Endangered Species Act – Section 7 Consultation

Biological Opinion and Incidental Take Statement

Agency: National Marine Fisheries Service
Alaska Region Sustainable Fisheries Division

Activities Considered: Authorization of Bering Sea/Aleutian Islands groundfish fisheries based on the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish; and

Authorization of Gulf of Alaska groundfish fisheries based on the Fishery Management Plan for Groundfish of the Gulf of Alaska.

Consultation By: National Marine Fisheries Service
Protected Resources Division

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EXECUTIVE SUMMARY

In compliance with section 7 of the Endangered Species Act (ESA), the National Marine Fisheries Service (NMFS) has completed this biological opinion consulting on the authorization of groundfish fisheries in the Bering Sea and Aleutian Islands region (BSAI) under the Fishery Management Plan (FMP) for the BSAI Groundfish, and the authorization of groundfish fisheries in the Gulf of Alaska (GOA) under the FMP for Groundfish of the GOA. This opinion is comprehensive in scope and considers the fisheries and the overall management framework established by the respective FMPs to determine whether that framework contains necessary measures to ensure the protection of listed species and critical habitat. The opinion determines whether the BSAI or GOA groundfish fisheries, as implemented under the respective FMPs, jeopardize the continued existence of listed species in the areas affected by the fisheries (i.e., the action areas) or adversely modify critical habitat of such species.

Action Area

The action area consists of "all areas to be affected directly or indirectly by the Federal action, and not merely the immediate area involved in the action" (50 CFR 402.02(d)). As such, the action area for the Federally managed BSAI groundfish fisheries covers all of the Bering Sea under U.S. jurisdiction, extending southward to include the waters south of the Aleutian Islands west of 170°W longitude to the border of the U.S. Exclusive Economic Zone. The action area covered by the GOA FMP applies to the U.S. Exclusive Economic Zone of the North Pacific Ocean, exclusive of the Bering Sea, between the eastern Aleutian Islands at 170°W longitude and Dixon Entrance. The area encompasses sites that are directly affected by fishing, as well as sites likely to be indirectly affected by the removal of fish at nearby sites. The action area would also, necessarily, include those state waters that are encompassed by critical habitat for Steller sea lions.

The action area includes the Alaska range of both the endangered western and threatened eastern populations of the Steller sea lion. However, the effects of the Federal FMPs on Steller sea lions generally occur within the range of the western population. Therefore, this consultation focuses primarily on areas west of 144° W longitude (the defined boundary of the western population of Steller sea lions).

NMFS has determined that the action being considered in this biological opinion may affect 22 species listed under the ESA, including 7 species of endangered whales, the two distinct populations of Steller sea lions, twelve evolutionarily significant units (ESU) of Pacific salmonids and one species of endangered sea turtle. The action area also includes 4 species of endangered or threatened seabirds, and 1 species of marine mammal, the northern sea otter, that has been proposed as a candidate species under the ESA.

Environmental Baseline

The environmental baseline for the biological opinion must include the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone consultations, and the impact of contemporaneous State or private actions (50 CFR §402.02). The environmental baseline for this biological opinion includes the effects of a wide variety of human activities and natural phenomena that may affect the survival and recovery of threatened and endangered species in the action area. The opinion recognizes that such phenomena and activities have contributed to the current status of populations of those listed species. While some may have occurred in the past but no longer affect these species, others may continue to affect populations of listed species in the study area.

The environmental baseline for this action includes fisheries and other FMP-associated activities that are occurring, and that have occurred prior to January 2000. Other human-related activities discussed that may affect, or have affected, the baseline include the impacts of human growth on the action area and the effects of commercial and subsistence harvests of marine mammals. Alaska managed commercial fisheries are also addressed. Those fisheries and their effects on listed species are expected to continue in the action area and into the future. Herring and salmon are fisheries that are managed entirely by the State of Alaska, or, in the case of pollock and Pacific cod, only a percentage of the fishery is managed by State authority, and are species found year-round in the diet of Steller sea lions.

The environmental baseline also discusses the potential effects of the environmental changes on the carrying capacity of the action area over the past several decades, including the relationship between the dietary needs of Steller sea lions, the regime shift hypothesis, and massive population declines in recent decades. The opinion concludes that it is highly unlikely that natural environmental change has been the sole underlying cause for the decline of Steller sea.

The environmental baseline attempts to bring together all of the estimated mortalities of Steller sea lions and a synthesis of the significance of those takes. The best available scientific information on the magnitude and likely impacts of Orca predation on listed species in the action area are analyzed. Other factors, such as disease, ecological effects of commercial whaling through the 1970s, and pollutants, while not entirely excluded as contributing factors, have been considered, but are given lesser importance in explaining the observed pattern of declines.

Effects of Actions

The scope of the "effects of actions" analysis is intended to be comprehensive. As such, the opinion is broad and examines a range of activities conducted pursuant to the FMPs including the manner in which the total allowable catch levels are set, the process that leads to the setting of these levels, the amount of prey biomass taken from sea lion critical habitat. The effects of other activities that are interrelated or interdependent are also analyzed. Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

The first part of the effects analysis is a description of fishery management as practiced under the FMPs, including an explanation of how ecosystem issues are considered. Particularly important sources of potential ecosystem effects are highlighted in subsequent sections. The second part of the effects analysis focuses on the current exploitation strategy and its potential relevance, both past and present, in shaping changes in the abundance and population structure of groundfish stocks. The present fishery management regime's maximum target fishing reference point of $B_{40\%}$ is used as an example to illustrate the potential direction and intensity of direct effects.

The third part of the effects analysis reviews the annual fishery cycle, from surveys through the establishment of Total Allowable Catch (TAC) levels. The effects are evaluated specific to the major stages of the cycle and to explore whether effects can be compounded through subsequent steps in the cycle. Finally, in the fourth part of the effects analysis, the FMPs and their management tools and policies are examined as guiding documents for management of the fisheries and protection of the associated ecosystems. This part also addresses the fisheries as they are prosecuted under the FMPs.

Cumulative Effects

Cumulative effects include the effects of *future* State, tribal, local, or private actions that are reasonably certain to occur in the action area. The State groundfish fisheries are generally smaller than the federal groundfish fisheries but are expected to have marginally more impacts (because of location) on listed species with respect to competition for prey and long term ecosystem impacts. The crab fishery is one of the biggest fisheries managed by the state. However, this fishery is not likely to directly compete for prey with either Steller sea lions or other listed species. Herring, salmon, Pacific cod, pollock, squid, and octopus are items found year-round in the diet of Steller sea lions. Species such as salmon and herring occur much more frequently in the summer as determined by analyses of Steller sea lion prey habits from 1990-1998.

Perhaps the most important interaction between state fisheries and listed species may arise from the pattern of localized removals of spawners. Although the patterns are generally similar from one fishery to the next, the sheer number of distinct fisheries makes it difficult to describe them individually. Likewise, each fishery is distinctly different in either the number of boats, gear used, time of year, length of season, and fish species. Therefore, we present the herring fishery as an example of this type of interaction to demonstrate some of the competitive interactions that may occur.

The impacts of some of the State fisheries on Steller sea lions and, in some cases, humpback whales would be similar to those of the Federal fisheries: cascade effects and competition. Steller sea lions and some of the State fisheries actively demand a common resource and the fisheries reduce the availability of that common resource to Steller sea lions while they satisfy their demand for fish. The State groundfish fisheries may reduce the abundance or alter the distribution of several prey species of listed species.

After reviewing the current status of each listed species in the action area, the environmental baseline for the action area, the effects of the FMPs for Alaska Groundfish in the BSAI and GOA, and the cumulative effects of the federal action, NMFS has determined that the FMPs are not likely to jeopardize the continued existence of any listed species in the action area except for the endangered western population of Steller sea lions. In addition, after reviewing the current status of critical habitat that has been designated for Steller sea lions, the environmental baseline for the action area, the FMPs for Alaska Groundfish in the BSAI and GOA, and the cumulative effects, it is NMFS' biological opinion that the FMPs are likely to adversely modify this critical habitat designated for Steller sea lions.

Reasonable and Prudent Alternative

Based on the effects discussion and NMFS determination that fishing activity under the FMPs are likely to jeopardize the continued existence of the western population of Steller sea lions and are likely to adversely modify their designated critical habitat, NMFS has developed a reasonable and prudent alternative (RPA) with multiple components for the groundfish fisheries in the BSAI and GOA. The fisheries effects that give rise to these determinations include both large scale removals of Steller sea lion forage over time, and the potential for reduced availability of prey on the fishing grounds at scales of importance to individual foraging Steller sea lions.

The first RPA element addresses the harvest strategy for fish removal at the global or FMP level. This RPA requires the adoption of a new harvest control rule that would decrease the likelihood that the fished biomass for pollock, Pacific cod and Atka mackerel would drop below $B_{40\%}$. ***The global control rule is a revised, more precautionary fishing strategy ($F_{40\%}$ adjustment procedure) for principal prey of Steller sea lions taken by the groundfish fisheries in the BSAI and GOA (pollock, Pacific cod and Atka mackerel) than that which currently exists under the FMP.*** The effect of using the global control rule is increased likelihood that the stock is maintained at or above the target stock size by reducing the exploitation rate at low stock sizes.

Other RPA elements completely protect sea lions from groundfish fisheries at global and regional scales, and in both temporal and spatial dimensions. The other RPA elements reflect a heirarchy of NMFS concerns about the effects of the groundfish fisheries on Steller sea lions. Those concerns are greatest with respect to critical habitat areas around rookeries and major haulouts, and in special foraging areas designated as critical habitat, and less for areas outside of critical habitat where take levels are not considered to be at a level that would jeopardize Steller sea lions. ***Significant interactions between sea lions and the fisheries for pollock, Pacific cod and Atka mackerel have been eliminated in critical habitat between November 1 and January 19, or 22% of the year.*** This level of partitioning is necessary in this period because sea lions at this time are considered extremely sensitive to prey availability. Because fisheries are restricted to the remaining 78% of the year, dispersive actions taken at finer temporal and spatial scales are also necessary to avoid jeopardy and adverse modification. ***The RPA extends 3 nautical mile (nm) protective zones around rookeries to all haulouts. In the GOA, EBS and AI, a total of 139 no-fishing zones (note: the rookeries are already no-entry zones) are established that will partition all pups and non-pups from disturbances associated with vessel traffic and fishing in close proximity to important terrestrial breeding and resting habitat. The RPA closes many rookeries and haulouts out to 20 nm to directed fishing for pollock, Pacific cod and Atka mackerel.*** This second spatial partitioning element excludes all fisheries for pollock, Pacific cod, and Atka mackerel from approximately 63% of critical habitat in the GOA, EBS, and Aleutian Islands. These measures significantly increase the amount of critical habitat protected from directed fishing for Steller sea lion prey, greatly reduces the number of potential takes of Steller sea lions through competition for a prey base inside critical habitat, completely protects all pups and non-pups on rookeries and haulouts out to 3 nm from the effects of fishing activity, and greatly reduces the interactions between fisheries and sea lions during winter months.

Fisheries occurring in the remaining 34% of critical habitat and the areas outside critical habitat require further dispersive actions to avoid jeopardy and adverse modification. The temporal concentration of fisheries for pollock, Pacific cod and Atka mackerel may result in high local harvest rates that may reduce the quality of habitat by modifying prey availability. The RPA establishes the following measures to disperse fishing effort at regional and local scales and to reduce the effects of groundfish fisheries on prey availability for sea lions to negligible or background levels.

The RPA separates the fisheries into four seasonal limits inside critical habitat, and two seasonal releases outside of critical habitat, and disperses fishing effort throughout the open portion of the year, January 20-October 31. Season start dates are spaced evenly throughout this period and portions of the TAC is allocated to each season. These actions reduce the proportion of pollock, Pacific cod and Atka mackerel taken inside critical habitat inside the GOA to less than 20% of the total catch. The measure also protects against excessive harvest rates that may rapidly deplete concentrations of prey inside critical habitat.   NMFS has concluded that a temporally dispersed fishery would not significantly harm the foraging success of Steller sea lions as the take would be reduced to a level that NMFS believes would not compromise them.

The spatial concentration of current fishing effort for pollock, Pacific cod and Atka mackerel may result in high local harvest rates that reduce the quality of habitat for foraging Steller sea lions. Fishing inside critical habitat may result in takes of Steller sea lions through adverse modification of habitat (i.e, prey availability). ***Therefore, this RPA reduces the percentage of pollock taken inside critical habitat from 80 to 42% in the GOA, from 45 to 14% in the EBS and from 74 to 2% in the AI compared to 1998. It also reduces the percentage of Pacific cod caught in critical habitat from 48 to 21% in the GOA, from 39 to 17% in the EBS and from 79 to 17% in the AI as compared to 1998. The RPA reduces the percentage of Atka mackerel caught inside critical habitat in the AI from 66 to 8 % as compared to 1998.***

Finally, the RPA is designed to close adequate portions of critical habitat to commercial fishing for the three primary prey species of groundfish, while imposing restrictions on fishing operations in areas open to fishing to avoid local depletion of prey resources for Steller sea lions. This approach of creating areas open and closed to fishing operations provides contrast between complete closures and restricting fishing areas within critical habitat and forms the basis for monitoring the RPA. Over the past decade the North Pacific Fisheries Management Council has noted the importance of assessing the efficacy of conservation measures intended to promote the recovery of the western population of Steller sea lions. To this end, NMFS has incorporated into its RPA a monitoring program that will allow for such an evaluation.

Incidental Take Statement and Conservation Recommendations

An Incidental Take Statement (ITS) specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary to minimize impacts and sets forth terms and conditions with which NMFS must comply in order to implement the reasonable and prudent measures and to be exempt from the prohibitions of section 9 of the ESA.

In addition to the RPA and ITS, conservation recommendations have been provided within this biological opinion. An example of one of the conservation recommendations that NMFS believes should be implemented is a more comprehensive stock assessment that would provide detailed information on groundfish stocks on spatial and temporal scales and to provide timely review of possible fishery interactions with listed species (and in the future on essential fish habitat). This would allow for better analysis of the possible impacts of target fisheries on listed species and the more proactive development of time/space harvest recommendations at the individual stock assessment level so that fishery interactions with listed species and essential fish habitat can be minimized.

The cumulative effect of the RPA elements contained in this biological opinion successfully removes jeopardy and avoid adverse modification of designated critical habitat. However, the State fisheries in Alaska, particularly those involving salmon, herring, and Pacific cod are likely to result in take of Steller sea lions and may require modification. As a conservation measure, NMFS also recommends that the State of Alaska request NMFS to assist in the development of a Habitat Conservation Plan (as authorized under section 10 of the ESA). This plan should be designed to mitigate adverse impacts on Steller sea lions and other listed species that might accrue from State managed fisheries. This plan should employ the same standards and principles as used in this biological opinion to prevent completion and minimize take between fisheries and listed species.

