infrastructure and development impact the ecosystem and communities	• Effects of coastal development on managed and non-managed species
	S. Interaction: Vessel traffic, and risk of vessel grounding and spillage, may impact ecosystem productivity	• More precise and annual information on shipping traffic through the Aleutian Islands fishery ecosystem • Cross-tabulate shipping traffic information with information about critical areas in the Aleutians to form a vulnerability index

AI Ecosystem Interaction		Data Gaps and Research Needs
	T. Interaction: Changes in the level of military activity in the area may impact communities	• Enhanced interaction of NOAA with the Alaska military command structure and the Missile Defense Agency through the Alaska Marine Ecosystem Forum to inform about military activities in the Aleutian Islands
	U. Interaction: Oil and gas development may impact ecosystem productivity	• Research and development of ocean currents models, incorporating information on likely spill sites, fishing grounds or other areas of particular concern, and information about vessel traffic.
	V. Interaction: Research activity may impact fisheries	• Periodic “clearing house” review of research conducted in AI to track long-term trends in amount of research activity in AI subarea. • Review of permit status reports by permitees to document conflicts with fishing activities.

7 What is the 'value added' of this FEP process?

The Ecosystem Team concludes that this pilot project to develop a FEP for the Aleutian Islands has been a valuable and informative process to date. The FEP approach characterized the AI ecosystem, highlighted its unique and distinctive qualities, and compared that viewpoint against existing management objectives and policies. As expected, the existing management policies focus heavily on fishery effects and regulatory interactions, and aspects of predator prey relationships. The interaction of the fishery with physical and climate influences, and other ongoing anthropogenic activities in the ecosystem area are less of a focus. A true ecosystem approach to fisheries management requires consideration of not only the interactions among the fisheries and their target species, but also of broader ecosystem interactions such as climate, predator-prey relationships and other socio-economic activities. In order for the Council to move forward with an ecosystem approach to fisheries management, it will benefit by a broader perspective of several types of cumulative interactions highlighted in this FEP.

In that respect, the FEP is a great resource. It brings together useful and important information in one place, and provides insight into areas of risk and issues of concern which the Council should focus on for the AI FEP area. The sharing of expertise among team members and their contributions has been valuable; hopefully this document will serve as an equally valuable resource to other scientists working on Aleutian issues.

The FEP process has also been useful for identifying an indicator framework designed for the Aleutian Islands. Up to now, the Council has been presented with various indicator datasets, but on an ad hoc basis – whatever data happens to be available. The FEP process has allowed the Team to develop an indicator framework that caters specifically to the ecosystem's unique characteristics and key interactions, and as such the indicators will hopefully be more pertinent. This approach is also instrumental for highlighting important data gaps and research needs.

It was also beneficial to approach the FEP in phases. This first iteration of the document brought together existing information, and attempted to compile as much information as possible within the one year timeframe of its preparation. Time constraints required that the risk assessment initially be non-quantitative in nature. This initial version of the document provides a good platform for moving forward with other ideas to expand the FEP, and to conduct original research and analysis to support its expansion. This iteration of the FEP provides a useful starting point for developing a comprehensive ecosystem assessment, and for the Council to consider defining a 'desirable state' for the Aleutian Islands ecosystem.

Finally, the Team discussed whether it would be useful to apply the FEP process to other areas in Alaska, and whether the learning experience would be as rich considering more is known about those other ecosystems. The Team believes that it would behoove the Council to wait, and learn lessons from this FEP first. In order for the document to be useful as a tool for the Council, it will likely undergo changes and additions in the next couple of years and any future FEPs should benefit from this learning experience. However, the Team felt confident that the approach taken here has been appropriate to provide the Council with the intended guidance and hopes that it may serve as a template for other regions in Alaska and elsewhere.

8 Future Steps

8.1 How to use the FEP

The FEP is intended as a living document and should be updated periodically, i.e., every 3 to 5 years. The Team has also produced an overview of the FEP, to present visually the understanding of the ecosystem and implications for management that are addressed in this document.

Tracking Ecosystem Indicators

The FEP suggests a framework for indicators that could constitute an ‘ecosystem warning system’ to the Council, to monitor for changing conditions that might require fishery managers to respond. In some ways, it would make most sense for these indicators to be tracked by the Council in the annual SAFE report Ecosystem Considerations chapter. This report is presented to the Council on an annual basis, and many of these indicators are already tracked in this report, although the FEP may suggest ways in which these indicators can be adapted specifically to the AI ecosystem. However, the limited staff who are responsible for managing the chapter are already fully committed. The implementation of changes and additions to the AI indicators highlighted in the chapter will thus likely be a gradual process. For the new indicators, both those for which data is available and those for which it is not, a consideration of the time frame and mechanisms for monitoring these indicators is important. The FEP does not currently provide recommendations on the desired frequency or mechanism for tracking these indicators.

Another consideration is that the Ecosystem Considerations chapter is currently geared towards the groundfish fishery and is a part of the groundfish SAFE document. Some of the other indicators suggested in the FEP deal with other fisheries, such as data on the crab fishery, or require data from non-NOAA sources, such as information on other socioeconomic activities occurring in the ecosystem. The AI Ecosystem Team members may be able to help provide contacts at other agencies to obtain information to track these indicators. Alternatively, the Council may be able to obtain such information through its discussions with and participation on the Alaska Marine Ecosystem Forum.

Currently, feedback from the indicators will be entered into the Council process through the Ecosystem Considerations chapter, which is presented annually at the groundfish plan team meeting, and its information is available to stock assessment authors for developing their assessments. It is also presented to the SSC, Advisory Panel and Council at the time of Council decisions on groundfish harvest levels. Information from the Ecosystem Considerations chapter is currently not formally presented to other plan teams. To serve its purpose as a ‘warning system’ for the AI, the Council may need an evaluation of the AI indicators to see whether any warning signs have been ‘triggered’. AFSC scientists include an ecosystem assessment as part of the Ecosystem Considerations chapter, and intend over time to develop it into such an evaluation that would assess ecosystem considerations with respect to designated thresholds. At some time in the future, the Council may want to consider tasking a group of AI experts to assist in this effort.

Periodic re-evaluation of the FEP

The FEP should be re-evaluated on a 3-5 year basis. The interactions that were selected as important by the Team would need to be reevaluated to see if they are still the most important interactions to capture the characteristics of the ecosystem. Also, it is hoped that on that time cycle, some of the new indicators would have available data, and trends may become apparent to show whether large scale changes are occurring in the ecosystem. The Council has tasked the Aleutian Islands Ecosystem Team with updating the FEP, and providing annual reports to the Plan Teams and the SSC.

Tool for environmental analysis

On an immediate basis, it is to be hoped that the FEP would be useful to staff conducting management analyses, such as NEPA documents and other environmental assessments, relating to the actions affecting the AI ecosystem. In particular, analyses should consider impacts at an Aleutian Islands ecosystem scale to the extent possible, rather than just a BSAI-wide scale.

Task forces

The Chapter 4 discussion of the interactions identifies a number of action items requiring further work to better understand each interaction. One way to sort through these actions might be to utilize the Council's Ecosystem Committee, to coordinate and prioritize some of the interactions and their implications for management. Working with the Ecosystem Committee, individual 'task forces' might be created to address some of the specific issues identified in the FEP.

Role for the Aleutian Islands Ecosystem Team

The AI Ecosystem Team remit was originally to write the FEP. The Council has requested that the Team remain active, as the designated group to help the FEP serve an effective role in the Council management process. Specific tasks for the team are as follows:

- refine the FEP on a periodic basis as new information becomes available,
- bring forward the assessment of FEP indicators and AI modeling to the Plan Teams, on an annual basis,
- report to the SSC with regard to the FEP indicators and updates to the document, and
- serve as a conduit for the Council to provide Aleutian Islands FEP information to other agencies, through the Alaska Marine Ecosystem Forum.

In order to make the document useful in the way that is envisioned, it will need both periodic updating and revising. As it is brought to bear on management actions and analyses, the Council and staff will discover elements and tools that are not a part of the FEP, but might be included. The Team will help fine tune the document in order for it to be truly useful to the Council in this respect. Additionally, the Team will consider how to move forward with enhancements to the FEP, such as are discussed in Section 8.2. In order to approach these tasks, the Team may consider holding an annual meeting, after which they would report to the Plan Teams, SSC and Council.

8.2 How to build on the FEP

There are a number of ways in which the FEP could be expanded, and further research and analysis would perhaps allow the document to be more useful to the Council. Below are some suggestions of ways to expand the FEP.

- Provide a comprehensive ecosystem assessment. This could include defining 'ecosystem health' through a public process, providing a baseline assessment of the ecosystem, determining whether the ecosystem is currently in a degraded state, and determining where we are with respect to the red green states identified in Figure 4.1. Where possible, the FEP should identify whether natural or anthropogenic influences have caused the ecosystem to move into its current state.

- Relative to the above, the Council could initiate a public process to identify undesirable states for the ecosystem. The FEP could be expanded to analyze the likely costs and benefits of moving away from the undersirable state for those areas which the Council may have control over.

- Pursue a detailed discussion of cumulative influences of the interactions. Identify which species are more vulnerable due to their life history and multiple risks operating on them. Once sensitive species or resource components are identified, the Council may wish to take further action to address the risk associated with those species.

- Analyze and identify ecologically important areas within the Aleutian Islands. Audubon Alaska has begun such a project with respect to seabirds; the Council could use this model to address other ecosystem components. Use spatial resolution of FEP food web model to look at finer spatial scales.

- Consider the FEP's connections outside the specified boundary. Relationship with Russian species and ecosystems, different ecosystems along the AI archipelago. It has been noted that the eastern Aleutians play a critical role as a transition zone for the GOA and EBS. The FEP could be expanded to consider these connections.

- Integrate this FEP process with Sea Grant which is developing a research database for the Aleutians.