Conclusion

After analyzing the cumulative, direct and indirect effects of the Alaska groundfish fisheries on listed species, NMFS concludes that the fisheries do not jeopardize any listed species other than Steller sea lions. The biological opinion concludes that the fisheries do jeopardize Steller sea lions and adversely modify their critical habitat due to competition for prey and modification of their prey field. The three main species with which Steller sea lions compete for prey are pollock, Pacific cod, and Atka mackerel. The biological opinion provides an reasonable and prudent alternative to modify the fisheries in a way that avoids jeopardy and adverse modification.

1 PURPOSE AND CONSULTATION HISTORY

The Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 et seq.; ESA), provides the primary legal framework for the conservation and recovery of species in danger of or threatened with extinction. The purposes of the ESA include

> "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species and threatened species ..." (16 U.S.C. § 1531(b)).

Section 7(a)(2) of the ESA requires that each Federal agency shall insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of[1] any endangered species or threatened species or result in the destruction or adverse modification[2] of critical habitat of such species. When the action of a Federal agency may affect a protected species or its critical habitat, that agency (i.e., the "action" agency) is required to consult with either the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the protected species or critical habitat that may be affected. Section 7(b) of the ESA requires the Services to summarize consultations in biological opinions that detail how actions may affect threatened or endangered species and designated critical habitat.

This biological opinion is intended to fulfill NMFS obligations under section 7 of the ESA by consulting on

(1) authorization of groundfish fisheries in the Bering Sea and Aleutian Island (BSAI) region under the Fishery Management Plan (FMP) for the BSAI Groundfish, and

(2) authorization of groundfish fisheries in the Gulf of Alaska (GOA) under the FMP for Groundfish of the GOA.[3]

This biological opinion is based on information provided in the 1998 Supplemental Environmental Impact Statement (SEIS) on the groundfish total allowable catch (TAC) specifications, preliminary analyses and discussions from the 2000 Draft Supplemental Environmental Impact Statement (DSEIS) on

[1] The term "jeopardize the continued existence of" means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers or distribution of that species" (50 CFR § 402.02).

[2] The term "destruction or adverse modification" means "a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical" (50 CFR § 402.02).

[3] Section 7 regulations allow a formal consultation to encompass a number of similar actions within a given geographic area or a segment of a comprehensive plan (50 CFR 402.14). Consistent with this regulatory provision and for purposes of efficiency, these two actions are summarized in a single biological opinion.

the Alaska groundfish FMPs, which is being prepared concurrent with this biological opinion, numerous documents produced for and by the North Pacific Fishery Management Council (Council), previous biological opinions and National Environmental Policy Act (NEPA) documents on council actions, and published and unpublished sources of information on the biology and ecology of the action area and listed species in the action area, the general history of fisheries in the action area, and fishery management. A complete administrative record of this consultation is on file at NMFS Alaska Regional Office [Consultation No. F/AKR/2000/00978].

Based on the ESA and implementing regulations, and the recent court findings with respect to previous opinions, the scope of this opinion is intended to be comprehensive. The opinion considers not only the fisheries themselves, but also the overall management framework as established under the respective FMPs, to determine if that framework contains the necessary conservation and management measures to insure the protection of listed species and critical habitat. The purpose of the opinion, then, is to determine if the BSAI or GOA groundfish fisheries, as implemented under the respective FMPs, are likely to jeopardize the continued existence of listed species in the areas affected by the fisheries (i.e., the action areas) or are likely to destroy or adversely modify critical habitat of such species.

The opinion is based on an evaluation of the direct and indirect effects of the actions on listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. These effects are considered in the context of an *Environmental Baseline* and *Cumulative Effects*. The *Environmental Baseline* includes (1) the past and present impacts of all Federal, State, Tribal, or private actions and other human activities in the action area, (2) the anticipated impacts of all proposed Federal projects in the action areas that have already undergone section 7 consultation, and (3) the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). *Cumulative Effects* are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of these groundfish fisheries (50 CFR 402.02).[4]

1.1 Consultation History

For the actions assessed in this document, the action agency is NMFS Office of Sustainable Fisheries (OSF). For the protected species considered in this document, the consulting agency is NMFS Office of Protected Resources (OPR). While the consultation is internal to NMFS, this opinion represents the views of the consulting agency, OPR. NMFS has conducted multiple internal section 7 consultations on the BSAI and GOA groundfish fisheries (Table 1.1). With respect to this opinion, the most recent and relevant consultations are:

! January 26, 1996 biological opinions on the FMPs for the BSAI Groundfish Fishery and the GOA Groundfish Fishery, the proposed 1996 TAC Specifications and their effects on Steller Sea Lions. These opinions concluded that the BSAI and GOA FMPs, fisheries, and harvests under the proposed 1996 TAC specifications were not likely to jeopardize the continued existence of

[4] The term "cumulative effects" is defined explicitly by the regulations implementing the ESA. That definition will be used throughout this document. However, in the context of management of the BSAI and GOA groundfish fisheries, the term "cumulative effects" has been used with a number of other meanings, including 1) long-term effects of a single fishery over time, 2) concurrent or combined effects of multiple fisheries at the same time (annual or longer time period) or in the same area, and 3) combined effects of fisheries and other human activities on any temporal or spatial scale. Each of these meanings will be addressed in the effects section, unless the issue under consideration falls within the ESA definition of cumulative effects.

Steller sea lions or to result in the destruction or adverse modification of their critical habitat. With respect to these opinions, the agency also concluded that the reasons for the decline of Steller sea lion populations and the possible role of the fisheries in the decline remain poorly understood.

- December 3, 1998 biological opinion on authorization of the BSAI Atka mackerel fishery, BSAI pollock fishery, and GOA pollock fishery under their respective FMPs for the period from 1999 to 2002. The opinion concluded that the Atka mackerel fishery was not likely to jeopardize the western population of Steller sea lion or adversely modify its critical habitat, but that the pollock fisheries were likely to cause jeopardy and adverse modification. These conclusions and the reasonable and prudent alternatives (RPAs) developed for the pollock fisheries were challenged in court; the conclusions were upheld, but the RPAs were found arbitrary and capricious for lack of sufficient information. The court ordered preparation of revised final reasonable and prudent alternatives (RFRPAs), which were issued by NMFS on October 15, 1999 and were implemented for the 2000 fisheries.

- December 22, 1998 biological opinion on authorization of the BSAI and GOA groundfish fisheries based on TAC specifications recommended by the Council for 1999. The opinion concluded that based on the 1999 TAC specifications, the groundfish fisheries were not likely to cause jeopardy or adverse modification for listed species or their critical habitat. The opinion was also challenged in court and subsequently found to be arbitrary and capricious for failing to include a sufficiently comprehensive analysis of the groundfish fisheries and their individual, combined, and cumulative effects. Based on this finding, the court determined that NMFS was out of compliance with the ESA (GreenPeace v. National Marine Fisheries Service, 80 F. Supp. 2d 1137 (WD. Wash. 2000).

- December 23, 1999 biological opinion on authorization of the BSAI and GOA groundfish fisheries based on TAC specifications recommended by the Council for 2000, and on authorization of the fisheries based on statutes, regulations, and management measures to implement the American Fisheries Act of 1998 (AFA). The opinion concluded that based on the 2000 TAC specifications and implementation of the AFA, the groundfish fisheries would not cause jeopardy or adverse modification for listed species or their critical habitat. The opinion has not been challenged in court, but was similar in scope to the December 22, 1998 opinion and therefore may not provide the comprehensive analysis of the BSAI and GOA groundfish fisheries required by the court.

2 DESCRIPTION OF THE PROPOSED ACTIONS

NMFS Office of Sustainable Fisheries (OSF), under the authority of the MSA, proposes to (1) authorize groundfish fisheries in the BSAI under the FMP for the BSAI Groundfish, and (2) authorize groundfish fisheries in the GOA under the FMP for Groundfish of the GOA. As stated in section 1, this opinion is comprehensive, including not only the fisheries covered under the FMPs, but an investigation of the overall management framework to determine if the framework contains the necessary conservation and management measures to ensure the protection of listed species and critical habitat.

The purpose of this chapter is to provide an overview of the MSA and the two FMPs for Alaska groundfish fisheries. The state and federal management agencies, the North Pacific Fishery Management Council (Council), and the fishery management process are described briefly. Then the annual management cycle is described, consisting of four main elements: stock assessment, setting the total allowable catch (TAC), implementation of the fisheries, and monitoring the catch and its effects.

2.1 Overview of the MSA

The MSA, passed in 1976, is the primary U.S. law dealing with the conservation and management of marine fisheries resources and fishing activities in Federal waters (those waters extending seaward from the edge of coastal state waters to the 200-mile limit). This area became known as the Exclusive Economic Zone (EEZ) in 1983.

The MSA created eight regional fishery management councils that are primarily charged with preparing fishery management plans and plan amendments that establish, once approved and implemented by NMFS, conservation and management programs for marine fisheries resources in the EEZ. The process for developing and implementing FMPs is described in 2.3.5.

To date, the councils have prepared, and NMFS has approved and implemented, 39 FMPs, some now with numerous amendments. These FMPs not only must comply with the MSA, but with the requirements of other Federal laws, such as NEPA, the Marine Mammal Protection Act (MMPA), the Regulatory Flexibility Act (RFA), and the ESA. The MSA contains provisions for taking into account the requirements of other laws, as well as the protection of marine ecosystems and the environment, some of which are contained in the definitions of "optimum yield" (OY) and "conservation and management":

> "The term "optimum", with respect to the yield from a fishery, means the amount of fish which–
>
> (A) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and <u>taking into account the protection of marine ecosystems</u>;
>
> (B) is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or <u>ecological factor</u>; and
>
> (C) in the case of an overfished fishery, provides for rebuilding to a level consistent with

producing the maximum sustainable yield of such fishery" (16 U.S.C. § 1802(3)(28)) (emphasis added).

The term "conservation and management" refers to all of the rules, regulations, conditions, methods, and other measures (A) which are required to rebuild, restore, or maintain, and which are useful in rebuilding, restoring, or maintaining, any fishery resources and the marine environment; and (B) which are designed to assure that–

(i) a supply of food and other products may be taken, and that recreational benefits may be obtained, on a continuing basis;

(ii) irreversible or long-term adverse effects on fishery resources and the marine environment are avoided; and

(iii) there will be a multiplicity of options available with respect to future uses of these resources" (16 U.S.C. § 1802(3)(5)) (emphasis added).

Section 301(a) of the MSA sets forth national standards for conservation and management with which FMPs and regulations must be consistent. In addition, NMFS established 10 National Standard Guidelines to assist in the development and review of FMPs, amendments, and regulations prepared by the Councils and the Secretary (50 CFR 600 Subpart D). The National Standards are as follows.

Standard 1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the OY from each fishery for the U.S. fishing industry.

Standard 2. Conservation and management measures shall be based on the best available scientific information available.

Standard 3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

Standard 4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various U.S. fishermen, such allocation shall be: (1) fair and equitable to all such fishermen; (2) reasonably calculated to promote conservation; and (3) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

Standard 5. Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.

Standard 6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

Standard 7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

Standard 8. Conservation and management measures shall, consistent with the conservation requirements of the Magnuson-Stevens Act (including the prevention of overfishing and rebuilding of overfished stocks), taken into account the importance of fishery resources to fishing communities in order to: (1) provide for the sustained participation of such communities; and (2) to the extent practicable, minimize adverse economic impacts on such communities.

Standard 9. Conservation and management measures shall, to the extent practicable: (1) minimize bycatch; and (2) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

Standard 10. Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

2.2 The FMPs

For Alaska groundfish fisheries, the North Pacific Council developed, and NMFS has implemented, two FMPs: one for groundfish fisheries in the BSAI area, and the other for the GOA area. The FMPs are the overall guiding and planning documents for management of the groundfish fisheries in all their aspects. They establish economic, social and biological goals that are consistent with the MSA and other laws and include specific management approaches for achieving these goals. In addition to other measures, the FMPs contain conservation and management measures designed to minimize the impacts of the fisheries on listed species and their critical habitat. These measures are detailed later in this chapter, along with other pertinent elements of the FMPs.

The BSAI FMP was approved by the Secretary of Commerce on October 27, 1979, and implemented by regulations published on December 31, 1981 (46 FR 63295, corrected January 28, 1982, 47 FR 4083). The GOA Groundfish FMP was approved by the Secretary on February 24, 1978, and implemented by regulations published on November 14, 1978 (44 FR 52709). A brief overview of the contents of the BSAI and GOA FMPs is provided in Appendix 1. Amendments to the plans are listed and briefly described in Tables 2.1 (BSAI FMP) and 2.2 (GOA FMP).

2.3 Overview of Management Agencies, the Council, and the Fishery Management Process

The principal management agencies for the BSAI and GOA groundfish fisheries include NMFS, the U.S. Coast Guard, the Alaska Department of Fish and Game (ADFG), and the Alaska Board of Fisheries. Additional information will be provided in the description of the annual fisheries cycle later in this section.

2.3.1 NMFS

The Alaska groundfish fisheries are managed under the authority of the Secretary of Commerce, who delegates that authority through the Under Secretary and Administrator of NOAA to the Assistant Administrator for Fisheries (that is, NMFS) and to the NMFS Regional Administrator, Alaska Region. The Secretary may rescind this delegation at any time or for any management decision. NMFS is responsible for the day-to-day management of the fisheries. The agency cooperates with the Council to develop fishery policies, conducts rulemaking to implement FMP or regulatory amendments, conducts analyses on the effects of the fisheries on the human environment, monitors the fisheries, and enforces the rules and regulations implemented under the MSA and other applicable law.

NMFS also conducts research programs required to support the fisheries. For the Alaska groundfish fisheries, research activities are conducted primarily by the Alaska Fisheries Science Center (AFSC). Groundfish stocks in the BSAI and GOA are surveyed by the Resource Assessment and Conservation Engineering (RACE) Division, stock assessment is conducted by the Resource Ecology and Fisheries Management (REFM) Division, and research on marine mammals (including listed large cetaceans and Steller sea lions) is conducted by the National Marine Mammal Laboratory (NMML), also a division of the AFSC.

NMFS is also the principal management agency responsible for the recovery of a number of listed or protected species in the BSAI and GOA regions. Those species are described in chapter 4.0 below.

2.3.2 U.S. Coast Guard

The U.S. Coast Guard provides services essential to the implementation of the fisheries, including monitoring for safety and compliance with regulations, enforcement of such regulations, and field assistance with research. The Coast Guard designates a non-voting representative to the Council to act as an enforcement advisor, ensuring that conservation and management measures reflect the practical realities of enforcement in the region. That member also advises Council members of the safety impacts of proposed conservation and management measures.

The U.S. Coast Guard enforces compliance with fishery regulations and supports NOAA management objectives. Using airborne and at-sea assets, the Coast Guard

- Prevents encroachment by foreign fishing vessels on the EEZ;
- Ensures compliance by U.S. fishermen with domestic living marine resource laws and regulations within the EEZ;
- Enforces regulations implemented under laws such as the Marine Mammal Protection Act and Endangered Species Act and protects threatened marine resources, and;
- Ensures compliance with international agreements for the management of living marine resources on the high seas.

The Coast Guard also provides enforcement policy guidance to domestic lawmakers and regulators, and to U.S. representatives in the international arena, ensuring national and international policy objectives are achievable and enforceable.

2.3.3 State of Alaska

Since the MSA was passed in 1976, fisheries off Alaska have been managed by a combination of state and federal agencies. Article VIII of the state constitution directs the Alaska legislature and executive branch to manage state fisheries in such a way as to achieve maximum benefit to its people and management of renewable resources on a sustained yield basis. The Alaska Department of Fish and Game (ADFG) is the primary state fisheries management agency. ADFG also manages some groundfish fisheries (especially cod) in state waters and lingcod and black rockfish fisheries throughout state waters and the EEZ. The agency is generally responsible for management of fisheries for salmon, herring, crabs, and other invertebrates. The agency monitors state fisheries, conducts fisheries research, assesses stock condition, and determines appropriate harvest levels. The agency also has in-season emergency authority to open and close fisheries. The Commercial Fisheries Entry Commission is a second state agency that has authority to establish moratoria or limited-entry systems for state-managed fisheries. The Alaska State Legislature created the Alaska Board of Fisheries to provide public access to the fishery management process and to give direction to ADFG. The Board of Fisheries is responsible for developing state fishery management plans, making allocative decisions, and promulgating regulations. State fisheries will be considered below in the chapters on the Environmental Baseline (section 5) and Cumulative Effects (section 7).

2.3.4 North Pacific Fishery Management Council

The Council, which is composed of 11 voting members, serves six main functions (16 U.S.C. 1852 § 302(h)(1-6)):

(1) prepares and submits FMPs for each fishery that requires conservation and management, as well as amendments to each plan;
(2) prepares comments on certain applications for foreign fishing and on FMPs or amendments prepared by the Secretary [of Commerce];
(3) conducts public hearings to allow public participation in the management process;
(4) submits to the Secretary reports that it deems necessary or that were requested by the Secretary;
(5) for each fishery, reviews on a continuing basis the assessments and specifications necessary to achieve optimum yield from, the capacity and extent to which United States fish processors will process United States harvested fish from, and the total allowable level of foreign fishing in, each fishery; and
(6) conducts any other activities required by the MSA or necessary and appropriate to the foregoing functions.

In addition to the main Council body, the Council maintains four committees and panels. The Advisory Panel consists primarily of representatives of the fishing industry and is intended to advise the Council on any matters pertaining to the FMPs and amendments. The Scientific and Statistical Committee consists of appointed scientists and is intended to assist in the development, collection, and evaluation of statistical, biological, economic, social, and other scientific information necessary for development and amendment of FMPs. The two remaining committees are Plan Teams for the BSAI and GOA groundfish fisheries. These teams review stock assessment methods and results, and make recommendations on harvest levels to the Council based on the status and trends of each stock and its tolerance for fishery removal.

2.3.5 Fishery Management Process

General regulations governing U.S. fisheries appear at 50 CFR Part 600, and regulations specifically governing the groundfish fisheries in the EEZ off Alaska appear at 50 CFR Part 679. The regulations therein prescribe the existing regulatory framework for the federally managed groundfish fisheries off Alaska. The following description of the management process is intended to be generic, illustrating the process by which FMP amendments and regulatory amendments are developed. The setting of TACs will be described below in the section on the annual cycle. The management processes for developing, approving, and implementing FMP amendments and TAC-setting are illustrated in Figure 2.1.

FMPs, amendments to FMPs, and regulatory amendments are developed by the Council, submitted to the

Secretary of Commerce (Secretary) for review, and, if approved or partially approved, implemented by federal regulations. Once approved, the regulations are put into effect and NMFS has responsibility for day-to-day management of the fisheries. Enforcement of the regulations is carried out jointly by NMFS and the U.S. Coast Guard. Disapproved and partially approved FMPs and FMP amendments are returned by NMFS to the Council with an explanation of the reasons for disapproval. The Council may then decide whether to revise and resubmit the FMP/amendment. If the Council fails to develop a necessary FMP/amendment, or fails to revise an FMP/amendment following Secretarial disapproval or partial approval within a reasonable period of time, the Secretary may develop a Secretarial FMP/amendment. Secretarial authority to approve, disapprove or partially approve is set out in Section 304(a)(3) of the Magnuson-Stevens Act.

Amendments to FMPs may be necessitated by a variety of events including new or triggered statutory requirements, operational need, or changes in the fisheries. In addition, the Council annually solicits FMP and regulatory amendment proposals from the public. These proposals are then reviewed, and qualitatively ranked in terms of analytical difficulty and priority for consideration. If a proposal is selected for consideration, then the next step is the preparation of an initial analysis of the proposal. These analyses serve at least three functions. First, they fulfill requirements under certain statutes and executive orders. Second, they provide opportunity for interested or affected members of the public to bring information to the Council's attention regarding the proposed and alternative actions. And third, they help the Council to contrast and compare the potential effects of alternative actions to their stated policy goals and objectives, and make a well-reasoned decision on which amendment proposal to recommend to the Secretary.

Additional analytical requirements include environmental assessments or environmental impact statements as required by NEPA; a Regulatory Impact Review (RIR) under Executive Order 12866; a Regulatory Flexibility Act (RFA) review; an assessment of potential impacts on marine mammals under the Marine Mammal Protection Act; a review of effects on essential fish habitat under the MSA; a review of effects on the state's coastal zone management program (under the Coastal Zone Management Act); an assessment under the Paperwork Reduction Act; and possibly a federalism impact statement under Executive Order 13132.

The next step for the Council is to review a draft summary of the initial analysis to determine whether it should be released for public review and comment. In making this decision, the Council relies on the advice it receives from its Advisory Panel and Scientific and Statistical Committee. The Council decision at this point may be to release the initial draft analysis for formal public review as it is, instruct staff to make certain minor revisions to it before releasing it, or request major revisions to it and another Council review before releasing it. Or the Council may decide to suspend further action on the analysis, which would stop further development of the proposal, at least temporarily. If the Council decides to release the initial draft analysis for public review, the comment period normally is scheduled to begin at least four weeks before the next action by the Council on the proposal.

After a period of public review, the next action by the Council on a management proposal is to decide on its preferred alternative. The Council's choice of a preferred alternative (other than the "no action" alternative) frequently is referred to as the final action of the Council to adopt an FMP or FMP/regulatory amendment for recommendation to the Secretary.

Once the Council has determined its final recommendation, the recommendation is transmitted to the Secretary of Commerce. The principal documents that are submitted include (a) the proposed FMP text or text changes in the case of an FMP amendment, (b) the draft analysis of potential environmental and socioeconomic impacts of the preferred alternative and other alternatives considered by the Council, and (c) proposed regulations that would implement the action, if it is approved. The document with the proposed implementing regulations is a draft Federal Register notice of proposed rule making.

After receipt of the official FMP/amendment review package, the Secretary must immediately commence review of the package to determine whether the proposed FMP or FMP amendment is consistent with MSA, including the national standards, and other applicable law and must immediately publish a notice of availability in the Federal Register to start the period of public review. Within 30 days after the public comment period, the Secretary must approve, disapprove or partially approve the FMP amendment by written notice to the Council. If Secretarial action is not taken within the required time period, then the FMP amendment takes effect as if it were fully approved.

Thus, the MSA vests the Councils with the primary role of developing management measures. The role of the Secretary (normally NMFS, on behalf of the Secretary) is usually limited to approval, disapproval, or partial approval of a Council recommendation. Sec. 304(a)(3) states that if an FMP or FMP amendment is disapproved or partially approved, the written notice to the Council must specify the applicable law with which the FMP/amendment is inconsistent, the nature of the inconsistency, and recommendations for correcting the inconsistency.

When the Council recommends regulations to implement an FMP or amendment, the Secretary reviews them to determine their consistency with the underlying FMP. If NMFS determines that the proposed regulatory amendment is consistent, then it is published in the Federal Register, but if the determination is negative, again, NMFS must notify the Council in writing specifying the inconsistencies and providing recommendations for revision that would make the proposed regulation consistent. An approved FMP, FMP amendment or regulatory amendment is implemented by publication of a notice of approval or a final rule in the Federal Register. The rule normally is not effective for an additional 30 days after it is published as required under the Administrative Procedures Act.

2.4 Annual Fisheries Cycle

The annual fisheries management cycle consists of activities that can be grouped into four main functions: (1) stock assessment, (2) setting the total allowable catch (TAC) levels, (3) implementation of the fisheries, and (4) monitoring the catch and fisheries effects. The activities that comprise these four steps are illustrated in Figure 2.1.

2.4.1 Stock assessment

2.4.1.1 Target species and stocks

In the BSAI region, finfish and invertebrates are grouped into five categories: target, prohibited, other, forage fish, and nonspecified (BSAI FMP Annex VI, p. 402; Table 2.3 here). In 1999 and 2000, TACs were determined for the BSAI species or species groups listed in Table 2.4. In the GOA region, finfish and invertebrates are also grouped into five categories: target, prohibited domestic, prohibited foreign, other, and forage fish (GOA FMP Table 3.1, p. 12; Table 2.5 here). In 1999 and 2000, TACs were determined for the GOA species or species groups listed in Table 2.6. Species, species groups, and management units targeted under the BSAI and GOA FMPs are as follows.

Stock	Management units
Arrowtooth flounder	Managed as a single unit in the GOA. With Kamchatka flounder, managed as a single unit in the BSAI.
Atka mackerel	Managed as separate units in the BSAI and in the GOA.
Deep-water flatfish	In the GOA, managed as a complex of three species, including Dover sole, Greenland turbot, and deep-sea sole.
Demersal shelf rockfish	In the GOA, managed as a complex of seven species, including canary, China, copper, quillback, rosethorn, tiger, and yelloweye rockfish.
Flathead sole	Managed as a single unit in the GOA. With Bering flounder, managed as a single unit in the BSAI.
Greenland turbot	Managed as a single unit in the BSAI, and included in the deep-water complex in the GOA.
Northern rockfish	Managed as a single unit in the GOA, included in the "other red rockfish" complex in the Bering Sea, and included in the northern/sharpchin complex in the Aleutian Islands.
Northern/sharpchin rockfish	Managed as a two-species complex in the Aleutian Islands.
Other flatfish	In the Bering Sea, managed as a complex of sixteen species, including Alaska plaice, Arctic flounder, butter sole, California tonguefish, C-O sole, curlfin sole, deepsea sole, Dover sole, English sole, hybrid sole, longhead dab, Pacific sanddab, petrale sole, rex sole, roughscale sole, sand sole, slender sole, and starry flounder.
Other red rockfish	In the Bering Sea, managed as a complex of four species, including northern, rougheye, sharpchin, and shortraker rockfish.
Other rockfish	In the Bering Sea and Aleutian Islands, managed as separate complexes of at least 33 species, including aurora, black, blackgill, blue, bocaccio, brown, canary, chameleon, chilipepper, copper, dark blotched, dark dusky, gray, greenstriped, harlequin, pink rose, pygmy, red banded, redstripe, rosethorn, rosy, silvergrey, splitnose, stripetail, tiger, vermilion, widow, yelloweye, yellowmouth, yellowtail, broad banded thornyhead, longspine thornyhead, and shortspine thornyhead rockfishes.
Other slope rockfish	In the GOA, managed as a complex consisting of 17 species, including aurora, blackgill, bocaccio, chilipepper, darkblotched, greenstriped, harlequin, pygmy, redbanded, redstripe, sharpchin, shortbelly, silvergrey, splitnose, stripetail, vermilion, and yellowmouth rockfish.

Stock	Management units
Other species	In the BSAI, managed as a complex of at least 44 species, including multiple species of sculpins, sharks, skates and octopus. In the GOA, managed as a complex of at least 30 species, including multiple species of sharks, skates, sculpins, octopus, and squids.
Pacific cod	Managed as separate units in the BSAI and GOA.
Pacific ocean perch	Managed as five units, including Bering Sea, Aleutian Islands, western GOA, central GOA, and eastern GOA.
Pelagic shelf rockfish	In the GOA, managed under Amendment 46 to FMP and includes dusky, yellowtail, and widow rockfish.
Black and blue rockfish	In the GOA, managed as multiple area specific units
Pollock	Managed as five units, including eastern Bering Sea, Aleutian Islands, Aleutian Basin/Bogoslof Island, western/central GOA, and eastern GOA.
Rex sole	Managed as a unit in the GOA; included in “other rockfish” in the BSAI.
Rock sole	Managed as a single unit in the BSAI; included in the shallow-water complex in the GOA.
Sablefish	Managed as separate units in the Bering Sea, Aleutian Islands, and GOA.
Shallow-water flatfish	In the GOA, managed as a complex consisting of 15 species, including Alaska plaice, butter sole, C-O sole, curlfin sole, English sole, hybrid sole, longhead dab, pacific sanddab, petrale sole, rock sole, roughscale sole, sand sole, slender sole, starry flounder, and yellowfin sole.
Shortraker/rougheye rockfish	In the Aleutian Islands and GOA, managed as separate two-species complexes.
Squid	Managed as a single unit in the BSAI; consists of multiple species.
Thornyhead rockfish	Managed as a single unit in the GOA; included in the “other rockfish” complex in the BSAI; consists of multiple species.
Yellowfin sole	Managed as a single unit in the BSAI, and included in the shallow-water complex in the GOA.

These stocks, their status, and the fisheries on each stock are described in detail in the 2000 Stock Assessment and Fishery Evaluation reports for the BSAI and GOA groundfish fisheries. Synopses of those descriptions are included here in Appendix 2.

2.4.1.2 Stock surveys

Stock assessment consists of two main functions, 1) determining the status (a measure of population size and trend) of the stock and 2) evaluating its tolerance to fishing. Stock surveys, along with the fishery observer program and catch statistics, are essential for assessment of the stocks fished under the BSAI and GOA FMPs. In general, these surveys involve deployment of standardized sampling gear according to consistent protocols to catch or measure fish abundance or biomass at a particular location. Estimates of overall fish abundance or biomass are then based on average catch rates per sampled location multiplied by the size of the total area. The results can be expressed as an index or estimate of abundance or biomass. Results from single surveys may be used separately to generate such indices/estimates, or results from multiple surveys may be combined.

Three types of surveys are conducted, including bottom trawl for shellfish and bottom fishes, hydroacoustic or echo integration-trawl (EIT) for the dominant semi-pelagic fishes, and longline for bottom fishes (e.g., sablefish) of the deeper waters of the continental shelf and slope. Summer bottom trawl surveys of the eastern Bering Sea have been conducted annually since 1972, with the current standardized time series beginning in 1979. These surveys follow a systematic grid of sampling stations. Triennial summer bottom trawl surveys for the Aleutian Islands and the GOA began in 1980 and 1984, respectively. These triennial surveys are based on area and depth-stratified random sampling among a set of predetermined stations. Annual winter EIT surveys were initiated in 1981 to study abundance of spawning pollock in Shelikof Strait, and in 1988 to study pollock abundance in the vicinity of Bogoslof Island. Summer longline surveys were initiated by Japanese scientists in 1979 to assess sablefish abundance over the upper continental slope in the GOA. These surveys are now conducted by U.S. scientists, and have been extended to the Aleutian Islands and the eastern Bering Sea slope, where they are conducted in alternate years. New surveys may be added to the existing survey schedule as follows.