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9.2 Preparers

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Appendices

Appendix A	Community meetings and public input on the development of the FEP
Appendix B	History of natural resource exploitation
Appendix C	Species listed under the Endangered Species Act
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Appendix A Community meetings and public input on the development of the FEP

Meetings of the AI FEP team were open to the public. Attendance included representatives of non-profit organizations and Adak Fisheries, LLC. The FEP was also discussed at Council meetings in October 2006, and February, April, and June 2007. In addition, the team sought to affirmatively solicit comments from members of communities within the fishery ecosystem, Atka and Adak. The Council also requested a community meeting opportunity in Dutch Harbor/Unalaska, including Nikolski and Akutan, as communities adjacent to the fishery ecosystem and with significant processing ties to AI fish in Dutch Harbor and Akutan.

ADAK

An AI FEP team representative will be going to Adak between May 20th and May 24th to meet with community members and solicit feedback on the plan.

Meeting summary

- Comments on choosing the Aleutians as the pilot FEP area
- Comments and clarifications on the FEP
- Additional ways the Aleutian ecosystem is different from the Bering Sea or the GOA
- Development and supporting an Adak small boat fishery
- Marine mammal (Steller sea lion, sea otter) protection measures and how they impact Adak

Adak Meeting Attendance
Rod Whitehead, FV Larisa M
Bernardo Diaz, Adak Fisheries
Michael Swetzof, Adak Fisheries
Dave Fraser, Adak Fisheries
Esther Bennett, Adak Fisheries, subsistence user
Richard Koso, Local Business, fisherman
Mike Downs, EDAW, NPFMC Contractor
Jack Stewart, Local
Stev Weidlich, EDAW- NPFMC Contractor
Steven Hines, City of Adak
Joe Galaktionoff, Adak Petroleum

ATKA

A community meeting was scheduled for May 11th at 4pm in the Community Building. Weather prevented the AI FEP team member from getting into Atka so the meeting was not held. Printed materials were sent to the community.

DUTCH HARBOR/UNALASKA including Akutan and Nikolski

AI FEP team members Diana Evans and Forest Bowers held a community meeting in Dutch Harbor on March 21st 2007 in the Unalaska City Council Chambers. No representatives from Akutan and Nikolski attended the meeting.

Meeting summary

- Discussion and clarifications on the purpose and use of the FEP, and the risk assessment
- Comments on missing elements, risk assessment methodology, and the FEP's reliance on models
    - food web model looks at 2 degree spatial variation; what about differences north/south?
    - are we building human history and human observations into the models?
    - should evaluate periodically for sources of bias (in models, among FEP team members)
    - should evaluate positive future changes as well as adverse ones
    - project is trying to assess resilience, but that is difficult to achieve through models

Unalaska Meeting Attendance
David Gregory, Unalaska Community
Dave Boisseau, Westward Seafoods
Evelyn Dickerson, Unalaska Native Fishermen's Association
Dustan Dickerson, Unalaska Native Fishermen's Association
Tom Enlow, UniSea
Sarah Duncan, International Pacific Halibut Commission
Reid Brewer, Alaska Sea Grant Map Unalaska
Brian Dixon, NOAA Fisheries
Peggy Osterback, Aleut Marine Mammal Commission
Frank Kelty, City of Unalaska

Appendix B History of natural resource exploitation

History of exploitation

The Aleutian archipelago has been occupied by humans for nearly 9,000 years (Laughlin 1975). Prior to the arrival of the Russians, the Aleut population numbered about 16,000 inhabitants with 6,000 in the western and central islands and the rest distributed from eastern islands to Port Moeller. Each group of islands was occupied by independent polities with varying degrees of contact with each other as well as the mainland. Their culture was based on marine resources, with particular reliance on marine mammals such as sea otters and fur seals. Common uses, besides food, included fur for clothing, covers and bedding (e.g. sea lion and hair seal skins were used to sit on, sleep in, or cover objects with; guts were used for waterproof garments and utensils). Fox furs were also utilized in the eastern islands, and skins of various land and seabirds supplemented the Aleuts' needs. Down and feathers from seabirds were used for clothing and decoration, bones for needles and nose sticks, beaks for jinglets and rattles, wings for fetishistic purposes. Nets and seines were known to the Aleuts, yet they were not common or universal (Hrdlicka, 1945, Ransom 1946). Living in the islands with little additional resources other than those available locally, the Aleuts kept close track of abundance, distribution and even behavioral changes of animals in their surroundings. Although Aleut populations were not evenly distributed throughout the islands, their population density with respect to the marine exploitation area was uniform over the three regions (eastern, central and western) (Laughlin 1975). Close observation of spatial changes in the amount of resources and their even exploitation was lost after the Aleuts lost control over the marine resources. The level of resource use switched from subsistence requirements to maximization of short term profits –regardless of local changes in abundance or distribution of the resources. This profits-oriented ethic remained mostly unaltered for the next 250 years.

Russian colonial exploitation, 1741-1867

The most significant feature of the Russian colonial period of Alaskan history from an ecological and economic standpoint is the fur trade, a series of exploitative waves which removed sea otters, fur seals, and other mammals from the Gulf of Alaska, Aleutian Islands, and Eastern Bering Sea ecosystems in unprecedented numbers (Figure 1.2-2), while generating wealth for Russian, British, and American corporations, and fashion for European and Chinese markets. The wealth was substantial: "By 1867, the year of the Alaska purchase, Russia had exported Alaskan furs worth over six times what she accepted for the vast territory herself (Matthiessen 1987)." But associated with the Russian fur trade are equally significant social impacts; the displacement and forced servitude of many Aleuts and Pacific Eskimos of the Gulf of Alaska, whose hunting skills and free labor, gained by violent coercion, became essential to the Russian traders' business (Gibson 1996). Ecological impacts were not measured at the time, but we do have information on the separate population impacts to sea otters and fur seals, which are detailed below, and viewing the entire exploitation history reconstructed here suggests hypothesized ecological impacts to test with modeling (chapter 2).

Vitus Bering is posthumously credited with "discovering" the fur resources of the Aleutian Islands for Russia after his officially mandated exploratory expedition returned to Siberia in 1742 without him, but with the recorded observations of the naturalist Georg Steller, and with 900 sea otter pelts (Wickersham 1927, Lensink 1960). Soon Russian vessels were sailing westward along the Aleutian chain, more intent on "soft gold" exploitation than exploration: "Once at sea, the Russians navigated more on the principle that the Aleutian Islands were close together and hard to miss, [rather] than on mathematical calculations (Mohr 1977)." The fur traders operated independently of the Russian government; this invasion was purely economic and funded by private investors, and therefore subject to no regulation (Haycox 2002). By 1760, sea otters were already depleted in the western Aleutian Islands, driving the fur traders further east to the Alaska Peninsula, Kodiak, Prince William Sound and Southeast Alaska (Wickersham 1927, Mohr 1977). Kodiak was where Gregori Shelekhov established the first permanent Russian settlement in 1783, and soon after in 1784 the first Russian salmon fishery was established at the Karluk River in Kodiak to supply local needs (Mohr 1977, Browning 1980). By this time, the native Aleut population had also been reduced by violence and disease to the point where Russian traders faced a shortage of hunting expertise and began conscripting Koniag sea otter hunters as well (Gibson 1996).

By 1775, sea otters in the Aleutian Islands had declined so much that the Russians developed renewed interest in fur seals, which had less valuable pelts than sea otters because guard hairs had to be laboriously plucked (Sulzer 1912, Mohr 1977), but these animals had been taken only occasionally in the water. The Russians again depended on Aleut ecological expertise to surmise that fur seals must breed north of the Aleutian Islands in the Bering Sea, based on reported migration patterns through Aleutian passes in the spring and fall. Active searches ensued to the north, where in 1786 Gerasim (or Gavriil, historians disagree on his first name) Pribilof found the islands used by the fur seals as their major rookeries (Sulzer 1912). He left a small party on the islands for a year, who managed to nearly extirpate the local sea otters as well as collecting 40,000 seal skins and 15,000 lbs of walrus tusks before Pribilof returned in 1787 (Sulzer 1912). That year, the Pribilof Islands' sea otter population was hunted to extinction (Matthiessen 1987). Aleuts were forcibly relocated to the formerly uninhabited and newly named Pribilof Islands to conduct the seal hunt (Gibson 1996), and their descendants remain there to this day. By 1799, the chaotic free exploitation by nearly 40 different Russian investment companies (and associated inefficiencies) were ended when the Russian government granted a monopoly to the Russian American Company to conduct the fur trade, by then predominantly in fur seals (Haycox 2002). While the fur seal hunts took place on rookeries in the Eastern Bering Sea, fur seals forage in the Gulf of Alaska and throughout the Pacific during the winter (Reeves et al 1992); therefore the intense exploitation of this apex predator on its breeding grounds between 1786 and 1867 (and later at sea in the Gulf of Alaska itself) represents a potentially important historical ecosystem impact throughout the North Pacific.

The Russians apparently never intended to occupy Alaska to establish a self-sufficient colony for the homeland, or even to learn to hunt sea mammals for themselves; "their chief objective was the exploitation of the available resources, mostly furs, on the least costly terms possible. Reflective of their concept of colonization in Alaska, the largest number of Russians ever in America at one time was a mere 823 (Haycox 2002)." Russian colonialism in American was actually an emergent property of exploitation by individual economic interests, as opposed to a government-sponsored and centrally controlled occupation (Haycox 2002). The exploitation benefited the government, however; between 1745 and 1823, a minimum of 123 boats came back to Siberia from North Pacific expeditions with 2.8 million declared sea otter, fox, and fur seal pelts (Mohr 1977). Given the economic incentives not to declare every pelt (ie, taxes), we may assume this is a minimal Russian take. But the Russians were not alone in exploiting marine mammals during the Russian colonial period; the British and American fur trade was well established in the Gulf of Alaska by 1792, peaking by 1812 (Mohr 1977). The period 1785-1825 had 300 fur trading ships recorded on the Northwest coast. Relationships between the fur trading colonial powers were altered over time by both external and internal events. In the competition for the North Pacific-China fur trade, Americans eventually dominated because the British were occupied with the Napoleanic wars in Europe. Russian and American traders initially cooperated; for example, Russian-enslaved Aleut hunters were provided to American vessels for the mutual profit of Americans and Russians, but eventually the Americans provided furs direct to China by sea, undercutting Russian prices (Mohr 1977). The Americans also undermined the Russian "relationship" with the Tlingits of Southeast Alaska by providing the essentials of "liquor, arms, and munitions" in trade for pelts so that again Russians had to pay natives more (Mohr 1977, Gibson 1996). Eventually, with fur stocks dwindling and profits eroding, the colonial nations switched to ride a new wave of exploitation: whaling.

In 1835 a whaler observed “abundant sperm and right whales” off Kodiak in the Gulf of Alaska, during the first Yankee exploration of the North Pacific (Morgan 1978). Whalers from the North Atlantic were exploring the Pacific whale stocks after nearly extirpating more local whales (Ellis 1991), largely uninterested in the fact that the Russians were already there. In contrast to the whalers in search of oil and baleen to supply European lighting and fashion markets, the Russians on Kodiak were just trying to eat, so they hired natives to kill a few whales for them in the early 1800s, and also had established a fishing industry of sorts to supply local needs. Right whales (so called because they were large, docile, and floated when killed, making them the “right” whale to hunt) from the Gulf of Alaska were the main target of first pelagic whaling wave in the Gulf of Alaska, and were heavily exploited from 1835 until 1848 (Scarff 2001, Shelden et al 2005). Just as the right whales were obviously severely depleted, bowhead whales were “discovered” in the Bering Sea (Bockstoce 1978). The next gold (or oil) rush was on, and the bowheads were 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 reduced to a quarter its original size; idle whalers hunted the walrus for ivory while they waited for ice to break up or bowheads to migrate by (Haycox 2002b). Bowhead whales were saved from full extinction by a combination of economic and social forces. First, there was a directed Civil war attack on the Yankee whaling fleet in which the Confederate vessel Shenandoah cruised 58 thousand miles between 1864-65 to destroy 29 whaling vessels and capture 38 more (Mohr 1977). Then, there was the discovery of petroleum oil and associated invention of plastics—diminishing the need for whale oil to light the lamps of Europe and America—and a final bad Arctic ice year (after many between 1871 and 1897) that crushed a significant portion of the active whaling vessels. It finally cost too much to catch the remaining bowhead whales for the companies to make any money on the products (Bockstoce 1978). For the Russian American Co., whaling never really got off the ground; they finally got 6 ships out in 1851 but the whaling was not profitable enough, and then the Crimean war with France and England removed financial backing entirely by 1854 (Mohr 1977). Eventually, declining profits in the fur trade, combined with evidence from the Crimean war of the limited capability of the Russian Navy to defend the colony from takeover, led Russia to sell its occupied territory in 1867 to a willing buyer (and the most likely invader), the United States of America (Haycox 2002).

History of commercial exploitation in the Aleutians

A bridge between Asia and North America, the Aleutian Islands boast a rich marine biodiversity that has evolved to withstand the strong winds, earthquakes, volcanic eruptions and tsunamis typical of the region. Despite the harsh conditions and sparsely scattered of settlements throughout the Aleutian chain, the history of the large scale exploitation of its natural resources has been almost uninterrupted for the past 250 years (Table 1). From fur trading to whaling and fisheries, the commercial ventures in the archipelago have a complex history of exhaustive exploitation followed by reactive conservation measures. Thus the islands’ current wealth of resources is the combined result of environmental conditions (e.g., productive seas) and cumulative exploitation/ conservation actions. The archipelago is divided at Amchitka Pass by the 180˚ meridian, so about half of the island chain, closes to Asia, is in the Eastern Hemisphere, and the half closest to North America is in the Western Hemisphere. This location generates economic and environmental driving forces from opposite ends that meet in an alternating/simultaneous manner in time and space. The interplay of these forces shapes the marine environment in a longitudinal gradient of predominantly Asian/oceanic nature in the Eastern Hemisphere and North American/coastal in the Western Hemisphere. It has also divided the history of the islands into exploitation waves coming from Russia and Japan (reflected in the name “Near Islands” identifying the westernmost group closest to Asia), and those coming mostly from America, but also Britain/Canada. Fisheries exploitation from the eastern nations came to an end with the passage of the Magnuson-Stevens Fisheries Conservation and Management Act (MSA) which extended US jurisdiction to 200 mi. offshore. Since then, domestic fishing activities have been based off the Alaska Peninsula and Dutch Harbor, in the eastern Aleutians.

Key historical events in the Aleutian Islands and timeline of exploitation of natural resources, 1740-2005. Modified from Ortiz (2007).

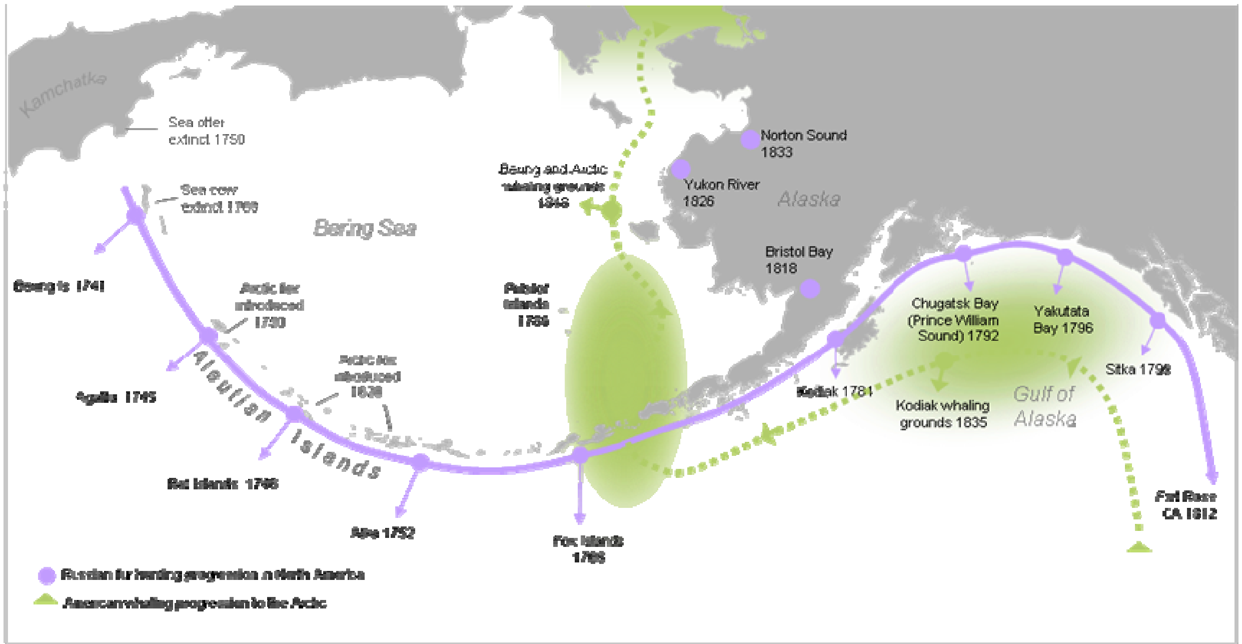
	Natural Resource Exploitation	Key Historic Events	
1745-64	First Russian/European exploration of the Aleutians	Bering arrives to Commander Islands	1741
1750	Arctic fox introduced in Attu; sea otter extinct in Kamchatka		
1768	Sea cow extinct	First wintering at Kodiak	1763
1784	Permanent settlements at Kodiak & Unalaska	Cooks's third voyage California-Bering Strait	1776
1786	Discovery Pribilof Islands	Ships from Flanders, France, Spain, England and California reach Alaska and Aleutians	1785-87
1792	Sea otters extinct at Kodiak-Kenai Bay; new settlement at Chugatsk Bay	English sell sea otters at Canton	1788
1796	Sea otters extinct at Chugatsk Bay; new settlement at Yakutat	Beginning of Russian American Company	1799
1802	800,000 fur seal skins spoiled in storage	Fur prices drop in China	1803
1804	Fur seal hunting ban		
1808	Ban removed		
1810-13	700,000 skins burned in Unalaska	Second charter of Russian American Co.	1819
1812	New settlement Ross in California	15 permanent settlements in Alaska	1820
1820	Sea otters extinct at Yakutat, Icy Bay, Cape St Elias	English trade throughout AK, except near Russian colonies	1825
1828	Fox introduced to Andreanof/ Rat Islands; only 300 sea otters furs at Atka; trade minimal	Native trade for Russian American Co. in Yukon-North Slope	1826
1828-50	Moved people from Amchitka to Adak and Atka to let sea otters at Rat Islands rest	Panic of 1837 (economic depression)	1837
1835	First whale killed at Kodiak by Yankee whalers		1840-50
1840	700 whaling, fishing and fur hunting American vessels active I North Pacific	Third charter of RA company begins	1844
1848	Arctic whaling begins, Dutch Harbor main stocking station	Sea otter fur prices decline	1845
1867	American whaling in AK; pelagic sealing	Gold Rush in California	1848
1880	First steam whaler returns from Arctic	Russian-American Co losses fur monopoly	1857
		Oil well discovered in Pennsylvania	1859
		Sale of Alaska to the United States/ Independence of Canada	1867
		US transcontinental railroad completed	1869
		Fashion for wide skirts crinolin made of baleen	
		Gold rush at Nome	1899
1905	Steller sea lions scarce		1903
1912	Shore whaling station at Akutan	North Pacific Fur Seal Convention	1911
1920	Peak cod fishery	Alaska becomes territory	1912
1939	Akutan shore whaling station closes	Aleutian Islands Wildlife Refuge established	1913
1913-40	Fox farming	WWI	1914-18
1950-72	Modern whaling	International Pacific Halibut Convention	1923
1952	High seas salmon fishery	Great Depression	1929
		Aleut internment?	1943
1960	Foreign crab & groundfish fisheries begin	WWII	1944
1962	POP *6336c2 f5sher5es start	International Whaling Convention	1948
		Island restoration by removing fox began	1949