(1) Summer bottom trawl surveys will continue in the eastern Bering Sea.

(2) Summer bottom trawl surveys will be conducted biennially (rather than triennially) in the GOA and Aleutian Islands.

(3) Summer EIT surveys may be initiated on an alternate year basis in the GOA and eastern Bering Sea.

(4) Summer longline surveys will continue for estimation of sablefish abundance.

(5) Winter EIT surveys will continue in the Bogoslof and Shelikof areas on an annual basis.

(6) Winter EIT surveys may be instituted to determine abundance of pollock in sea lion critical habitat.

(7) Based on results of a bottom trawl slope survey this summer (2000), biennial slope surveys may be initiated in the eastern Bering Sea.

As noted above, surveys are conducted to assess the abundance or biomass of stocks. In addition, they also provide important information on age and sex composition, recruitment of young fish to the fished stock, length and weight at age, reproductive status or condition, food habits, and other pertinent biological characteristics. Assessment of each of these parameters may be affected by sampling variability, measurement error, or systematic bias. Considerable effort is directed at minimizing measurement error and bias, but sampling variability may still occur and must be evaluated and reported to provide an indication of the confidence with which final parameter estimates may be used. Table 2.7 provides an indication of the sampling variability observed for each assessed stock. The error is expressed as the coefficient of variation (CV) which is equal to ((standard error/estimate)*100). For example, the CV for pollock in the eastern Bering Sea is 23%. This CV indicates that if the surveys were conducted repeatedly under the same conditions, 68% of the time (i.e., ± 1 standard error) the new estimates would fall within the interval from current estimate minus 23% to the current estimate plus 23%. If this estimation procedure is unbiased, then 68% of the time this interval also would be expected to enclose the true value for pollock in the area assessed.

2.4.1.3 Stock modeling

The second major process in stock assessment is modeling of each stock to further describe its status and investigate its tolerance to fishing. The information required for modeling comes from the stock surveys, from the fisheries themselves, and from other studies. For a given target stock, the objective of modeling is to 1) estimate the state of the population by creating a simulated population that is most consistent with the data on the wild population, and 2) estimate the tolerance of the wild population to fishing based on the characteristics of the simulated population.

Three types of models or modeling approaches are used for the stocks fished under the BSAI and GOA FMPs (Table 2.7): stock synthesis, AD model builder, and stock index. In general, these models include a range of elements from simple numerical or accounting procedures to complex mathematical functions. The nature and blend of these elements depends, in part, on the information that is available and the preferences of the scientist(s) modeling the stock. Nonetheless, all have the same general purpose of describing the wild stock and evaluating its tolerance to fishing.

The stock synthesis approach has been the primary modeling tool for the past decade. The approach was developed by Methot (1990) to conduct an age- or length-structured analysis using life history, catch, survey, and other information, as well as the level of uncertainty in such information. Given a set of values for the model parameters (e.g., annual fishing mortality rates and recruitment), a simulated stock is created and subjected to simulated fisheries and surveys for comparison with the real catch and survey data. The degree of similarity between the simulated data and the real data is referred to as the “goodness of fit,” which is expressed in terms of a “likelihood.” The likelihood is then assessed as the probability of the data given the model parameters. The best simulated population (i.e., the one in most agreement with the data) is found by adjusting the model parameters of the simulated population until the likelihood expression is maximized (accomplished using a computer “optimization” routine). The stock assessment authors then complete their assessment by weighing and considering the best simulated population, along with other reasonable or possible model outcomes.

For evaluation of some stocks, the stock synthesis approach is being replaced or supplemented by analyses using the AD Model Builder (Fournier 1998). AD Model Builder is essentially a set of pre-programmed computer subroutines that enable faster and more reliable estimation of various parameters used in stock assessment modeling and which also enable efficient calculation of the probabilities of alternative parameter values. The equations representing population dynamics and statistical likelihood in models developed under AD Model Builder can take exactly the same form as those in the stock synthesis approach or they can take different forms, thereby enabling exploration of alternative modeling assumptions. In effect, AD Model Builder expands the capabilities of the stock assessment modeling efforts.

"Stock index modeling" encompasses a variety of assessment approaches that are used to describe the wild population and its tolerance for fishing when the available data are too limited to conduct a full age- or length-based assessment. They are frequently based on indices of the population derived from survey estimates alone.

Where the data allow, the general modeling approach is to create a simulated population of a particular size (number) and age/sex composition. That is, the model is based on year-classes or cohorts. A new cohort enters the model population in each year of the simulation. The numerical abundance of a cohort at the age where it first enters the model population is a parameter estimated by the model. This is sometimes referred to as "recruitment" to the model population, which may occur at a different age than recruitment to the surveyed population or recruitment to the fished population. For example, for a particular stock the model population might begin at age 1, even though fish in that stock are seldom detected by the survey before age 2 or caught in the fishery before age 3. After the age of recruitment to the model, each cohort decays over time due to natural mortality and fishing mortality (when appropriate). As a cohort ages over time in the model, the average length, weight, maturity, and selectivity of fish in the cohort are assumed to vary in predictable fashion. In the wild, these functions may vary unpredictably under a number of influences, including density-independent factors (e.g., environmental conditions) or density-dependent factors (e.g., stock size). In modeling, however, these functions are generally treated as fixed or constant parameters. The processes of growth, maturation, reproduction, natural mortality, fishing mortality, and recruitment are described in further detail below.

Growth

Individuals in a cohort grow over time. Information on physical size and growth is important because the replicate and wild populations consist of numbers of individuals, but harvests are measured in terms of biomass. Thus, growth information is necessary to convert numbers available to biomass available. Growth is assessed using samples taken during surveys and from the fisheries catch. The estimated relations may include length as a function of age, weight as a function of age, or weight as a function of length. Age is estimated using the ear bones (otoliths), which exhibit annual growth layers or rings. Weight at age and numbers at age are necessary to determine overall biomass. Weight also appears to be an important determinant of fecundity (number of viable eggs produced by a female).

Maturation

Maturation is an expression of the reproductive capacity of an individual. While individuals are generally described as "immature" or "mature" (i.e., fully one or the other), maturation may involve physiological and behavioral changes that are not abrupt but transition over a period of time. For example, young females in the process of maturing may be able to produce eggs, but those eggs may not be as viable as the eggs of an older female. Maturation is expressed most often as a function of age but, weight may also be an important determinant of the maturation process. Maturity is assessed using samples taken during surveys and from the fisheries catch. Maturation of all individuals in a cohort may occur over a single year or over a period of several years.

Reproduction

As females mature they begin to produce eggs. The number and viability of a female's eggs determine the contribution of that female to the new cohort. However, the size of the cohort at recruitment age is also a function of environmental (e.g., currents, temperature) and ecological (e.g, predators, prey) factors that determine growth and survival from fertilization to recruitment. Depending on the method used for modeling recruitment, reproductive functions may or may not be essential or important for the modeling effort. For example, if recruitment is modeled as a density-independent random variable based on estimates of past recruitment, then reproduction by adult females need not be included explicitly in the model.

Natural mortality

Natural mortality refers to the instantaneous rate of decline of a population or cohort due to natural causes such as disease or predation. The rate of decline may vary as a function of age, but for most fish populations harvested in the BSAI and GOA groundfish fisheries, natural mortality is generally treated as constant for cohorts at or above the age of recruitment to the fishery. In most age- or length-structured stock assessments the natural mortality rate is assumed to be known from previous studies, although occasionally it is estimated within the stock assessment model itself. For fish populations, natural mortality is most often expressed as M in the function

$$N_1 = N_0 * e^{-(M + F)},$$

where N_0 and N_1 represent numbers at time 0 and time 1.

Fishing mortality

F in the above equation, is the instantaneous rate of decline of a population or cohort due to fishing. Age- or length-structured stock assessment models estimate annual fishing mortality rates for each year in a time series as parameters of the model.

Recruitment

Recruitment is the process by which fish enter some portion of the population, such as the portion available to the fishery. The process may be defined in terms of the age or size of the fish, which are usually closely related. The numbers or biomass of fish recruited to the fishery in a given year is determined by the quantity and quality of reproductive output by mature fish, plus factors that affect the growth and survival of individuals from fertilized egg up to recruitment. Defining the age of recruitment to the model population is largely a matter of convenience and may be governed by such considerations as the youngest age observed in the survey or the youngest age above which natural mortality can reasonably be viewed as constant. Above the age of recruitment to the model population, most stock assessment models treat fishery selectivity as a continuous function of age or size, making designation of “the” age of recruitment to the fishery a somewhat tenuous exercise.

The modeling of recruitment is a crucial component of population models used for fishery evaluation and projection. The population models used for these fished stocks are “closed” in the sense that they do not include immigration or emigration in or out of the population (except for the possibility that recruitment to the model population could potentially include an immigration component). Therefore, as cohorts are stepped through time (years) they can only diminish in numbers due to natural or fishing mortality. In terms of numbers, the stock or population is replenished only through the addition (recruitment) a new cohort each year.

Recruitment can be incorporated into fisheries models in a variety of ways, two of which will be described here. First, recruitment can be modeled as a function of the reproductive stock (based on either numbers or biomass) (Fig. 2.2). The shape of an assumed or demonstrated stock-recruitment function is a crucial consideration in modeling recruitment. Importantly, among all the stocks fished under the BSAI and GOA FMPs, a stock-recruitment function has been characterized only for the pollock stock of the eastern Bering Sea.

The second approach to modeling recruitment is to assume that it is independent of stock size (i.e., density independent). For BSAI and GOA groundfish, the assumption is that while spawning biomass (used as a proxy for number of eggs produced) may be an important determinant of subsequent year class strength when stock size is low, spawning biomass in not an important determinant of subsequent year class strength at stock sizes typically observed. Because stock-recruitment functions have not been identified for the majority of stocks fished under the BSAI and GOA FMPs, recruitment is modeled as a density-independent random variable based on past recruitment levels.

The significance of these processes in the model depends on the sensitivity of model results to each function and the extent to which the real processes are appropriately and accurately represented in the modeling process. Again, all of the above processes except recruitment are incorporated into the models as fixed rates or schedules, some estimated within the model and others estimated from separate studies. Recruitment is the only model process that is treated stochastically. Uncertainty is incorporated into the model for input data collected in the field (e.g., catch at age, age-length relation, survey biomass).

2.4.2 Setting the TAC

After the target stocks or stock complexes have been assessed and modeled, the next step in the process is to determine the tolerance of each stock/stock complex to fisheries removal. The TAC for each stock/stock complex is determined annually on the basis of that tolerance plus other considerations (e.g., social, economic, ecological).

2.4.2.1 Surplus production and MSY

Stock assessment is generally based on the assumption that the fished populations are closed. Under this assumption, populations can increase in number only through recruitment and can decrease in number only through mortality. That is, the populations are replenished numerically only by the annual addition of a new cohort or year-class. In terms of biomass, the populations change by additions due to recruitment and physical growth, and by losses due to natural and fishing mortality.

The number of fish constituting the fished part of a population is determined, then, by the combination of ongoing mortality of all cohorts and annual recruitment of a new cohort. Mortality may result from natural causes (i.e., natural mortality), or may result from fishing (i.e., fishing mortality). Recruitment is determined by a number of factors, the roles of which may vary considerably by (among other things) stock, area, and time. The factors that determine recruitment are a matter of considerable debate and research. For example, the Fisheries-Oceanography Coordinated Investigations (FOCI) program was instigated by the National Oceanic and Atmospheric Administration (NOAA) in 1984 to investigate the factors determining recruitment of pollock in the GOA.

For an unfished stock of a particular size, recruitment may occur at levels greater than necessary to replace a stock (i.e., maintain the stock at that size). Such “excess” is essential, for example, for population growth. In a deterministic “single-species context”, this excess is considered a surplus that can be removed by fishing without harm to the stock. The concept of surplus recruitment is illustrated by the Ricker (1954) stock-recruitment relation in Figure 2.2. The Ricker curve indicates a density-dependent relation between stock and recruitment where recruitment varies as a function of some measure of stock size (e.g., number or biomass). The Ricker curve also suggests that recruitment reaches a peak at some stock level and then declines with increasing stock size. The excess or surplus recruitment in this case is represented by the vertical difference between the stock-recruitment line and the replacement line. In the simplest case, without random variability and where the fishable stock consists of a single age group, this excess represents sustainable yield. At some stock size, the excess reaches a maximum, which is the maximum sustainable yield. The BSAI FMP (p. 16) defines the maximum sustainable yield as an average over a reasonable length of time of the largest catch which can be taken continuously from a stock under current environmental conditions.

In the Ricker curve, recruitment reaches a peak and then declines. While the decline could indicate changes in both reproduction of the stock and mortality of pre-recruits, Ricker (1954) attributed it to compensatory mortality of pre-recruits through mechanisms such as predation and, in particular, cannibalism. Thus, the number of young produced probably continues to increase with increasing stock size, but fewer young survive to recruitment. The remainder are “lost” to various forms of mortality.

2.4.2.2 MSY proxies and F_X

In the absence of evidence for a clear stock-recruitment relation, the question is how to determine what stock size and rate of removal will provide the maximum sustainable yield. Clark (1991) characterized this problem as a question of "how to choose a fixed exploitation rate that will provide a high yield at low risk, when the investigator has no knowledge of the yield curve or th e spawner-recruit relationship of the stock."

The GOA FMP (p. 3-4) and the BSAI FMP (p. 16) both state that "where sufficient scientific data as to the biological characteristics of the stock do not exist or the period of exploitation or investigation has not been long enough for adequate understanding of stock dynamics, the MSY will be estimated from the best information available." Regulations pertaining to optimum yield (50 CFR § 600.310(c)(3)) recognize that alternatives to MSY may be required. The regulations state the following:

> When data are insufficient to estimate MSY directly, Councils should adopt other measures of productive capacity that can serve as reasonable proxies for MSY, to the extent possible. Examples include various reference points defined in terms of relative spawning per recruit. For instance, the fishing mortality rate that reduces the long-term average level of spawning per recruit to 30-40 percent of the long-term average that would be expected in the absence of fishing may be a reasonable proxy for the MSY fishing mortality rate. The long-term average stock size obtained by fishing year after year at this rate under average recruitment may be a reasonable proxy for the MSY stock size, and the long-term average catch so obtained may be a reasonable proxy for MSY. The natural mortality rate may also be a reasonable proxy for the MSY fishing mortality rate. If a reliable estimate of pristine stock size (i.e., the long-term average stock size that would be expected in the absence of fishing) is available, a stock size approximately 40 percent of this value may be a reasonable proxy for the MSY stock size, and the product of this stock size and the natural mortality rate may be a reasonable proxy for MSY.