	Natural Resource Exploitation	Key Historic Events	
		International North Pacific Fishery Commission	1953
1963	Sablefish and Greenland Turbot fisher5es start	Foreign fleets restricted to west of 175°W	
1970	Flatfish fishery beg5ns	Alaska and Hawaii become states	1959
1972	Atka mackerel fishery beg5ns	Marine Mammal Protection Act	1972
1980	Joint ventures begin	Endangered Species Act	1973
1990	Groundfish fleet fully domestic	Fisheries Management Conservation Act	1977
1997	Steller sea lion listed endangered under ESA	200 mi EEZ worldwide	1982
2000	Pollock fishery almost closed		

Commercial exploitation

During the early Russian period (1741-1799), discovery and intense exploitation went hand in hand. Lack of involvement and direction from the Russian government allowed the traders to hunt on land, unrestrained, and investments on exploration were secured by maximizing the number of furs obtained per trip. The discovery of the entire Aleutian region spanned some 20 years (Haycox, 1997) (**Error! Reference source not found.**). Along the way Aleuts were encountered and used as hunters and arctic foxes were introduced to islands formerly devoid of them (Black 2004). The extirpation of sea otters from the Kamchatka Peninsula and their decline along the western Aleutians pressed the fur traders to the east, arriving on the Alaska Peninsula in 1760 (Smith 2003). An earthquake had reportedly scared the sea otters away from the Kuriles in 1780, and there were subsequent declines in the sea otter populations along the Aleutian archipelago that directed exploration towards southeast Alaska (Berkh 1823, Tikhmenev 1861, Black 2004). The fur traders continued to exploit and explore Alaska until 1799. In all, the independent traders brought to Russia an estimated 1,120,000 furs: roughly 76% from fur seals, 12.5% from sea otter, and 11.5% from various types of foxes, not counting furs in storage houses or from land mammals other than foxes (Berkh 1823). These first 50 years of exploitation by independent fur traders yielded more sea otters furs than the subsequent 65 years under the auspice of the Russian American Company.

In 1798 Shelikov formed the Russian American company and was awarded the fur trade monopoly in 1799 (Berkh 1823, Tikhmenev 1861, Black 2004).The Russian American Company was modeled after the Hudson Bay Company and the British East Indian Company as a private enterprise in charge of trade, and served as the de facto local government. However, unlike the independent fur hunters who had no competition at the beginning, the company faced the established American and British trade, and its monopoly on fur trade was only within Russia. Under the freedom of the seas doctrine, waters more than 3 miles from the coast were considered international waters. James Cook’s maps of the northwest coast were widely distributed (Hayes 2002), and the stories of the high prices obtained by his crew in exchange for sea otter furs at the port of Canton were highly publicized (Haycox et al. 1997). In the late 1780s, Alaskan waters were visited by Spain, the United States, England and France (Black 2004). British and American ships had continued sailing along the Northwest coast trading with the natives for furs (Malloy, 1998), eventually flooding the Chinese market with cheaper furs and causing prices to fall (Gibson 1992, Black 2004).



Initial advance of Russian fur hunters and American whalers during the Russian period 1741-1867. Reprinted from Ortiz (2007).

The Russians reacted by increasing the number of settlements, but had difficulty supporting those settlements without relying on international traders (Okun 1951, Black 2004). The company thus had gained domain over the land in Alaska, but at sea the independent American whalers and traders prevailed. The first right whale killed at Kodiak (Gulf of Alaska) in 1835 marked the beginning of American commercial whaling in Alaska (Starbuck, 1878). Hunting grounds extended east to the nearby Fox Islands (eastern Aleutian Islands) where right whales were commonly seen (Shelden et al. 2005). After only five years (1840) there were at least 250 American vessels whaling, fishing, and fur hunting in seas which fell under the jurisdiction of the Russian American Company (Alekseev 1990). Ten years later, in 1845, catches deteriorated markedly (Bockstoce 1986) but the discovery of bowhead whales in the Arctic and Bering Sea grounds gave rise to a second whaling surge farther north.

The Russian American Company operated from 1799 to 1864, and shipped to Russia a total of 1,678,000 fur seal skins, 117,000 sea otter pelts, and 128,000 fox furs, all of them largely obtained during its first of its three charters. Overall, catches declined steadily during the company’s lifetime. Aggravating these circumstances was Russia’s lack of means to defend the colonies in the event of war, and so in 1867 the American colonies were sold to the United States in the Alaska purchase (Berkh 1823, Tikhmenev 1861, Okun, 1951, Black 2004). The US-Russia Convention Line of 1867 delimits the Aleutian Islands east and west of 170°E, so the Commander Islands (easternmost portion of the Aleutian Archipelago) remained under Russian jurisdiction.

Disregarding the Russian experience, American fur seal hunting was unrestrained between 1867 and 1868, when 140,000 animals were killed. The US Treasury Department intervened, leased the hunting rights on the island to a private company and imposed the Russian practice of selecting individuals by sex and age (Riley 1967). Just like its predecessor, the US did not have control over the offshore waters and as whaling vessels took on fur trading to offset declining catches, fur seal hunting shifted from land-based to pelagic operations. The pelagic hunting extended from around the Pribilof Islands to the Aleutian passes and the waters of the Gulf of Alaska (Bockstoce 1977, Jordan 1898).

Whaling ships eventually participated in pelagic sealing as well when whale populations declined. Bowhead whales had been depleted very quickly, but whaleships had taken walruses from 1859 to 1878 to make the trip worthwhile (Bockstoce 1986). By the time whale catches in Kodiak were rare, the Aleutian Islands were visited frequently as ships had to enter the Bering Sea through the passes and get provisions (Starks 1923, Tønnessen and Johnsen 1982). Whale oil prices declined, but those of whalebone for the fashion industry and multiple other purposes consistently increased. This, combined with cheaper shipping costs, allowed whaling to continue (Bockstoce 1977). American whaling profits were substantial despite the losses. From 1835 until after the Alaska Purchase, the northwest coast whaling grounds produced 60 percent of all the oil secured by the American whaling fleet (Kushner 1972). In 1880 offshore whaling had a third boost with the inception of steam whaling and later a final boost with the entrance of schooners to the fleet. Dutch Harbor became a frequented port, as passing steam whalers would get coal, supplies, and catch and salt cod (Bockstoce, 1977). It is in this last phase that fur trade became an additional incentive for the schooners, when furs offset the losses from the declining baleen catches (Bockstoce 1977). Whaling in the western Arctic ended in 1907 but by then pelagic sealing had long become a worthwhile pursuit on Alaskan waters.

By 1889, pelagic sealing was taking around 30,000 seals per year, one fourth of the total catch. In the 1890s pelagic sealing increased to 40,000 and 60,000 seals (86 percent of the catch) despite the Fur Seal Arbitration Tribunal banning pelagic sealing within 60 miles from the Pribilof Islands and the Act of Congress in 1897 banning pelagic sealing to all American vessels and citizens (Anonymous, 1907). This simply re-distributed effort south, towards the Aleutian passes and Gulf of Alaska, where fur seals herds could be found on their way to the Pribilofs. Pelagic sealers came from east and west as Canadians and Japanese continued to take seals in the water. The stock declined from an estimated 1,000,000 in 1891 to 185,000 in the early 1900s (Anonymous 1907). Scientific opinion was split as to the cause of the decline, some blaming the land based practices and others the pelagic catch; the issue became a highly publicized international affair. After multiple negotiations, Japan, Russia, the United States and Great Britain (for Canada) accepted the North Pacific Fur Seal Convention of 1911. Pressed by environmentalists, the United States issued a complete sealing moratorium in 1913. The moratorium lasted 5 years, the scientific debate was unresolved, and the recovery of the herd was and is still considered one of the biggest victories of conservation efforts and management (Fur Seal Investigations 1896, Hornaday 1920, Jordan 1913, 1920, Riley 1967).

An amendment to the North Pacific Fur Seal Convention also ended the international hunting of the nearly extinct sea otter, which had been recognized on the brink of extinction as early as 1895 (Dall 1896). The Act of 1910 had approved protection of the seal fisheries, sea otters, and fur bearing mammals in Alaska. The sea otter hunting had increased concurrently with pelagic sealing (Bureau of Fisheries 1906), and by the time the Convention was signed, the total number of sea otters was estimated between 1,000 and 2,000. Although both sea lion and walrus were also reported nearly extinct at this time, no direct law was issued to protect either one specifically. Whaling (the industry behind walrus hunting) had ended and sea lions were hunted by native Alaskans only. The Pribilof Islands had been named a Reservation in 1869, but this did little to prevent walrus hunting during the whaling era. Similar to the Russian's observation on the impact of whaling on native Alaskans (Alekseev 1990), the US Bureau of Fisheries (1906) noted they were the most affected by the depletion of sea lions, as the native Alaskans' dependence on this particular resource was heightened by the scarcity of other once abundant marine mammals.

Subsequent commercial activities in the Aleutians in the first half of the twentieth century focused on fox farming, shore-based whaling and nearshore fisheries. Little information exists as to the furs produced by fox farming, except that introductions were restarted and the activity peaked from 1913 to 1940. The farming of foxes was encouraged despite an early warning by Turner (1886) in the 1870s about the decline of seabirds due to foxes. To top it off, ground squirrels were introduced to serve as food for foxes.

All this happened after the Aleutian Islands (including Unimak and Sanak) had been declared a Reservation in 1913 to preserve breeding ground for native birds, promote propagation of reindeers and fur bearing animals, and encourage the development of fisheries. The same year saw a bill passed in which the take of fish and whales by non-US citizens were prohibited in Alaskan territorial waters, at the time defined as three miles from shore. Alaska had just become a territory of the United States and the bill's purpose was to take official claim of the marine resources in the adjacent waters.

A shore whaling station built in 1907 by a Norwegian company in Akutan (eastern Aleutians) was directly affected by the US claim of marine resources, as the whaling boats had to be registered in the US and fly the American flag. The Akutan whaling station's operations lasted from 1912 to 1939 (Tønnessen and Johnsen, 1982). Only 1913 and 1921 reported no activity. During its operations some 10,181 whales were processed at Akutan, mostly those with neritic (coastal) affinities: 37% humpbacks, 37% fin whales, 13% blue, 9% sperm, and 0.5% sei whales; 3% were beluga whales caught in Cook Inlet. Gray and right whales, once abundant, were rarely taken (US Fisheries Bureau 1912-1939). Blue whales vanished from the east and western Pacific and only the waters south of the Aleutians sustained an average annual catch of 50 animals up until 1930. With the introduction of floating factories in the 1920s, Japan initiated pelagic whaling off the Aleutians; however these catches were outside the 3 mile limit and hence there are no records of catches (Tønnessen and Johnsen, 1982). In 1939, with the threat of World War, the facilities in Akutan were sold to the navy, and the shore-whaling industry came to an end in the Aleutians.

Formal commercial exploitation of fish stocks in the eastern Aleutians region started in 1906 when cod stations were opened at Sanak and Unimak Island by various companies (Bureau of Fisheries 1907). Vessels moved to the Alaska Banks of the Bering Sea, to south of Unimak Island, and around the Shumagin Islands to offset the end of cod fishing off the Russian coast after the 1909 season. Cod were to be found almost everywhere in the banks with less than 100 fathoms of water. The fishery operated from the permanent shore stations and was based primarily in harbors (Shields 2001). Overall, the Pacific cod fishery peaked during WWI when estimated annual catches ranged from 12,000 to 14,000 metric tons. Later, in 1915, there was an unexplained change in the migration pattern of cod, the fish began to disappear from harbors and a portion of the fishery moved outside the harbors (Shields 2001). The inshore winter fishery gradually declined after 1920 and ended in 1930. The rest of the fishery declined later due partly to cod deliveries by Japanese vessels and poor quality processing, which made the end product inferior to that of the East Coast. The fishery was terminated in 1950 (Dall 1896, INPFC 1979, Bakkala 1981, Shields 2001).

Other fishing stations opened in 1916 throughout the eastern Aleutians, and one shore station opened at Attu (western Aleutians) where Atka mackerel and greenling was caught. Salmon canneries opened in the eastern islands of Unalaska and Umnak, with limited success. The total salmon catch from 1916 to 1939 was only 5,521 metric tons with a peak in 1924 of 1,803 metric tons (Bureau of Fisheries 1906-1939). The halibut fishery had extended to Dutch Harbor after successive depletion from Banks all the way from Oregon to the Gulf of Alaska, but catches in the Aleutians were minor (Adams 1935, Fiedler 1940, Russell 1943). The Convention for the Preservation of the Halibut Fishery of the Northern Pacific Ocean was signed on March 2, 1923. Later, in 1953, Regulatory areas were established however it was not until 1966 that the Aleutians were included in an explicit regulatory area. A purse seine fishery for herring developed in the vicinity of Unalaska. Catches peaked in 1932 at 2,277 metric tons and ranged between 1,000 and 2,000 metric tons until 1937. From then on catches declined until the fishery was abandoned in 1946 (INPFC 1979, Bakkala 1981).

While the American vessels stayed in nearshore/eastern areas during the 1920's and 30's, foreign fishing fleets exploited the offshore/eastern grounds. Japan had developed a self sufficient fleet of motherships, and had the capacity to fish salmon and halibut in the high seas (i.e. outside territorial waters). However, in order to avoid conflicts with the United States over the catch of salmon or halibut (the main US Alaska fisheries at the time), Japanese confined their catches to crab and fish meal in which the US fishing industry had no interest (Barnes 1936, Fielder 1940). From 1933 to 1939 crab was caught north of Umnak and the fleet worked its way eastward along the north coast of the Alaska Peninsula (Parker 1974). An eventual Japan-US conflict over salmon raised controversy over the "ownership" of salmon stocks and access rights. Alaska was the primary supplier of manufactured fishery products and catches in Bristol Bay were higher than those at Japan's fishing zones. The conflict was characterized as one between conservation (on the US side) and advancing techniques (Japan's motherships). The fact that Japan restricted motherships from fishing off Kamchatka for fear of damaging their own shore-fishing operations (Barnes 1938) did little to appease concerns with regards to the future of Alaska fisheries. The onset of World War II brought a temporary halt to Japan's fishing fleet expansion, but the controversy between conservation and advancing techniques would resurface later. During World War II the Supreme Command Allied Powers limited fishing to coastal waters. Furthermore, Attu and Kiska were occupied by Japan, to be recovered by the US in 1943. Overall, pelagic fishing during World War II was restricted to a minimum in the Aleutian Islands (Mathieson 1958).

After World War II, whaling and fisheries by foreign fleets expanded to areas immediately outside the territorial waters of the Aleutian Islands and catches exceeded historic high levels. Whaling was the first fishery to be reactivated in Aleutian waters. The International Convention for the Regulation of Whaling of 1946 was signed by the US, Canada and the Union of Soviet Socialist Republics among others. Japan joined in 1951 (IWC 2006) when it planned on extending its whaling grounds eastwards in the North Pacific. The signatories agreed on the establishment of the International Whaling Commission (IWC) to regulate catches. In the early 1950s Japanese factory ships expanded catches to the south coast of the western Aleutians. The total catches in the Aleutians increased steadily from a couple hundred whales in the early 1950s to over 4,000 by the end of the decade. Soviets subsequently increased effort in the North Pacific, and by 1963 had a fleet of 37 vessels. Baleen whales were half or less of the catch, and sperm whales made up the rest of it. Japanese and Soviet Union fleets operated freely in the North Pacific until their increased effort and the decline of Antarctic catches caught the attention of the IWC. By this time, global regulation was needed for both shore and pelagic whaling. The Scientific Committee requested limits on humpback and blue whales catches in 1965 and asked for their complete protection in 1966. This restriction, however, had little effect on the whaling activities around the Aleutians because the catch of humpbacks and blue whales rarely exceeded 200 individuals and comprised less than 10 percent of the catch throughout the archipelago. Nevertheless, sperm whale, followed by fin and sei whale continued to be caught in the central and western Aleutians while fin whales prevailed in the eastern islands. The whaling fleets operated offshore, seldom within 30 km of the coast until 1972 (Merrel 1971) when catches north of 50°N ceased, although globally stocks kept declining until a moratorium was set in 1982 (Tønnessen and Johnsen 1982, IWC 2006). Failure of international agreements to restrain whale catches pushed the implementation of one of the most comprehensive conservation laws in the United States: the Marine Mammal Protection Act (1972). The far reaching umbrella of this law established the legal grounds for many of the conservation and management actions of fishery-related resources in place today (Bean 1983).

Following the trend in whaling activities, foreign fleets expanded their operations to waters right outside the territorial limit of the U.S, encroaching into the eastern Bering Sea and the western Aleutians. Japanese fleets had started fishing for salmon near the Aleutians in 1952. The International North Pacific Fisheries Convention was signed by Canada, the US and Japan in 1953. By 1955 the Japanese had 12 independent flotillas operating in the Aleutian area (Mathieson 1958). Meanwhile the US fleet operated west of Unimak Pass. Pink salmon was the primary species (greater than 90 percent) caught in the Aleutian Islands area and were taken almost exclusively in the bays of Unalaska (INPFC 1979). Alaska had gained statehood in 1959, and this transferred government of the coastal fisheries from the federal to the state government. The 1953 Convention established the division between Japan and Canada/US areas of fishery and fisheries conservation with Japan restricted from activities east of 175°W. Towards the west, fishing activities were regulated by a Treaty between with the Soviet Union and Japan. This left fisheries beyond the 3 mile limit in the central and western Aleutians effectively outside US jurisdiction and open to Japanese, Russian and other foreign fishing fleets (Merrel 1971).

In 1960 the Japanese and Soviet fishing fleets were operating at full force in the Aleutian Islands. They were later joined by Korea (1967), Taiwan (1974) and Poland (1979) (Bakkala 1981). The initial targets were Pacific Ocean perch and walleye Pollock, but soon expanded to sablefish and Greenland turbot (1963), Pacific cod (1964) flatfish (1970), and Atka mackerel (1972). Peak total groundfish harvest occurred in 1965 when almost 112,000 metric tons were taken. Most was Pacific Ocean perch, taken off the entire central and western Aleutians (Merrel 1971). Pacific Ocean perch remained the primary target until the 1970s when the stock declined and catches comprised only about a third or less of the total harvest in the region. Between 1973 and 1977 total catches were below 50,000 metric tons (Bakkala 1981).

The American fleet started fishing for Red king crab near Adak and Dutch Harbor in 1960 (NPFMC 2006). In 1964, the US ratified the Convention of the Continental Shelf and designated both king and tanner crabs as shelf creatures; bilateral agreements were concluded with Japan and the USSR. The Soviets remained in the fishery until 1971 and the Japanese until 1974. Meanwhile the US crab fishery developed rapidly during the 1960s and was receiving half of the total harvest by the early 1970s. Foreign fleets were excluded from the fishery by 1975, however this did not necessarily result in better management of crab stocks. As the abundance of red king crab declined in the Aleutian Islands, fishers gradually transitioned to harvesting golden king crab and by 1982, golden king crab landings exceeded those for red king crab, although the total volume of golden king crab landed was never as high as for red king crab (Otto 1981). At its peak, the red king crab harvest in the Aleutian Islands exceeded 17,000 metric tons.