Clark (1991) suggested that for groundfish with typical life history parameters, "yield will be at least 75% of maximum sustainable yield so long as the spawning biomass is maintained in the range of about 20-60% of the unfished level, regardless of the spawner-recruit relationship." He also suggested that "relative spawning biomass in this range can be achieved by choosing a fishing mortality rate that will reduce the spawning biomass *per recruit* to about 35% of the unfished level." (emphasis in original). The fishing mortality rate that will result in a spawning biomass per recruit of about 35% of the unfished level is denoted $F_{35\%}$. Clark's (1991) results were supported by a review of harvest levels for various fisheries around the world (Mace 1994), and by the analyses of Restrepo et al. (1998).

In the absence of sufficient information about stock-recruitment relations for the stocks targeted under the BSAI and GOA FMPs, the results of Clark (1991), Mace (1994), and Restrepo et al. (1998) have been used to create surrogate or proxy MSY reference points.

2.4.2.3 Limits, targets, and harvest control rules

The National Standard Guidelines distinguish between *limiting* reference points (which management seeks to *avoid*) and *target* reference points (which management seeks to *achieve*). In the case of target harvest levels or rates, the Guidelines encourage a precautionary approach as follows (50 CFR § 600.310(f)(5)).

(1) Target reference points should be set safely below limit reference points.

(2) A stock that is below its MSY level should be harvested at a lower rate than if the stock were above its MSY level.

(3) Criteria used to set target catch levels should be explicitly risk averse, so that greater uncertainty regarding the status or productive capacity of a stock corresponds to greater caution in setting target catch levels.

The Guidelines envision that limit and target fishing mortality rates will often be cast in the form of "harvest control rules," which are functions that determine fishing mortality based on stock size (50 CFR § 600.310(c)(2), § 600.310(f)(4)(ii)). In particular, the Guidelines presume that MSY will be estimated using an "MSY control rule" which describes how the Council would set harvest rates if maximization of long-term average yield were its primary goal. An MSY control rule would be an example of a limit reference point. A wide variety of functional forms can be used to define harvest control rules (Restrepo et al. 1998).

The BSAI and GOA Groundfish FMPs define two sets of harvest control rules which follow the precautionary approach outlined above to a considerable extent. One set of control rules defines the limit harvest rate that is used to determine the "overfishing level" (OFL), and the other defines the upper boundary for the target harvest rate that is used to determine the "acceptable biological catch" (ABC). The ABC is defined as a preliminary description of the acceptable harvest (or range of harvests) for a given stock or stock complex. Its derivation focuses on the status and dynamics of the stock, environmental conditions, other ecological factors, and prevailing technological characteristics of the fishery.

The two sets of harvest control rules in the BSAI and GOA Groundfish FMPs are prescribed through a set of six tiers which are listed below in descending order of preference, corresponding to descending order of information availability. For tier (1), a "pdf" refers to a probability density function. For tiers (1-2), *MSY* refers to maximum sustainable yield, which is the largest catch which the stock can withstand, on average, over a long period of time (given current environmental conditions). For tiers (1-3), the coefficient "a" is set at a default value of 0.05, with the understanding that a different value for a specific stock or stock complex may be used if supported by the best available scientific information. For tiers (2-4), a designation of the form "F" refers to the fishing mortality (F) associated with an equilibrium level of spawning biomass per recruit (SPR) equal to $X\%$ of the equilibrium level of spawning biomass per recruit in the absence of any fishing. For tier (3), the term $B_{40\%}$ refers to the long-term average biomass that would be expected under average recruitment and $F=F_{40\%}$. Tiers for fished stocks are listed in Table 2.7.

Tier 1) Information available: Reliable point estimates of B and B_{MSY} and reliable pdf of F_{MSY}.

1a) Stock status: $B/B_{MSY} > 1$
$F_{OFL} = m_A$, the arithmetic mean of the pdf
$F_{ABC} \leq m_H$, the harmonic mean of the pdf

1b) Stock status: $a < B/B_{MSY} \leq 1$
$F_{OFL} = m_A \times (B/B_{MSY} - a)/(1 - a)$
$F_{ABC} \leq m_H \times (B/B_{MSY} - a)/(1 - a)$

1c) Stock status: $B/B_{MSY} \leq a$

$F_{OFL} = 0$
$F_{ABC} = 0$

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

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

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

2c) Stock status: $B/B_{MSY} \leq a$
$F_{OFL} = 0$
$F_{ABC} = 0$

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

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

3b) Stock status: $a < B/B_{40\%} \leq 1$
$F_{OFL} = F_{35\%} \times (B/B_{40\%} - a)/(1 - a)$
$F_{ABC} \leq F_{40\%} \times (B/B_{40\%} - a)/(1 - a)$

3c) Stock status: $B/B_{40\%} \leq a$
$F_{OFL} = 0$
$F_{ABC} = 0$

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

Tier 5) Information available: Reliable point estimates of B and natural mortality rate M.
$F_{OFL} = M$
$F_{ABC} \leq 0.75 \times M$

Tier 6) Information available: Reliable catch history from 1978 through 1995.
OFL = the average catch from 1978 through 1995, unless an alternative value is established by the SSC on the basis of the best available scientific information
ABC $\leq$ 0.75 × OFL

2.4.2.4 Status determination

The MSA requires the Secretary of Commerce to "report annually to the Congress and the Councils on the status of fisheries within each Council's geographical area of authority and identify those fisheries that are overfished or are approaching a condition of being overfished" (16 U.S.C. § 304(e)(1)). The Guidelines define two "status determination criteria" to be used in making this identification. The first of these, the "maximum fishing mortality threshold" (MFMT), is used to determine whether a stock is being subjected to a rate of fishing mortality that is too high. The second, the "minimum stock size threshold" (MSST), is used to determine whether the stock has fallen to a level of biomass that is too low. Exceeding the MFMT results in a determination that the stock is being subjected to overfishing. Falling below the MSST results in a determination that the stock is overfished.

More specifically, the Guidelines require that the MFMT be at least as conservative as the MSY control rule (50 CFR 600.310(d((2)(i)), and they define the MSST as whichever of the following is greater: one-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years if the stock were exploited at the MFMT (50 CFR 600.310(d((2)(ii)).

When expressed in units of catch, the MFMT is equivalent to OFL in the BSAI and GOA FMPs, and when expressed in units of fishing mortality, the MFMT is equivalent to F_{OFL}. Thus, prevention of overfishing is accomplished simply by insuring that catch does not exceed OFL in any given year.

For each BSAI and GOA groundfish stock managed under tiers 1-3, the following algorithm is used to determine stock status with respect to MSST (Figure 2.3).

- If the stock is below ½ B_{MSY}, it is below MSST.

- If the stock is above B_{msy}, it is also above MSST.

- If the stock is between ½ B_{MSY} and B_{MSY}, then 1000 simulations are conducted in which the population is projected forward 10 years with randomly varying recruitment and with fishing mortality set equal to F_{OFL} in all years. Recruitment is drawn from a probability distribution based on recruitment estimates from 1978 to 1998.

- If the average ending stock size in these simulations is above B_{msy}, the stock is above its MSST.

- If the average ending stock size in these simulations is below B_{msy}, the stock is below its MSST.

MSSTs can not be estimated for certain stocks because the necessary reference stock levels can not be estimated reliably. These stocks are (by definition) managed under harvest tiers 4-6.

The stock is considered to be *approaching* an overfished condition if NMFS (for the Secretary) estimates that the stock will become overfished within two years (16 U.S.C. 1854 § 304(e)(1)). For each BSAI and GOA groundfish stock managed under tiers 1-3, the determination as to whether the stock is approaching an overfished condition is made on the basis of 1000 simulations in which the population is projected forward 12 years with randomly varying recruitment and with fishing mortality set equal to the maximum permissible value of F_{ABC} for the first two years and equal to F_{OFL} thereafter:

- If the mean spawning biomass for the third year is below ½ B_{MSY}, the stock is approaching an overfished condition.

- If spawning biomass for the third year is above B_{MSY}, the stock is not approaching an overfished condition.

- If spawning biomass for the third year is between ½ B_{MSY} and B_{MSY}, the determination depends on the mean spawning biomass at the end of 12 years.

- If the average ending stock size in these simulations is below B_{MSY}, the stock is approaching an overfished condition.

- If the average ending stock size in these simulations is above B_{MSY}, the stock is not approaching an overfished condition.

2.4.2.5 From ABC to TAC

ABC and OFL are first recommended by the stock assessment authors, who evaluate the biological state of the fished stock and its tolerance for fishing. Their recommendations are summarized in Stock Assessment and Fishery Evaluation (SAFE) reports. SAFE reports provide the Council with "a summary of information concerning the most recent biological condition of stocks and the marine ecosystems in the FMU [fishery management unit] and the social and economic condition of the recreational and commercial fishing interests, fishing communities, and the fish processing industries. [They summarize], on a periodic basis , the best available scientific information concerning the past, present, and possible future condition of the stocks, marine ecosystems, and fisheries being managed under Federal regulation" (50 CFR § 600.315(e)(1)). Each SAFE report must be scientifically based and should contain (50 CFR § 600.315(e)(2-3)).

(1) information on which to base harvest specifications,

(2) a description of the maximum fishing mortality threshold and the minimum stock size threshold for each stock or stock complex, along with information by which the Council may determine (a) whether overfishing is occurring or any stock is overfished, and whether overfishing or overfished conditions are being approached, and (b) any measures necessary to rebuild an overfished stock.

Each report may also contain "additional economic, social, community, essential fish habitat, and ecological information pertinent to the success of management or the achievement of objectives of each FMP" (50 CFR § 600.315(e)(4)).

The BSAI FMP (p. 287) and GOA FMP (p. 20) require the following minimum contents of the SAFE reports.

(1) Current status of Bering Sea and Aleutian Islands area groundfish resources, by major species or species group.

(2) Estimates of MSY and ABC.

(3) Estimates of groundfish species mortality from nongroundfish fisheries, subsistence fisheries, and recreational fisheries, and differences between groundfish mortality and catch, if possible.

(4) Fishery statistics (landings and value) for the current year.

(5) The projected responses of stocks and fisheries to alternative levels of fishing

mortality.

(6) Any relevant information relating to changes in groundfish markets.

(7) Information to be used by the Council in establishing prohibited species catch limits (PSCs) for prohibited species and fully utilized species with supporting justification and rationale.

(8) Any other biological, social, or economic information which may be useful to the Council.

The stock assessments and recommendations are reviewed by the BSAI and GOA groundfish plan teams, which consist of members from the Alaska Fisheries Science Center, ADFG, the Washington Department of Fisheries, the U.S. Fish and Wildlife Service, the International Pacific Halibut Commission, and the University of Alaska at Fairbanks. The plan teams then prepare their recommendations to the Council's Advisory Panel and Scientific and Statistical Committee, and the main body of the Council. The Council's Scientific and Statistical Committee has final authority for determining whether a given item of information is "reliable" for the purpose of determining ABCs and OFLs, and may use either objective or subjective criteria in making such determinations.

TAC

Based on the reviews and recommendations of the stock assessment authors, the plan teams, the Scientific and Statistical Committee, and the Advisory Panel, the Council then considers the ABC and OFL levels for each stock, and pertinent social, economic, and ecological information to determine a total allowable catch (TAC) for each stock or stock complex under the BSAI and GOA FMPs.

The TAC for a specific stock or stock complex may be sub-divided for biological and socio-economic reasons according to percentage formulas established in FMP amendments. For particular target fisheries, TAC specifications are further allocated within management areas (eastern, central, western Aleutian Islands; Bering Sea; eastern, central, western GOA; Figs. 2.4 and 2.5), among management programs (open access or community development quota program), processing components (inshore or offshore), specific gear types (trawl, non-trawl, hook-and-line, pot, jig), and seasons according to regulations.

The Council and its committees review the information and recommendations and consider TAC specifications at both their October and December meetings. Once a final recommendation has been made, NMFS proposes the Council's recommended TAC levels as a proposed rule. After a public comment period, NMFS publishes a final fule, usually around February or March of the fishing year. However, the TAC specifications define upper harvest limits for the year from January 1 to December 31. Therefore, a set of interim TAC specifications is required to start the fishery. Regulations provide that interim TACs are either the first seasonal allowance or equal to one-fourth of the previous year's TAC specifications and apportionments thereof toward fisheries occurring in the first quarter of the calendar year. The TAC specifications for 1999 and

2000 are listed in Tables 2.4 and 2.6. TAC specifications for 2001 are under development will be changed by the RPAs in Chapter 9 of this document if necessary.

Optimum yield

The BSAI FMP (p. 285) states:

> "The groundfish complex and its fishery are a distinct management unit of the Bering Sea. The complex has more than 10 commercially important species and many others of lesser or no commercial importance. This complex forms a large subsystem of the Bering Sea ecosystem with intricate interrelationships between predators and prey, between competitors, and between those species and their environment. Therefore, the productivity and MSY of groundfish should be conceived for the groundfish complex as a unit rather than for many individual species groups."

Under the MSA, optimum yield is prescribed on the basis of the maximum sustainable yield from each fishery, as reduced by any relevant economic, social, or ecological factor (16 U.S.C. 1802 § 3(28)(B)). In both the BSAI FMP (p. 285-286) and GOA FMP (p. 16), the concept of optimum yield has been applied to the sum total of the groundfish catch in these regions. In 1981, optimum yield for total BSAI groundfish catch was set as a range from 1.4 million mt to 2.0 million mt. The endpoints of the range were determined by subtracting 15% from the endpoints of the range of MSY estimates available at that time. The BSAI FMP (p. 285) justified the 15% reduction by stating that it 1) reduces the risk associated with relying upon incomplete data and questionable assumptions in assessment models used to determine the condition of stocks, and 2) is probably a conservatively safe level for the groundfish complex.

In 1986, optimum yield for the total GOA groundfish catch was set as a range from 116,000 mt to 800,000 mt (GOA FMP, p. 16). The low end of the range is approximately equal to the lowest historical groundfish catch during the 21-year period from 1965 to 1985. The upper end is approximately equal to the lowest MSY estimate from the period 1982 to 1986.

2.4.2.6 Incidental catch

While fishery participants may target a certain species, they are not 100% effective in limiting their catch to that specific target. Other fishes and marine life are also caught to varying degrees depending on target species, gear type and fishing method, area fished and habitat type, season, depth, and other physical and biological factors. These other fishes and marine life are referred to as "incidental catch" or "bycatch."[5] Whether a species or stock is caught as a target by a fishing vessel, or incidentally by a vessel after another target, the catch is supposed to be

[5] The terms "incidental catch" and "bycatch" are often used to mean catch of species or marine life not targeted. In regulations, the terms are given specific meanings. "Incidental catch" applies to the unintended catch of species that may be targeted or the unintended catch of species other than prohibited species. "Bycatch" is used in the regulations to refer to the incidental catch of prohibited species.

included against the overall total allowed for a species or stock. That is, TACs are intended to represent the sum of all catch including targeted catch and incidental catch.