In response to foreign high exploitation rates in waters adjacent to its 3 miles limit, the US passed the Magnuson-Stevens Fishery Conservation and Management Act in 1976 (MSFMCA) which established the Fishery Conservation Zone (FCZ) from 3 to 200 miles offshore. Its objective was to rebuild depleted groundfish stocks, achieve and maintain an optimum yield for the various fisheries and "Americanize" the fleets. Foreign countries were allocated quotas based on their contribution to developing the domestic industry, and so the groundfish fisheries went through a period of joint ventures that lasted through the 1980s. These ventures transitioned foreign involvement in the fisheries from active fishing to investment in US harvesting and processing capacity and destination markets.

During the 1980s groundfish catches increased back to over 100,000 metric tons as joint ventures successfully developed US fisheries. US vessels fishing for pollock, cod and yellowfin went into joint ventures with the USSR and Korea; and Japan's new shipboard methods to produce surimi at sea allowed the pollock fishery to rapidly expand (Bakkala 1981). Pollock catches peaked in the Aleutians during the 1980s. By 1990 the fleets were domestic, and total catches remained in excess of 150,000 metric tons throughout the decade. In 1999 the pollock fishery was severely restricted due to concerns regarding the fishery's impact on Steller sea lions (Barbeaux 2004). Since then, total groundfish catches have averaged slightly above 100,000 metric tons and are roughly 50% Atka mackerel, 30% Pacific cod and 15% Pacific Ocean perch.

Were not Japanese high seas drift nets still used near the western Aleutians until the mid-late 1980s? Wasn't there a big deal about banning them? Should be mentioned.

Appendix C Species listed under the Endangered Species Act

Due to declines based on past exploitation or because of other, often poorly understood, factors, a number of marine mammals, several species of birds and one plant occurring in the Aleutians are listed as endangered or threatened under the Endangered Species Act. The table below summarizes those species.

Endangered Species Act-listed species that range in the Aleutian Islands

Common Name	Scientific Name	ESA Status
Steller Sea Lion (Western Population)	*Eumetopias jubatus*	Endangered
Blue Whale	*Balaenoptera musculus*	Endangered
Bowhead Whale	*Balaena mysticetus*	Endangered
Fin Whale	*Balaenoptera physalus*	Endangered
Humpback Whale	*Megaptera novaeangliae*	Endangered
Right Whale	*Balaena glacialis*	Endangered
Sei Whale	*Balaenoptera borealis*	Endangered
Sperm Whale	*Physeter macrocephalus*	Endangered
Northern Sea Otter	*Enhydra lutris*	Threatened
Short-tailed Albatross	*Phoebaotria albatrus*	Endangered
Steller's Eider	*Polysticta stelleri*	Threatened
Spectacled Eider	*Somateria fishcheri*	Threatened
Kittlitz Murrelet	*Brachyramphus brevirostris*	Candidate
Aleutian Shield Fern	*Polystichum aleuticum*	Endangered

Appendix D Food web interaction strength tables

Table 1 Interaction strengths for key species in the Aleutian Islands food web
Table 2 Interaction strengths for protected species and fisheries
Table 3 Prey overlap for euphausiids and copepods to assess potential competition for these resources

The following tables were constructed from food web model summaries of diet information and mortality estimates for each species in the Aleutian Islands ecosystem. The intent is to show both sides of a predator-prey interaction. First, from the prey standpoint, how much a prey might be affected by that predator as measured by the percent of the prey's total mortality caused by that predator. Second, from the predator standpoint, how much a predator depends on a given prey as measured by the percent of that prey in its diet.

In Table 1, we highlight the focus species selected by the FEP team, but also include other ecosystem groups linked to these focus species. Table 1 columns list species as prey, while rows list species as predators (consumers). Focus species as prey have two consecutive columns to show the two relationships. The percent of mortality caused by the consumer (row) on the prey (column) is listed in the first prey column of a given row. If you are viewing a color document, the percent mortality caused is in red. The percent of the consumer's diet that the prey represents is listed in the second prey column of a given row (in black if you are viewing a color document). Therefore, the total mortality for a given prey is found by summing values in red down the first column across all rows. Similarly, the total diet of a given predator is found by summing across values in black for all columns in a given row. Note that the columns stretch across multiple pages for diet information.

For example, the second row and first column lists the amount of mortality that halibut (row two) cause on Atka mackerel (column one) in the Aleutian Islands according to food web model estimates: 2%. Therefore, halibut do not cause much Atka mackerel mortality. However, the importance of Atka mackerel in halibut's diet is found in row two, column two, which shows that Atka mackerel represent 16% of the halibut diet according to food habits collections in the Aleutians. Therefore, the relationship might be considered weaker in terms of halibut's influence on Atka mackerel, but stronger in terms of Atka mackerel's importance to halibut.

In Table 2, we use a similar format to compare predator-prey interactions for apex predators including fisheries. In all cases, there are two columns for each prey type, the first representing the amount of mortality caused by the predator listed in the row, and the second representing the percent of the predator's diet comprised by that prey. For example, in the first column (red) the mortality caused by piscivorous seabirds on the aggregated other forage fish group is 3%. However, the other forage fish group represents 45% of the piscivorous seabird diet according to column two, row one (black). Therefore, while seabirds may not cause much mortality to other forage fish, other forage fish are likely very important to piscivorous seabirds.

At the bottom of Table 2 we summarize both total mortality and total percent of diet by all birds combined, all mammals combined, and all fisheries combined. Therefore, we can see that the other forage fish group (first and second column) have more mortality caused by mammals in this ecosystem than birds or the fishery (7% mammals, 4% birds, 0% fishery). However, other forage fish make up 22% of the combined diet of birds, 14% of the combined diet of mammals, and 0% of the combined diet of fish. Note that two fisheries are estimated to have other forage fish in their "diet" (catch composition): subsistence and ADF&G net, at 42% and 100%. This is because we aggregated salmon with other forage fish for the purposes of this analysis in the Aleutian Islands model. While these fisheries have high dependence on salmon, it is apparent they cause almost no mortality on salmon in the Aleutians for the time period modeled, and furthermore that these fisheries are a very small proportion of fisheries overall in the area when viewing the fishery total.

Table 1 Interaction strengths for key species in the Aleutian Islands food web.

NOTE: High interaction strength arises from combined diet and mortality impacts between species; in general, more than 10% in diet or 10% mortality caused could be strong interactions.

NOTE: blank cells mean no interaction reported, 0% cells are trace (less than 0.5%)

Consumer (row) causes this % of Prey mortality | Prey (column) is this % of Consumer diet

Focus species as Prey

	Atka mackerel		Halibut		King crabs		P.Ocean perch		Pacific cod		Sablefish		Pollock		Grenadiers		Myctophids		
Focus species as Consumer																			Diet from focus species
Atka mackerel			1%	0%									52%	6%			3%	1%	7%
Halibut	2%	16%	0%	0%	3%	0%			0%	1%	17%	2%	1%	9%			0%	2%	29%
King crabs																			
P.Ocean perch													0%	0%	0%	0%	1%	3%	3%
Pacific cod	20%	15%			1%	0%	1%	0%	1%	0%	18%	0%	4%	4%	0%	0%	1%	4%	24%
Sablefish													0%	4%			0%	0%	4%
Pollock	18%	2%			0%	0%							2%	0%			30%	14%	16%
Grenadiers																	23%	47%	47%
Myctophids																	2%	0%	0%
Mort explained by focus spp	40%		1%		5%		1%		2%		35%		58%		0%		61%		

Other Consumers of Focus species	Atka mackerel	Halibut	King crabs	P.Ocean perch	Pacific cod	Sablefish	Pollock	Grenadiers	Myctophids
ADF&G Pots			62%						
Baleen whales	0%						2%		
Detritus (unexplained mortality)	7%	57%	14%	69%	50%	7%	19%	83%	20%
Flatfish	6%	1%	0%	4%	0%	19%	2%		8%
Forage							0%		
IPHC Longline		34%							
NMFS Longline	0%	3%	0%	0%	17%	31%	0%	11%	
NMFS Pot	0%	0%	0%	0%	4%	0%	0%	0%	
NMFS Trawl	17%	3%	0%	12%	18%	3%	13%	1%	0%
Other fish	1%		1%				0%		0%
Pinnipeds	0%	0%	0%	0%	0%	0%	0%		0%
Pisc Seabirds	0%			7%	0%		1%		0%
Plnkt Seabirds	0%			0%	0%		0%		
Rockfish	0%		16%				0%		0%
Sharks		1%	0%	0%	0%	5%	0%		
Skates	5%		2%				2%	0%	0%
Squids									10%
Steller Sealion	24%		0%	2%	7%		2%		
Toothed whales		0%		4%	2%	0%	0%	5%	1%
Zoop							0%		0%
Total Mortality	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 1 continued. Remainder of diets for focus species.

Consumer (row) causes this % of Prey mortality / Prey (column) is this % of Consumer diet	*Other prey of focus species*														
	Copepods	Crabs	Detritus	Epifauna	uphausiids	Flatfish	Forage	Infauna	Other fish	lagic micro	Rockfish	Shrimp	Squids	Zoop	Total Diet
Focus species as Consumer															
Atka mackerel	36%	0%	0%	6%	29%	0%	0%	1%	0%			0%	10%	11%	100%
Halibut		18%	5%	12%	0%	0%	3%	1%	7%			3%	22%	0%	100%
King crabs		4%		56%				40%							100%
P.Ocean perch	76%			1%	14%		0%	2%	0%	0%		0%	0%	4%	100%
Pacific cod	0%	6%	5%	5%	0%	0%	4%	5%	16%			28%	6%	0%	100%
Sablefish		0%	0%	3%	35%			4%	0%	0%	0%	1%	2%	49%	100%
Pollock	28%	0%	0%	9%	21%		0%	0%	2%			7%	1%	14%	100%
Grenadiers				2%	0%		1%						45%	6%	100%
Myctophids	12%			6%	77%									6%	100%

Table 2 Interaction strengths for protected species and fisheries.