2.4.2.7 Bycatch of prohibited species

Prohibited species include Alaska king crab, Tanner and snow crab, Pacific halibut, Pacific salmon species and steelhead trout, and Pacific herring. With some exceptions (explained below) retention is prohibited in the BSAI and GOA groundfish fisheries to eliminate any incentive to target these species.

Crab

Alaska king, Tanner and snow crab fisheries are managed by the State of Alaska, with federal oversight and following guidelines established in the FMP for the BSAI crab fisheries (NPFMC 1989). The commercially important crab species are: red king crab, blue king crab, golden or brown king crab, Tanner crab, and snow crab. Crabs use benthic habitat, which is vulnerable to destruction and alteration by bottom trawling. In the BSAI, the Bristol Bay Habitat Conservation Area, the Red King Crab Savings Area, and the Pribilof Islands Habitat Conservation Area serve to protect crab habitat. In the GOA, seasonal and year-round closures are used to protect crab habitat in the EEZ and Alaska state waters.

Bycatch of king, Tanner, and snow crab in groundfish fisheries is a significant issue. Typically, the crab bycatch are juveniles. PSC limits for each species by zone and by fishery closes the fishery for the remainder of the season when the PSC limit has been reached. Area closures and a vessel incentive program are also used to limit crab bycatch (Witherell and Pautzke 1997). Trawl fisheries are limited to less than 1% of crab populations, except for Tanner crab in Zone 2. However, trawling may also cause unobserved mortality and habitat degradation, and closed areas are likely to be more effective than PSC limits in reducing the impacts of trawling on crab stocks (Witherell and Harrington 1996).

Pacific halibut

Pacific halibut fisheries are managed by a treaty between the United States and Canada through recommendations of the International Pacific Halibut Commission (IPHC). Pacific halibut is considered as one large interrelated biological stock; but it is regulated by subareas through catch quotas, time-area closures, and since 1995 in Alaska, by an IFQ program adopted by the Council and implemented by NMFS.

Bycatch of Pacific halibut constrains the groundfish fisheries in both the BSAI and GOA, preventing the TAC of many groundfish target species from being harvested. In recent years, halibut mortality limits of 3,675 mt for trawl and 900 mt for non-trawl fisheries have been established in the BSAI. Halibut mortality limits for the GOA can be changed each year as part of the annual specification process, but in recent years they have remained at 2,000 mt for trawl and 300 mt for non-trawl fisheries. For each gear type, these caps have been further apportioned by target species and for each individual target species, further apportioned by season. This halibut bycatch management program has the effect of directing fisheries to the highest volume or highest value target species with the lowest seasonal halibut bycatch rates throughout the fishing year. Total bycatch is estimated by extrapolating observed vessel catch to unobserved vessels. In recent years pot gear, jig gear, and hook-and-line gear targeting sablefish under the IFQ program have been exempted from halibut mortality limitations. Other measures taken to reduce the bycatch mortality of halibut have included area closures (both seasonal and year round), careful release requirements, a vessel incentive program to hold individual vessels accountable for excessive bycatch, public reporting of individual vessel bycatch rates, and gear modifications.

Pacific salmon

Pacific salmon and steelhead fisheries off the coast of Alaska are managed under a complex mixture of domestic and international bodies, treaties, regulations, and other agreements. Federal and state agencies cooperate in managing salmon fisheries. The ADFG manages salmon fisheries within state jurisdictional waters where the majority of harvest occurs. Management in the EEZ is primarily the responsibility of the Council. Regulation of the directed salmon fishery occurring in the EEZ off southeast Alaska is deferred to the state. The EEZ off central and western Alaska is closed to directed salmon fisheries. Management of Alaska salmon fisheries is based primarily on regional stock groups of each species and on time and area harvesting by specific types of fishing gear. Over 25 different commercial salmon fisheries in Alaska are managed with a special limited-entry permit system that specifies when and what type of fishing gear can be used in each area. Gear types include drift gillnets, set gillnets, beach seines, purse seines, hand troll, power troll or fish wheel harvest gear. Sport fishing is limited to hook-and-line, while subsistence fishers may use gillnets, dip nets, or hook-and-line. Some subsistence harvesting of salmon is also regulated by special permits. Harvesting of Pacific salmon on the high seas is prohibited

Five species of Pacific salmon, pink, chum, sockeye, coho, and chinook salmon as well as steelhead trout occur in Alaska. All five species of salmon are fully utilized. Alaska commercial salmon harvests generally increased over the last three decades but may have peaked in 1995 (Burger and Wertheimer 1995, Wertheimer 1997). A number of factors have contributed to the current high abundance of Alaska salmon, including 1) pristine habitats with minimal impacts from extensive development; 2) favorable ocean conditions that allow high survival of juveniles; 3) improved management of the fisheries by state and federal agencies; 4) elimination of high-seas drift-net fisheries by foreign nations; 5) hatchery production; and 6) reduction of bycatch in fisheries for other species. Nonetheless, the potential for overfishing, bycatch in other fisheries, and loss of freshwater and nearshore marine habitat are still important issues that are addressed in the FMPs.

All groundfish fisheries are prohibited from retaining salmon, but the salmon must be held for counting and collection of scientific samples by an observer before discarding (and salmon can be turned over to food banks for distribution). Most salmon bycatch is taken by vessels using pelagic trawl gear targeting pollock. Between January 1 and April 15 in the Bering Sea, the PSC limit for trawl gear is 48,000 chinook salmon in the Chinook Salmon Savings Area. Between August 15 and October 15, the PSC limit is

42,000 non-chinook salmon in the Catcher Vessel Operational Area (CVOA). In the GOA, PSC limits have not been established for salmon, although the timing of seasonal openings for pollock in the central and western GOA have been adjusted to avoid periods of high chinook and chum salmon bycatch.

Pacific herring

Pacific herring fisheries occur in specific areas of the GOA and the Bering Sea when the stocks come inshore to spawn. In the GOA, spawning concentrations occur mainly off southeastern Alaska, in Prince William Sound, and around the Kodiak Island-Cook Inlet area. In the Bering Sea, the centers of abundance are in northern Bristol Bay and Norton Sound. The fisheries occur within state waters and are, therefore, managed by the State of Alaska. Although most herring are harvested in the sac-roe season in spring, fall seasons are also designated for food and bait harvesting. The ADFG regulates and monitors the resource and associated fisheries.

Pacific herring bycatch is limited for trawl groundfish fisheries in the Bering Sea. The limit is determined each year during the TAC-setting process, and is set at 1 percent of the estimated eastern Bering Sea herring biomass. The limit is then apportioned by target fishery. Should the PSC limit for a particular groundfish target be reached during the fishing year, the trawl fishery for that species is closed in the Herring Savings Areas.

PSC management measures

A variety of management measures have been used to control the bycatch of prohibited species, including 1) PSC limits by fishery for selected prohibited species (red king crab, Tanner and snow crab, Pacific halibut, Pacific salmon, and Pacific herring in the BSAI and Pacific halibut in the GOA); 2) time and area closures; 3) seasonal apportionments of groundfish TACs; 4) gear restrictions; 5) groundfish TAC allocations by gear type; 6) reductions in groundfish TACs; 7) at-sea and on-shore observer programs to monitor bycatch; 8) a vessel incentive program with civil penalties for fishing vessels that exceed established bycatch rates for Pacific halibut or red king crab; 9) required retention of Pacific salmon bycatch until counted by an observer; 10) Individual Transferable Quota (ITQ) management for the fixed-gear Pacific halibut and sablefish fisheries; 11) careful release regulations for longline fisheries; and 12) public reporting of individual vessel bycatch rates.

Groundfish fisheries or fisheries under the FMPs for which the quota has been reached shall be treated in the same manner as prohibited species. Species identified as prohibited must be avoided while fishing groundfish and must be immediately returned to the sea with a minimum of injury when caught and brought aboard, except when their retention is authorized by other applicable law.

2.4.3 Fisheries Removal

2.4.3.1 Fishery status

The fishery for a target species may be categorized as open to directed fishing, closed to directed fishing, or prohibited. When a species fishery is open to directed fishing, vessels are allowed to target and retain it with no restrictions on the amount harvested. If the catch is expected to reach the TAC and some amount of TAC must be held in reserve for incidental catch in other fisheries, then a portion of the TAC may be established as a "directed fishing allowance," meaning that directed fishing is allowed only on that portion of the TAC. For example, for the BSAI pollock fishery, 5% of the TAC is established as an "incidental catch allowance" and the directed fishery is based on the remaining 95% of the TAC. For fisheries other than BSAI pollock, the amount for a "directed fishing allowance" is determined by NMFS as the season progresses, and is established by an in-season regulatory action. Once the directed fishing allowance for a species is taken, the fishery is closed to directed fishing. When a species is closed to directed fishing, vessels are allowed to retain up to the maximum retainable amounts shown in Tables 2.8 and 2.9 at any time during the fishing trip. This provision does allow targeting for the species on a haul-by-haul basis, as long as the maximum retainable amount for the trip is not exceeded. If the catch reaches the TAC, then the status changes to "prohibited," and retention is prohibited for the rest of the year. If NMFS determines that harvest of a species will reach the OFL, then the Regional Administrator has the authority to close the fisheries in which the species is taken to prevent overfishing.

2.4.3.2 Access and permits

Until recently, access to fishing was generally open within the following constraints and with the following exceptions. Nearly all vessels and plants harvesting or processing groundfish from federal waters in the BSAI and the GOA are required to comply with federal permit requirements. In 2000, the permit requirements are as follows.

Catcher vessels: Federal Fisheries Permit, License Limitation Program Permit, American Fisheries Act (AFA) Permit;

Catcher/processors and motherships: Federal Fisheries Permit, Federal Processor Permit, License Limitation Program Permit, AFA Permit;

Shore plants: Federal Processor Permit, AFA Permit;

IFQ vessels: IFQ Permit, IFQ Card;

IFQ buyers and processors: Registered Buyer Permit.

In 2000, the License Limitation Program (LLP) replaced the vessel moratorium program and qualifying vessels were issued LLP permits instead of moratorium permits. The LLP permits are based on the vessel catch history during the LLP qualifying period (the general qualification period was January 1, 1988 to June 27, 1992).

The following vessel categories are exempt from the license program requirements.

1. Vessels fishing in State of Alaska waters (0-3 miles offshore).

2. Vessels less than 32' LOA in the BSAI and 26' in the GOA.

3. Jig gear vessels less than 60' LOA using a maximum of 5 jig machines, one line per machine, and a maximum of 15 hooks per line.

4. GOA vessels using fixed gear to fish sablefish and demersal shelf rockfish in the southeast outside area (east of 140°). Vessels exempted from the GOA groundfish license program are limited to the use of legal fixed gear in the southeast outside area.

5. BSAI vessels using fixed gear for to fish sablefish.

Hook-and-line sablefish fisheries are managed under Individual Fishing Quota (IFQ) programs. AFA permits are issued for those vessels and plants qualified to harvest or process pollock in the BSAI. The AFA also allowed for fishing cooperatives for the three sectors (other than the Community Development Quota [CDQ] sector) fishing BSAI pollock. Experimental Fisheries Permits authorize fishing for groundfish in a manner that would otherwise be prohibited and that otherwise may not be available through research or commercial fishing operations. Under specific conditions, Letters of Authorization are issued to qualified research agencies to fish groundfish outside the established TAC quotas. Scientific research may be conducted by either fishery research vessels or fishing vessels chartered by NMFS.

2.4.3.3 Sector and gear allocations

Gear types authorized by the FMPs are trawls, hook-and-line, pots, jigs, and other gear as defined in regulations. Gear types and sector allocations for specific BSAI fisheries are listed in Table 2.10. In the BSAI, pollock is allocated among four sectors, with 10% of the TAC allocated to the CDQ Program, 5% held in reserve for incidental catch, and the remainder split among the inshore, mothership, and catcher/processor sectors in the ratio of 50:10:40, respectively. For all other BSAI fisheries (except sablefish - see below), 7.5% of the TAC is held as reserve for CDQ. After removal of CDQ reserve for Pacific cod, the remainder is allocated to jig (2%), hook-and-line (51%) and trawl (47%), with the trawl portion split evenly between catcher vessels and catcher/processors. For sablefish in the Bering Sea, hook-and-line and pot together are allocated 50% and trawl is allocated 50%. For sablefish in the Aleutian Islands, hook-and-line and pot receive 75% and trawl 25%. (Twenty percent of hook-and-line/pot allocation is held as CDQ reserve, as is 7.5% of the trawl allocation.) For Atka mackerel, 2% of the allocation goes to jig gear. 15% of each target species or species group, except for fixed gear sablefish, is placed in a non-specified reserve category.

In the GOA (Table 2.11), 20% of pollock, cod, flatfish and "other" species is held for initial reserve, and 100% of the pollock allocation goes to the inshore sector. For Pacific cod, the allocation is split 90% to the inshore sector and 10% to the offshore sector. Sector allocations are not made for flatfish, rockfish, or other species in the GOA. The purpose of the reserves is to give management the flexibility needed to prevent the catch from exceeding the TAC.

2.4.3.4 Spatial and temporal division of TACs and catch

The temporal and spatial distribution of TAC and catch varies for each of the groundfish fisheries managed under the BSAI and GOA FMPs. Areas used in fisheries management are illustrated in Figs. 2.4 and 2.5, and also listed in the TAC specifications tables (Tables 2.4 and

2.6). In the BSAI, no spatial allocations are made for Pacific cod, yellowfin sole, Greenland turbot, arrowtooth, rock sole, flathead sole, other flatfish, squid, and other species. Atka mackerel is allocated spatially among eastern, central, and western regions of the Aleutian Islands, and inside and outside of Steller sea lion critical habitat. True Pacific ocean perch is allocated among the eastern Bering Sea and eastern, central, and western regions of the Aleutian Islands. Other POP is allocated only for the eastern Bering Sea. Sablefish, and other rockfish are allocated between the eastern Bering Sea and the Aleutian Islands. Pollock is allocated to the eastern Bering Sea, Bogoslof area, and Aleutian Islands regions, but Bogoslof and Aleutian Islands region allocations are for incidental catch only. In the eastern Bering Sea, pollock is also allocated inside and outside of the Steller Sea Lion Conservation Area (SCA), which is comprised of the southeastern Bering Sea special foraging area of Steller sea lion critical habitat and the portion of the catcher vessel operation area to the east of the special foraging area.

In the GOA, spatial allocations of TAC are generally made to the western, central, west Yakutat, and east Yakutat/southeast outside regions. Exceptions include 1) pollock, where the Central region is split into area 620 and 630 and a Shelikof Strait management area is used in the A and B seasons; 2) Pacific cod, shortraker/rougheye, and thornyhead whose allocations are just to western, central, and eastern regions; 3), Atka mackerel, and other species whose allocations are gulf-wide (i.e., no allocation on a spatial basis); and 4) demersel shelf rockfish whose TAC is specified in the Eastern Regulatory Area by the Council, and ADFG manages the fishery in this portion of their range .