% of Prey mortality caused by consumer	% of Prey in each consumer's diet	*prey groups*																		
ConsGroup	Consumer	Forage	Forage	Squids	Squids	P.Ocean	P.Ocean	Pollock	Pollock	Rockfish	Rockfish	Myctoph	Myctoph	Copepoc	Copepoc	Epifauna	Epifauna	Euphaus	Euphaus	Atka ma
Birds	Pisc Seabirds	3%	45%	1%	25%	7%	8%	1%	6%	14%	5%	0%	3%	0%	3%	0%	2%	0%	2%	0%
	Plnkt Seabirds	0%	5%	1%	22%	0%	0%	0%	0%	1%	0%		0%	0%	38%	0%	0%	0%	28%	0%
Mammals	Pinnipeds	0%	15%	0%	3%	0%	0%	0%	16%	0%	0%	0%	0%			0%	11%			0%
	Sea Otters	0%	11%													0%	62%			
	Steller Sealion	1%	9%	1%	6%	2%	2%	2%	10%	5%	1%					0%	0%			24%
	Baleen whales	5%	33%	0%	1%			2%	7%					0%	7%			0%	42%	0%
	Toothed whales	1%	3%	11%	87%	4%	2%	0%	0%	7%	1%	1%	5%							
Fishery	Subsistence	0%	42%																	
	ADF&G Net	0%	100%																	
	IPHC Longline			0%	0%															
	ADF&G Pots																			
	NMFS Pot			0%	0%	0%	0%	0%	0%	0%	0%					0%	4%			0%
	NMFS Longline	0%	0%	0%	0%	0%	0%	0%	0%	3%	3%					0%	0%			0%
	NMFS Trawl	0%	0%	0%	0%	12%	7%	13%	42%	22%	3%	0%	0%			0%	0%			17%
			Prey																	
	ConsGroup	Forage	Forage	Squids	Squids	P.Ocean	P.Ocean	Pollock	Pollock		Rockfish		Myctophids		Copepods		Epifauna		Euphausiids	
	Birds Total	4%	22%	2%	23%	7%	4%	1%	3%	15%	2%	0%	1%	0%	23%	0%	1%	0%	17%	0%
	Mammals Total	7%	14%	12%	36%	6%	1%	4%	5%	12%	1%	1%	2%	0%	2%	0%	4%	0%	12%	24%
	Fishery Total	0%	0%	0%	0%	13%	5%	13%	34%	25%	3%	0%	0%			0%	0%			17%
Mort not explained by these groups		90%		86%		74%		82%		49%		99%		100%		100%		100%		59%

Table 2 continued. Interaction strengths for protected species and fisheries.

% of Prey mortality caused by consumer	% of Prey in each consumer's diet																			
ConsGroup	Consumer	Infauna	Infauna	Detritus	Detritus	Pisc Sea	Pisc Sea	Plnkt Se	Plnkt Se	Pacific c	Pacific c	Shrimp	Shrimp	Other fis	Other fis	Crabs	Crabs	Grenadie	Grenadie	Flatfish
Birds	Pisc Seabirds	0%	0%	0%	0%	25%	0%	13%	0%	0%	0%									
	Plnkt Seabirds	0%	1%							0%	0%									
Mammals	Pinnipeds									0%	4%	0%	16%	0%	20%	0%	1%			1%
	Sea Otters	0%	4%									0%	3%	3%	19%	0%	0%			
	Steller Sealion			0%	0%					7%	4%	0%	0%	1%	3%	0%	0%			
	Baleen whales													1%	1%					
	Toothed whales									2%	1%			0%	0%			5%	1%	0%
Fishery	Subsistence																			
	ADF&G Net																			
	IPHC Longline																			
	ADF&G Pots																			
	NMFS Pot					0%	0%	0%	0%	4%	88%			0%	8%	0%	0%	0%	0%	0%
	NMFS Longline					5%	0%	3%	0%	17%	51%	0%	0%	0%	3%	0%	0%	11%	21%	4%
	NMFS Trawl					1%	0%	0%	0%	18%	9%	0%	0%	1%	1%	0%	0%	1%	0%	10%
	ConsGroup		Infauna		Detritus		Pisc Seabirds		Plnkt Seabirds		Pacific cod		Shrimp		Other fish		Crabs		Grenadiers	
	Birds Total	0%	0%	0%	0%	25%	0%	13%	0%	0%	0%									
	Mammals Total	0%	0%	0%	0%					9%	1%	0%	0%	6%	3%	0%	0%	5%	0%	1%
	Fishery Total					6%	0%	3%	0%	39%	16%	0%	0%	1%	1%	0%	0%	12%	3%	14%
Mort not explained by these groups		100%		100%		68%		83%		52%		100%		93%		100%		83%		85%

Table 2 continued. Interaction strengths for protected species and fisheries.

% of Prey mortality caused by consumer	% of Prey in each consumer's diet																			
ConsGroup	Consumer	Halibut	Halibut	King cral	King cral	Sablefisl	Sablefisl	Skates	Skates	Baleen v	Baleen v	Toothed	Toothed	Steller S	Steller S	Sharks	Sharks	Sea Otte	Sea Otte	Pinniped
Birds	Pisc Seabirds																			
	Plnkt Seabirds																			
Mammals	Pinnipeds	0%	0%	0%	0%	0%	0%													
	Sea Otters																			
	Steller Sealion			0%	0%			2%	0%							0%	0%			
	Baleen whales																			
	Toothed whales	0%	0%			0%	0%	4%	0%	24%	0%	7%	0%	8%	0%	6%	0%	10%	0%	14%
Fishery	Subsistence													1%	45%					11%
	ADF&G Net																			
	IPHC Longline	34%	100%																	
	ADF&G Pots			62%	100%													0%	0%	0%
	NMFS Pot	0%	0%	0%	0%	0%	0%	0%	0%											
	NMFS Longline	3%	1%	0%	0%	31%	6%	45%	7%							62%	0%			
	NMFS Trawl	3%	0%	0%	0%	3%	0%	12%	0%			0%	0%	0%	0%	17%	0%			

	ConsGroup		Halibut		King crabs		Sablefish		Skates		Baleen whales		Toothed whales		Steller Sealion		Sharks		Sea Otters	
	Birds Total																			
	Mammals Total	0%	0%	0%	0%	0%	0%	6%	0%	24%	0%	7%	0%	8%	0%	6%	0%	10%	0%	14%
	Fishery Total	40%	2%	62%	2%	34%	1%	56%	1%			0%	0%	1%	0%	79%	0%	0%	0%	11%
Mort not explained by these groups		60%		38%		66%		38%		76%		93%		91%		15%		90%		75%

Table 3. Prey overlap for euphausiids and copepods to assess potential competition for these resources.

Consumer	causes % of Euphausiids mort	% of diet that is Euphausiids
Myctophids	27%	77%
Forage	23%	86%
Squids	12%	42%
Atka mackerel	8%	29%
Shrimp	4%	20%
Pollock	4%	21%
P.Ocean perch	1%	14%
Zoop	1%	1%
Rockfish	1%	20%
Other fish	0%	5%
Baleen whales	0%	42%
Plnkt Seabirds	0%	28%
Flatfish	0%	4%
Sablefish	0%	35%
Pisc Seabirds	0%	2%
Grenadiers	0%	0%
Pacific cod	0%	0%
Sharks	0%	1%
Skates	0%	0%
Halibut	0%	0%
Detritus (unexplain	*20%*	*3%*

Consumer	causes % of Copepods mort	% of diet that is Copepods
Euphausiids	48%	25%
Zoop	11%	25%
Atka mackerel	6%	36%
Squids	4%	20%
Pollock	3%	28%
Myctophids	3%	12%
P.Ocean perch	2%	76%
Forage	2%	10%
Rockfish	1%	43%
Plnkt Seabirds	0%	38%
Baleen whales	0%	7%
Pisc Seabirds	0%	3%
Pacific cod	0%	0%
Other fish	0%	0%
Flatfish	0%	0%
Sharks	0%	0%
Skates	0%	0%
Detritus (unexplain	*20%*	*5%*

Appendix E Sample size for spatial diet data in the AI

The following tables indicate the how many, from which area, and in what year Atka mackerel and pollock stomachs were collected for the diet composition data. These stomachs form the source data for Figure 3-22.

Number of stomachs
Atka Mackerel

	Area													
Year	172 E	174 E	176 E	178 E	180	178 W	176 W	174 W	172 W	170 W	168 W	166 W	164 W	Total
1986									68					68
1987						110			685				8	803
1988					35	24			8				15	82
1989													6	6
1990						26			8					34
1991	15	15		45	45	70	15		32			1		238
1992														
1993														
1994	10	10	10	80	50	20	9	29	32					250
1995														
1996											16			16
1997	15		30	74	60	33	13		17	9		1		252
1998														
1999									252	198	3	6		459
2001												3	18	21
Area Total	40	25	40	199	190	283	37	29	1102	207	19	11	47	2229

Number of stomachs
Walleye Pollock

	Area													
Year	172 E	174 E	176 E	178 E	180	178 W	176 W	174 W	172 W	170 W	168 W	166 W	164 W	Total
1981												25		25
1982										6		92	71	169
1983			2	7	26								30	65
1984										24				24
1985												33	172	205
1986					7				181	29		139	293	649
1987						10	78		534		101	695	156	1574
1988					56	9	10		9	39	16	744	263	1146
1989												45	227	272
1990									113	59	70	37	57	336
1991		31	43	15	84	88	97	63	88	7	320	181	223	1240
1992									19			76	51	146
1993							20	22	38	39	72	173	431	795
1994	25	45		85	45	144	69	75	183	197	4	85	50	1007
1995								22	47		160	85	172	486
1996									12		99	154	329	594
1997	29	32	44	23	75	65	47	33	105	40	30	70	35	628
1998							20					16	28	64
1999											7	77	121	205
2001											11	61	186	258
Area Total	54	108	89	130	293	316	341	215	1329	440	890	2788	2895	9888

Appendix F Research activity in the AI

The following is a brief overview of some of the ongoing research activity in the Aleutian marine waters.