In establishing fishing seasons, the BSAI FMP and GOA FMP require the Council to consider the following criteria.

Biological: spawning grounds, migration, biological factors

Bycatch: biological and allocative effects of season changes.

Exvessel and wholesale prices: effects of season changes on prices.

Product quality: producing the highest quality product to the consumer.

Safety: potential adverse effects on people, vessels, fishing time, and equipment.

Cost: effects on operating costs incurred by the industry as a result of season changes.

Other fisheries: possible demands on the same harvesting, processing, and transportation systems needed in the groundfish fishery.

Coordinated season timing: the need to spread out fishing effort over the year, minimize gear conflicts, and allow participation by all elements of the groundfish fleet.

Enforcement and management costs: potential benefits of seasons changes relative to agency sources available to enforce and manage new seasons.

Allocation: potential allocation effects among users and indirect effects on coastal communities.

Temporal allocations for the BSAI fisheries are listed in Table 2.10. For the majority of the BSAI fisheries, trawling is open from January 20 to December 31, and fishing with non-trawl gear is open from January 1 to December 31. Greenland turbot is limited to the period from May 1 to December 31. Trawling for Atka mackerel is allocated equally between two seasons from January 20 to April 15 and from September 1 to November 1. Non-trawl fishing for Atka mackerel is open year-round. The Pacific cod TAC is released in three allowances: January 1 to April 30 (71% annual TAC), May 1 to August 31 (0% annual TAC), and September 1 to December 31 (29% annual TAC) --- Pacific cod is effectively fished in two seasons. Pollock TAC is allocated among four seasons inside the SCA: January 20 to April 1 (30% annual TAC), April 1 to June 10 (10% annual TAC), June 10 to August 20 (30% annual TAC), and August 20 to November 1 (30% annual TAC). Outside the SCA, the first two inside seasons are combined to form one season, and the third and fourth inside seasons are combined into a second outside season, as illustrated below.

Outside SCA	A+B (40% annual TAC)		C+D (60% annual TAC)	
Inside SCA	max 15% annual TAC	max 5% annual TAC	max 4.5% annual TAC	max 7.5% annual TAC
Season	A	B	C	D

Jan. 20 Apr. 1 Jun. 10 Aug. 20 Nov. 1

Temporal allocations for the GOA fisheries are listed in Table 2.11. For the majority of the GOA fisheries, trawling is open from January 20 to December 31, and fishing with non-trawl gear is open from January 1 to December 31. Trawling for rockfish is open from July 1 to December 31. Pollock TAC is allocated among four seasons: January 20 to March 1 (30% annual TAC), March 15 to May 31 (15% annual TAC), August 20 to September 15 (30% annual TAC) and October 1 to November 1 (25% annual TAC).

2.4.3.5 Time/area closures

In addition to temporal and spatial allocation of TACs, certain areas are closed seasonally, year-round, or under special circumstances as established in regulations. In the BSAI region, these time/area closures are as follows (BSAI FMP p. 302).

- Prohibited species bycatch limitation zones and areas (Fig. 2.6) include the following.

  A. Red King Crab Zone 1 (see description under next bullet).
  B. Red King Crab Zone 2 (see description under next bullet).
  C. Crab and Halibut Protection Zone. Trawling is not permitted in this zone.
  D. Herring Savings Areas. For the time periods listed, all trawling is prohibited in an herring savings area when the herring PSC limit (set at 1% of biomass) is attained.
     1) Summer Herring Savings Area 1 (June 15 to July 1).
     2) Summer Herring Savings Area 2 (July 1 to August 15).
     3) Winter Herring Savings Area (September 1 to March 1).

E. *C. Opilio* Bycatch Limitation Zone. Upon attainment of the bycatch allowance of *C. opilio* specified for a particular fishery category, the zone is closed to directed fishing for that category for the remainder of the year or the remainder of the season.

- Prohibited species catch (PSC) limits include the following.

A. Red King Crab - A Zone 1 PSC limit for red king crab is established in the following manner.

When the number of mature female red king crab is below or equal to the threshold of 8.4 million mature crab or the effective spawning biomass is less than 14.5 million lb., the Zone 1 PSC limit will be 35,000 red king crab.

When the number of mature female red king crab is above the threshold of 8.4 million mature crab and the effective spawning biomass is equal to or greater than 14.5 but less than 55 million 1b., the Zone 1 PSC limit will be 100,000 red king crab.

When the number of mature female red king crab is above the threshold of 8.4 million mature crab, and the effective spawning biomass is equal to or greater than 55 million lb., the Zone 1 PSC limit will be 200,000 red king crab.

B. The PSC limit(s) for *C. bairdi* Tanner crab is established by regulation based on abundance of *C. bairdi* crab as indicated by the NMFS bottom trawl survey.

C. The PSC limit(s) for *C. opilio* crab is established by regulation based on total abundance of *C. opilio* as estimated by the NMFS bottom trawl survey. Minimum and maximum PSC limits also are established by regulation.

D. Annual BSAI-wide Pacific halibut bycatch mortality limits for trawl and non-trawl gear fisheries will be established in regulations and may be amended by regulatory amendment. When initiating a regulatory amendment to change a halibut bycatch mortality limit, the Secretary, after consultation with the Council, will consider information that includes:

1. Estimated change in halibut biomass and stock condition;
2. Potential impacts on halibut stocks and fisheries;
3. Potential impacts on groundfish fisheries;
4. Estimated bycatch mortality during prior years;
5. Expected halibut bycatch mortality;
6. Methods available to reduce halibut bycatch mortality;
7. The cost of reducing halibut bycatch mortality;
8. Other biological and socioeconomic factors that affect the appropriateness of a specific bycatch mortality limit in terms of FMP objectives.

- Trawl fishing area restrictions are imposed at the following areas:

A. Pribilof Islands Habitat Conservation Area: closed to all trawling from January 1 to December 31.

B. Chum Salmon Savings Area: closed to trawling from August 1 to August 31. If 42,000 non-chinook salmon have been caught by trawl from August 15 through October 14 in the CVOA, NMFS will prohibit fishing with trawl gear for the remainder of the period September 1 through October 14 in the chum salmon savings area.

C. Chinook Salmon Savings Area: closed to trawling from January 1 to April 15 if 48,000 chinook salmon are caught by trawl from January 1 to April 15.

D. Red King Crab Savings Area: closed to non-pelagic trawling year round, except that a portion may be opened at the discretion of the Alaska Director.

E. Nearshore Bristol Bay Trawl Closure: closed to all trawling on a year round basis, with the exception of a subarea that remains open to trawling April 1 to June 15 each year.

- Amendment 13 to the BSAI FMP prohibited groundfish fishing in waters seaward of 3 miles out to 12 miles around the Walrus Islands (Round Island and the Twins) and Cape Peirce from April 1 through September 30.

In the GOA (GOA FMP, p. 28-30), a time/area closure has been developed to protect and rebuild the King Crab stock around Kodiak. Three area types have been designated as follows. In Type I areas, bottom trawling is closed year round. In Type II areas, bottom trawling is prohibited during the soft-shell season (February 15 to June 15). Type III areas are those that may be converted to Type I or Type II if a recruitment event occurs. A Type III area is open to bottom trawling until the number of females assessed for the area meets or exceeds the number required to hold a crab fishery. If a crab fishery is initiated, then no closure is in effect. If no crab fishery is initiated, then the Regional Administrator may designate the Type III area as a Type I or II area based on the information available. Type I, II, and III areas are illustrated on page 29 of the GOA FMP, and coordinates of the areas are listed on page 30.

In both the BSAI and GOA, a series of time/area closures were established in the early 1990s and again in 1998 and 1999 to prohibit trawling and pollock trawling around Steller sea lion rookeries and major haulouts. Specific sites are listed in Table 2.12. In addition, principal sea lion rookeries in the BSAI and GOA are protected by 3-nm “no entrance” zones.

Beginning in 1999, the Aleutian Islands (areas 541, 542, and 543; Figure 2.4) were closed to directed fishing for pollock.

2.4.3.6 Age/size structure of stocks and catch

Age/size structure of fished stocks is estimated on the basis of survey information and the age/size distribution of the catch. The age/size distribution of the catch is determined from observer sampling of catch on vessels and in processing plants. Larger fish are generally sought, as they provide greater market value and flexibility (e.g., large pollock can be filleted as well as ground into surimi). Market/economic constraints are considered sufficient to keep the fisheries targeting older/larger catch.

2.4.3.7 Reproductive condition of catch

Two kinds of restrictions pertain to the reproductive condition of the catch. Second, the fishing of stocks during their reproductive period may be indirectly affected by seasonal and spatial allocation of TAC. For example, the catch of pollock in the BSAI and GOA during the winter and spring seasons is limited to 40% and 45% of the annual TACs, respectively, thereby limiting the amount of reproductive pollock that can be taken in those periods. Other than these constraints, stocks may be fished during their reproductive period.

2.4.3.8 Forage fishes, other species and non-reported species

Forage fishes are listed in Tables 2.3 and 2.5. Directed fishing for forage fish is prohibited in the BSAI and GOA groundfish fisheries. They are taken as incidental catch in amounts up to several hundred tons per year.

Other species consist primarily of sculpins, sharks, skates, squid, and octopus. Many species of sculpins are taken as incidental catch. From 1992 to 1995, total annual catch ranged from 6,000 to 11,000 mt in the BSAI and from 500 to 1,400 mt in the GOA. Based on annual BSAI surveys, this catch ranges from 1% to 4% of the estimated biomass of sculpins.

From 1992 to 1995, annual incidental catch of sharks ranged from 300 to 700 mt in the BSAI and 500 to 1,400 mt in the GOA. Shark biomass in the BSAI and GOA is unknown.

From 1992 to 1995, annual incidental catch of skates ranged from 13,000 to 17,000 mt in the BSAI and 1,000 to 2,000 mt in the GOA. Based on annual BSAI surveys, this catch ranges from 1% to 4% of the estimated biomass of skates.

Non-reported species include a range of vertebrate (fish) and invertebrate species that are not of commercial value and for which no data is collected. Their occurrence in the BSAI and GOA groundfish fisheries, or the effects of the fisheries on these species is, therefore, unknown.

2.4.4 Monitoring and Evaluation of Fisheries Catch

Catch data used to manage the groundfish fisheries under the BSAI and GOA FMPs are collected from vessels, processors, and fishery observers trained by NMFS. This section discusses recordkeeping and reporting requirements, data used for catch estimation, and the inseason fishery management programs.

2.4.4.1 Recordkeeping and reporting requirements

Fishery participants issued federal fisheries permits, federal processor permits, groundfish LLP permits and AFA permits are required to comply with record keeping and reporting requirements to report groundfish harvest, discard, receipt, and production (50 CFR § 679.5). Reporting requirements include both logbooks maintained at the shoreside processing plant or onboard the processor vessel, and forms that are submitted to NMFS. Information common to all the logbooks includes: participant identification; amount and species of harvest, discard, and product; gear type used to harvest the groundfish; area where fish were harvested; and observer information.

Catcher vessels and buying stations (tender vessels and land-based buying stations) are required to record fishery information in logbooks daily. Processors (motherships, catcher/processors, shoreside processors, and stationary floating processors) are required to record fishery information in logbooks daily, summarize the information on Weekly Production Reports and submit them by fax or using an approved electronic reporting system to NMFS. To assist NMFS in determining fishing effort by species, processors also report the start and end of their participation in fishing operations (Check-in/Check-out Reports). CDQ groups must submit CDQ Catch Reports to NMFS detailing the groundfish and prohibited species catch by vessels fishing for the CDQ group.

2.4.4.2 Collection of catch data

Catch accounting for groundfish and prohibited species is based on logbook data, data collected by observers, and detailed location data collected the automated Vessel Monitoring System.

Estimating catch weight

Observers provide estimates of total catch and species composition, and species-specific biological data used in stock assessments. Observers are required aboard vessels 125 feet or greater in length overall (LOA) for 100% of their fishing days, and aboard vessels 60-124 feet LOA for 30% of their fishing days. Observers are required at shoreside and floating processing plants according to processing rate, with 100% observer coverage of plants processing 1,000 metric tons or more per month, and 30% observer coverage of plants processing 500 to 1,000 metric tons per month. Observers have multiple duties, but highest priority is given to estimation of catch weight, species composition, and timely inseason reporting. Haul-specific total catch weights are estimated by observers using volumetric, direct weight, or tally methods. Volumetric and direct weight methods of catch weight estimation are applied primarily in trawl fisheries, while tally methods are used in hook-and-line and pot fisheries. Observers are instructed to make independent estimates of catch weight for as many hauls/sets as possible. Unverified vessel estimates of catch weight are reported by observers as Official Total Catch (OTC) for hauls and sets where observers are unable to make an independent estimate. In 1997, observers independently estimated 72% of hauls/sets aboard observed vessels, accounting for 68% of the total reported observed OTC of 1.5 million metric tons. Vessel estimates were used for 7% of hauls/sets (10% of OTC by weight), and alternate estimates (proportioned delivery weight, expansion from sampled to unsampled hook-and-line sets, etc.) were used for the remaining 20% of hauls/sets (22% of OTC by weight). The catch estimation methods used by observers vary among the vessel types, due to differences in available equipment and in fishery operations.

Observers aboard catcher vessels make volumetric (usually cod-end) estimates of catch weight for individual hauls at sea. In some cases this is not possible due to large codend sizes. Discard information is also collected. When the vessel delivers to a shoreside processor, the catch is weighed on scales. The observer then uses the at-sea volumetric estimates and any discard information to proportion the delivery weight back to individual haul weights. If an observer is unable to make volumetric estimates at sea, vessel estimates of individual haul weights may be used to proportion the delivery weight.

In-line flow scales are installed aboard many catcher/processor vessels and can provide accurate individual haul weights. The trawl catcher/processors which fish under AFA or CDQ regulations are required to weigh their catches using NMFS-inspected, in-line motion-compensated scale systems. All fish coming aboard these vessels are weighed, and the weights are reported to NMFS by the observer. The observer also has a role in monitoring the daily testing of the scale to ensure it is accurate.

Catch weight is estimated by tally methods aboard hook-and-line and pot vessels. Observers count or estimate the total number of hooks in each set, tally the number and species caught in sampled sections of the set, estimate the average weight of individuals of each species sampled, and multiply these average species weights and numbers by the number of hooks in the entire set.

When observers do not make an independent estimate of total catch or obtain a weighed catch from a flow scale, a vessel estimate of total catch is used as OTC. Variable methods are applied on different vessels for obtaining vessel estimates of catch weight. The accuracy or precision of vessel estimates, or the effect of their incorporation into observer reported Official Total Catch, are unknown.

Estimating species composition

On all vessel types, hauls to be sampled for species composition are selected at random. Samples must be collected from different parts of the haul and samples must total at least 300 kg. Sampling methods are determined by conditions on the vessel and may be biased. On hook-and-line and pot vessels, observers use tally methods to sample for species composition.