National Marine Fisheries Service Fishery Research
Resource assessment surveys have been conducted in the Aleutian Islands by the Alaska Fisheries Science Center with bottom trawls on a mostly triennially basis from 1980 to 1997, and biennially since 2000. The Aleutian Islands survey area which extends from Unimak Pass (165º W. longitude) to Statemate Bank (170º E. longitude), includes Petrel Bank and Petrel Spur, and covers the continental shelf and upper continental slope to 500 m. The objectives of the survey are to provide distribution and relative abundance data for the principal groundfish and commercially or ecologically important invertebrate species in the Aleutian Islands, and to collect data to estimate biological parameters such as growth rates, length-weight relationships, feeding habits, and size, sex, and age compositions. The most abundant groundfish species in the area are Atka mackerel, POP, northern rockfish, walleye pollock, Pacific cod, arrowtooth flounder, and giant grenadier. However, fish populations which extend into areas that are either untrawlable with the survey gear, such as several rockfish species, or extend further up in the water column, are not fully represented.

The Aleutian Islands has also been surveyed biennially by longline gear since 1996. Surveyed depths vary from 200 m to 1000 m. The objectives are to determine the relative abundance and age and size composition of sablefish. The survey also provides relative abundance and size composition information for shortspine thornyhead, rougheye and shortraker rockfish, Pacific cod, arrowtooth flounder, grenadiers, and Greenland turbot. The longline survey is also used as a platform to tag sablefish, shortspine thornyhead, and Greenland turbot to determine migration patterns.

In late 2000 the AFSC formed a Fishery Interaction Team (FIT) to investigate the effects of commercial fishing on top trophic level consumers. Members of the team conduct studies to determine whether commercial fishing operations are capable of impacting the foraging success of Steller sea lions, either through disturbance of prey schools or through direct competition for a common prey. The present research focus is on the three major groundfish prey of Steller sea lions: walleye pollock, Pacific cod and Atka mackerel.

FIT investigates the potential effects of commercial fishing on sea lion prey fields in two ways. First, by conducting field studies to directly examine the impact of fishing on sea lion prey fields and to evaluate the efficacy of trawl exclusion zones. Since 2000, Atka mackerel have been tagged, released and recovered at Seguam Pass, Tanaga Pass, Amchitka Island, and Kiska Island in the Aleutian Islands. The second way that FIT investigates the potential effects of commercial fishing on sea lion prey is by studying fish distribution, behavior and life history at spatial scales relevant to sea lion foraging (tens of nautical miles). Ongoing FIT research projects address the reproductive ecology, growth and food habits of Atka mackerel in the Aleutian Islands.

In 2006 the Aleutian Islands Cooperative Acoustic Survey Study was conducted to test the feasibility of using small (less than 30 m) commercial fishing vessels to conduct acoustic surveys in the Aleutian Islands. The project was successful; seven separate surveys were completed in a designated survey area and the data were determined to be of high enough quality for management purposes, verifying that commercial fishing vessels could be used as platforms for conducting scientifically valid acoustic surveys of pollock in the Aleutian Islands. For 2007 study expanded to a larger survey area in order to quantify the abundance of pollock in the region of the Central Aleutian Islands thought to be within small boat delivery distance of Adak Island.

The Auke Bay Laboratory of the AFSC initiated a pilot study in 2002 to provide new information on coral and sponge habitat in the Aleutian Islands (Heifetz et al. 2005, Stone 2006). The occupied submersible *Delta* was used to explore coral habitat in the Aleutians near the Andreanof Islands and on Petrel Bank just north of the Aleutians in the Bering Sea. This was the first and only directed exploration of coral communities at any depth in the Aleutian Islands since the surveys conducted by the RV *Albatross* nearly a century ago. Preliminary results from this research confirmed the high diversity and wide distribution of corals in the central Aleutians in water less than 365 m (the depth limit of the *Delta*). Corals and sponges were found at 30 of the 31 dive sites investigated. This research was expanded in 2003–2004 with multibeam habitat mapping and expanded *in situ* sampling with the *Delta* and deeper water (greater than 365 m) sampling with the *Jason-II* remotely operated vehicle.

Habitat classification of the multibeam maps will enable extrapolation to a broad geographic area of coral densities assessed from *in situ* sampling. The major objectives of this ongoing research are to: (1) assess the distribution and abundance of corals and sponges in the central Aleutians with respect to major environmental factors and construct a predictive model based on the assessment; (2) determine the importance of corals and sponges as habitat for commercially important fish and invertebrates; (3) evaluate the extent of fishing gear impacts on coral and sponge habitats; and (4) collect corals to describe new species, aid in taxonomic revisions, and determine coral reproductive schedules and larval dynamics (Heifetz et al. 2005).

Alaska Department of Fish and Game Fishery Research

The Alaska Department of Fish and Game has conducted triennial golden king crab pot surveys in the waters near Yunaska Island and The Island of Four Mountains Since 1991 (Watson *in press*). The survey occurs over a one month period of time in July and August and is conducted by ADF&G biologists onboard a chartered commercial fishing vessel using research pots. This survey is not designed to produce abundance estimates, but does provide fishery managers with relative abundance trends, estimates of spatial and temporal migratory patterns and estimates of fishery removals from the survey area. Results from this survey are incorporated into the annual stock assessment and TAC setting process.

Surveys targeting red king crab in the Petrel Bank area were conducted by the Alaska Department of Fish and Game in January, February and November 2001 (Bowers et al. 2002) and again in November 2006 (Gish *in press*). The 2001 pot surveys were approximately one month in duration and were conducted using commercial fishing vessels and provided relative abundance, distribution, size frequency and shell age data that were used to open commercial fisheries for red king crab on Petrel Bank in 2002 and 2003. Data from the 2006 survey will be utilized for stocks assessment and TAC setting in the fall of 2006 and another pot survey on Petrel Bank is planned for November 2007.

In November 2002 ADF&G used several commercial fishing vessels to conduct red king crab surveys in selected locations near Atka, Amlia and Adak Island. That survey yielded very low catches of red king crab and the department does not have current plans to repeat the survey (Granath 2003).

The Alaska Department of Fish and Game (Dr. Bob Small), NMFS, and the refuge have collaborated on research to evaluate population change in Aleutian harbor seal populations over the past 25 years (Small et al. in review).

US Fish and Wildlife Seabird and Sea Otter Research

Long-term seabird monitoring on Alaska Maritime National Wildlife Refuge includes several sites in the central and western Aleutians (Dragoo et al. 2006). Ongoing annual monitoring at breeding colonies includes population trends, patterns of reproductive success, and diets of a number of fish-eating and plankton-feeding species. Data for some of the sites span more than 30 years (mid-1970s to present--

Buldir in the w. Aleutians and others span the past 15 years—Kasatochi in the central Aleutians). A number of other sites are surveyed less than annually. The objectives are to determine changes in seabird populations and provide time-series from which hypotheses about causes of change may be tested.

Seabird, marine mammal, oceanography coordinated investigations is a cooperative project with the National Marine Mammal Laboratory, the Institute of Marine Sciences at University of Alaska, and the US Geological Services (USGS), Biological Resources Division designed to describe physical and biological characteristics of nearshore marine ecosystems at annual seabird monitoring sites on Alaska Maritime National Wildlife Refuge. Two of these sites are in the central and western Aleutians. Specific objectives include measuring on a series of transects within 40 km of selected islands, the sea temperature and salinity, biomass of prey in the water (including test fishing to evaluate relative abundance of species), and the distribution of birds and marine mammals at sea. Plankton tows also are conducted along with salinity measurements.

Endangered short-tailed albatrosses and other albatrosses have been captured and fitted with satellite transmitters in Seguam Pass in the past several years to document movements relative to bycatch issues (Balogh _).

Kittlitz's murrelet, a candidate species for listing under the Endangered Species Act (ESA), and marbled murrelets have been surveyed at several sites in the central and western Aleutians since 2003 to document indices to abundance and distribution. Furthermore, in 2005 and 2006 nesting pairs of Kittlitz's murrelets were discovered on Agattu Island providing a basis for future study of breeding ecology (R. Kahler unpubl. data).

At sea observations of seabirds and marine mammals throughout the central and western Aleutians have been made opportunistically since 1988 from the US Fish and Wildlife Service (USFWS) ship the M/V Tiglax during primarily summer work conducted annually in the Aleutians (marine mammal observations are submitted to the NMFS ships of opportunity data base and seabird observations will be included in the Pelagic Seabird Database maintained by USGS Biological Resources Division and USFWS.

The marine mammal management division of the USFWS has a monitoring plan in place for sea otter populations in the Aleutians including aerial survey of the entire area periodically and more frequent boat-based monitoring at selected sites.

Also, research on sea otter ecology has been underway for years in the central and western Aleutians under the guidance of Dr. Jim Estes, USGS Biological Resources Division and this research continues with a recent extension to include the Commander Islands.

Restoration of Natural Biodiversity

Following removal of introduced foxes on a number of islands (Bailey 1993, Ebbert and Byrd 2002), research is being conducted to document the response of island ecosystems (Byrd et al. 1995; Croll et al. 2005). Studies are underway currently to evaluate the potential for removing introduced rats from islands within Alaska Maritime National Wildlife Refuge (e.g., Rat I.).

Other research

Dr. Ian Jones of Memorial University, Canada, and his students have been studying plankton-feeding auklets in the central and western Aleutians for 15 years to document, among other things, changes in adult survival and diets relative to climate variation.

A consortium of university researchers and USFWS archeologists are conducting archeological research in the western and central Aleutians. Studies by the Western Aleutians Archaeological and

Paleobiological Project have been conducted since 1991 supported by funding from the National Science Foundation and the Institut Français pour la Recherche et la Technologie Polaires. The project has had a dual focus; first, to identify, document, and define the characteristics, and development of the distinctive western Aleut culture and second to document Holocene environmental processes and determine to what extent observed changes can be ascribed to natural and/or anthropogenic factors. Archaeological research is one of the few ways to obtain information on ecosystem function and process over hundreds or thousands of years (Corbett et al. in press).