Estimating discards

In most cases, estimation of at-sea discards is based on the observer's best guess at the percentage of each species that is retained. This estimate may be more standardized between observers on catcher vessels where portions of hauls are discarded or all discards occur within the observer's view at one point on deck. In some cases the discarded catch is retained by the vessel long enough for the observer to make a volumetric estimate of weight, or to weigh each species, if the amount discarded is very small; these circumstances are rare. The estimate of at-sea discard aboard catcher/processors may be less standardized between observers, because discards occur simultaneously at multiple points from the deck and throughout the factory, often after the observer has taken the samples.

2.4.4.3 Reporting of catch data

Vessel data

Observers record catch weight and effort information from vessel logbooks and their own estimates of catch and effort. The data is sent to the Observer Program by various methods, depending on the level of technology available on the vessel. The Observer Program has implemented a comprehensive electronic reporting system (called ATLAS) on processing vessels and at shoreside processors. The program allows the observer to send raw data which is automatically error checked and incorporated into NMFS databases. It also allows daily communication between observers in the field and Observer Program staff. Currently, the program is installed on most catcher/processors and shoreside processors. Further expansion of the system to catcher vessels that deliver to shoreside processors is planned.

Weekly summary reports of observer data are sent to the Alaska Region for use in groundfish and prohibited species accounting. Daily reports are sent as needed to monitor specific fisheries.

Processor data

All processors that receive groundfish from any vessel holding a federal fisheries permit are subject to federal reporting requirements and must report all groundfish and prohibited species from all vessels and areas. Processors must maintain a Daily Cumulative Production Logbook (DCPL). NMFS issues logbooks for Shoreside Processors, Mothership Processors, and Catcher/Processors. Daily production amounts by species and product type, and vessel reports of discards are recorded in Mothership and Catcher/Processor Logbooks. Daily landing weights of fish by species, as well as daily products derived from those landings, are recorded in Shoreside Processors Logbooks. Weekly cumulative totals are reported to NMFS. The weekly reports contain amounts of each species and product type, including discards, aggregated by federal reporting area, gear type, and whether the catch accrues to the CDQ fishery or a standard groundfish quota. Completed logbooks are forwarded to NMFS Enforcement, which maintains them in hard copy. Shoreside processors may use a NMFS-approved electronic logbook. Processors that receive groundfish harvested by AFA catcher vessels are required to use a NMFS-approved electronic reporting system. The electronic reporting system provides information to the species level on each delivery of fish, and provides more detail on catch by vessel and harvest location. These data are submitted to NMFS daily, rather than weekly.

Vessel monitoring system data

A vessel monitoring system (VMS) consists of a Global Positioning System (GPS) unit and satellite communication device configured as a tamper-proof system. The VMS determines vessel location in latitude and longitude at the resolution available from the GPS system and transmits the vessel identifier, position, and time to NMFS. VMS data are used to monitor compliance with closed areas and to verify the location of catch when separate quotas are established inside small or irregularly shaped areas that do not correspond with the standard reporting or statistical areas.

2.4.4.4 Estimation of groundfish catch

Groundfish catch is estimated using information from weekly production reports and observer reports. These data are used differently depending on the industry component. For shoreside processors, landed weights from the weekly reports are used to account for the landed component of catch, and these weights are used in conjunction with observer data from catcher vessels which deliver to shoreside processors to estimate at-sea discards of groundfish. For observed catcher/processors and motherships, catch is estimated by comparing observer and weekly production records and picking one or the other based on their consistency. For unobserved processor vessels, the weekly production report provides the only source of data on groundfish catch by species. Observer data from observed vessels are used to estimate prohibited species catch for the unobserved vessels.

Catch is also estimated from processor records. Again, the results are summed by species, gear, and area across all processors to obtain the total catch for the fishery. Total groundfish catch from the groundfish catch accounting system is also used as the basis for computing estimates of prohibited species catch. The different reports and quota monitoring processes for groundfish catch accounting vary by processing sector. Observers at shoreside plants collect biological samples, but do not verify the accuracy of landed weights.

NMFS estimates at-sea discards by extrapolating observed discard rates from catcher vessels delivering to shoreside processors to the total catch. Observers on catcher vessels delivering to shoreside processors collect data on at-sea discards of groundfish. All observer data for a month, gear, and target fishery are used to calculate discard rates for each groundfish species they observe being discarded. These discard rates are expressed as a ratio of the weight of the discarded species to the total retained groundfish weight. These discard rates are multiplied by the retained landings for each shoreside processor to make an estimate of total at-sea discards of groundfish.

2.4.4.5 Comparing catch to TAC

The sub-allocation of TACs among areas, sectors, and seasons results in a set of quotas monitored by NMFS. The CDQ program receives a percentage of the TAC for each groundfish species or species group fished in the BSAI, and a percentage of allowed limits for PSC. The overall CDQ suballocation is further divided into six quotas for each of the six CDQ participants. These quotas are monitored based on reports submitted from each CDQ group to NMFS, and corroborated by observer data, shoreside processor reports, or reports of IFQ landings. The sablefish IFQ fishery is monitored based on records from a real-time transaction processing system. The AFA pollock fishery TAC is divided among a catcher/processor sector, a mothership sector, and an inshore sector with seven inshore cooperatives and an open-access allocation for inshore vessels not participating in a cooperative. All pollock caught by vessels using pelagic trawl gear is attributed to directed fishing, and pollock caught with bottom trawl gear is considered incidental catch. The pollock cooperatives actively monitor their harvest and cease fishing activity when their catch equals their quota. NMFS also monitors the pollock harvest and can close a cooperative fishery if needed.

Separate pollock quotas have been established for the SCA in the Bering Sea. NMFS monitors pollock catch to ensure that the pollock quota inside the SCA is not exceeded. For observed catcher vessels, the haul retrieval location as recorded by the observer is used to establish the location of catch. Vessels with observers can fish both inside and outside the SCA during a single trip, with the observer reports of haul location providing information on the amount caught inside the SCA. Vessels without observers may carry a VMS unit that provides detailed information on vessel location and speed. These vessels may fish either entirely inside or entirely outside the SCA during a single trip, and the VMS data are used to verify the reported fishing location. If they fish both inside and outside the SCA during a single trip, the pollock catch for the entire trip is counted against the SCA pollock quota, as NMFS has no way to verify the proportion of catch caught outside the SCA on an unobserved vessel. Catches from unobserved vessels that do not provide VMS data are counted against the SCA pollock quota regardless of the vessel's claimed fishing location, as NMFS has no way to verify the catch location on an unobserved vessel without VMS. If the SCA is closed to fishing for pollock because the SCA quota is reached, the requirement to provide VMS data to have unobserved pollock catch counted outside the SCA is removed.

For the general groundfish fishery, which is all groundfish fishing that is not under the CDQ, IFQ, and AFA Cooperative Programs, NMFS monitors catch and issues regulatory notices to open and close specific fisheries. In some cases catch is monitored from daily or weekly reports and the closure date is projected by extrapolating catch rates. In cases where fishing effort is high relative to the available quota, NMFS will estimate the length of the fishery using historic effort and catch rates, and open the fishery for a specific length of time, ranging from as little as six hours up to several days.

A running total of PSC is maintained from a combination of observer reports from vessels and processors, extrapolated when necessary to unobserved vessels and processors. Where sufficient observer data is not available, other means of estimated PSC may be required, such as use of historical data on catch rates for specific sectors, gear types, or areas.

2.4.4.6 Retention/utilization

All vessels participating in the BSAI and GOA groundfish fisheries are required to retain all catch of all designated IR/IU (improved retention/improved utilization) species (pollock and cod beginning January 1, 1998 and shallow water flatfish beginning January 1, 2003) when directed fisheries for those species are open, regardless of gear type employed and target fishery. When directed fishing for an IR/IU species is prohibited, retention of that species is required only up to any maximum retainable incidental catch amount in effect for that species, and these retention requirements are superseded if retention of an IR/IU species is prohibited by other regulations. No discarding of whole fish of these species is allowed, either prior to or subsequent to that species being brought on board the vessel. At-sea discarding of any processed product from any IR/IU species is also prohibited, unless required by other regulations. All IR/IU species caught in the GOA must be either (1) processed at sea subject to minimum product recovery rates and/or other requirements established by regulations, or (2) delivered in their entirety to onshore processing plants for which similar processing requirements are implemented by state regulations.

2.4.4.7 Evaluation of fishery effects

The fundamental purpose of this consultation and resulting opinion is to assess the effects of the fisheries on listed species and their critical habitat. Effects may occur directly on listed species or critical habitat, or indirectly through changes in the ecosystem, including target species, non-target species, habitat, and the ecosystem at large. In this section, we describe the methods used to assess the effects of the fisheries on target species, non-target species, habitat, and the affected ecosystems.

Target species

The effects of fishing on target species are monitored through the same process used to establish TAC levels; i.e., stock surveys and stock modeling to determine tolerance to fishing. These surveys occur annually to triennially and provide trend and status information on fished stocks. Assessment information is also available from the fisheries themselves (as described above in sections 2.4.4.1 - 2.4.4.4).

Non-target species

In the BSAI and GOA, catch of prohibited, other, and forage fish is monitored by observers on vessels and at processors, and by vessel and processor logs. The effects of the groundfish fisheries on prohibited, other, and forage fish are based on comparison of estimated catch with estimated biomass of the stock or stock complex if such information is available. Where stock biomass or stock status is unknown, the effects are assumed to be insignificant if the estimated catch is relatively small. For example, the biomasses of octopus and sharks are not assessed in either region, the catches are on the order of hundreds of metric tons, and are therefore assumed to be insignificant. Similarly, the catch of forage fish is considered insignificant with respect to the reproductive capacity of these species. Total catch of forage fish is estimated to have been about 1000 mt for 1994 and 1995. In 1999, catch for the forage fish category was estimated at 63 mt in the BSAI and 218 mt in the GOA. The significance of catch of non-specified species is unknown, as these species are not reported.

Habitat

Both the BSAI FMP (p. 269) and the GOA FMP (p. 282) state the following with regard to monitoring of fishery effects on habitat:

> The NPFMC (Council) and the Secretary of Commerce have taken appropriate actions when threats to fish habitat have been identified. These include cumulative effects from fishing activities and non-fishing activities. Cumulative effects have been examined in the Stock Assessment and Fishery Evaluation (SAFE) reports, which are produced annually for the crab, scallop, and groundfish fisheries. In addition, an Ecosystem Considerations section to the SAFE reports is prepared which identifies specific ecosystem concerns that are considered by fishery managers in maintaining sustainable marine ecosystems.

The BSAI FMP (p. 272) and the GOA FMP (p. 285) also state the following with regard to habitat conservation and enhancement recommendations for fishing threats to EFH:

> Area closures to trawling and dredging in the BSAI area serve to protect EFH

from potential adverse impacts caused by these gear types. Other management measures, such as the Pribilof Islands Habitat Conservation Area, the Bristol Bay Closure Area [BSAI] and the proposed Cape Edgecumbe Pinnacle closure [GOA], are designed to reduce the impact of fishing on marine ecosystems. Catch quotas, bycatch limits and gear restrictions control removals of prey species. Studies that compare seafloor habitats in areas heavily trawled with areas that have had little trawl effort and research efforts on Alaskan scallops may reveal future habitat conservation and enhancement measures necessary to protect EFH. Additionally, the annual review of existing and new EFH information during the SAFE development process is expected to identify adverse effects to EFH from fishing and proposals to amend the FMP to minimize those adverse effects. Proposals can be submitted during the Council's plan amendment cycle.

Recent habitat research reported in the 2000 SAFE document (ecosystems considerations) include underwater video to identify and characterize Atka mackerel reproductive habitat, submersible-based line transect surveys of trawled versus untrawled seafloor habitat near Kodiak Island in the GOA, video investigation of nearshore habitat use by juvenile groundfish in southeast Alaska, studies of the effects of urbanization on essential fish habitat in estuarine wetlands, trawl impact studies in the eastern Bering Sea, evaluation of acoustic technology for seabed classification, development of a benthic sled to observe seafloor habitat, retrospective analysis of benthic community structure in areas of high and low commercial bottom trawl effort in the GOA and Aleutian Islands, observations of one-year-old trawl tracks from a research submersible, effects of trawling on hard bottom habitat in the Aleutian region at Seguam Pass, and description and distribution of coral in the GOA and the Bering Sea.

Effects on ecosystem composition and processes

Ecosystem research is focused on the effects of fishing on exploited resources and non-exploited resources, the habitat requirements of species, climate- and fishing-induced changes to habitat (physical water properties, biological water properties such as prey, and cover/substrate). Research categories include fisheries oceanography, predator-prey interactions, human impacts, and habitat identification. A review of marine ecosystem research in Alaska was undertaken in 1997 to advise the NMFS Ecosystem Principles Advisory Panel on the scope of ecosystem related research that was ongoing in each of the fishery management regions. Marine ecosystem research programs in the Alaska region include the following. While these programs are part of the FMPs, they provide information relevant to the assessment of the effects of the groundfish fisheries.

NMFS Pinniped Ecosystem Studies in Alaska focus primarily on Steller sea lion, northern fur seal and harbor seals. The purpose of these studies is to define foraging behavior, evaluate responses to changing prey base, develop techniques to measure availability of prey and evaluate their role in marine ecosystems.

NOAA's Coastal Ocean program has sponsored for several years the Southeast Bering Sea Carrying Capacity Program. The goal of this program is to increase understanding of the southeastern Bering Sea ecosystem, document the role of juvenile pollock in the ecosystem, and examine factors that influence pollock survival and develop indices of pre-recruit pollock abundance..

NMFS Resource Ecology and Ecosystem Modeling Program looks at groundfish feeding ecology and trophic interactions with other species in the NE Pacific and Bering Sea. This program has a field and lab component to quantify groundfish trophic interactions and incorporates those data into single species, multispecies, and ecosystem models. This program is attempting to develop indicators of ecosystem change to provide early warning of climate- or human-induced effects. Quantifying food web linkages is essential to increase our understanding of how external forces such as fishing may cause unanticipated shifts in ecosystem composition. The group also takes the lead in providing an Ecosystem Considerations document to accompany the standard stock assessment advice provided to Councils/Regions. This document compiles status and trends of ecosystem components and provides ecosystem management indicators to assess efficacy of ecosystem-based management measures. Research focus has been on understanding how fishing 1) influences predator-prey relationships through selective fishing practices that selectively removes a particular predator or prey, 2) re-directs energy in the food web through discarding practices, 3) causes unintended or unmeasured mortality to non-target species, or 4) affects system or community level measures such as diversity.

NMFS Stock Assessment and Multispecies Modeling Program provides annual stock assessments for groundfish to assist Councils/Regions in evaluating potential biological consequences of proposed fishery management schemes. This group is working to incorporate climate and predation research into stock assessments, evaluating spatial/temporal implications of fishery catch relative to marine mammal foraging areas, performing a pilot survey to assess impacts of commercial harvest on local abundance and distribution of key sea lion prey species, developing initial descriptions of essential fish habitat for managed groundfish.

NOAA's OAR Arctic Research Initiative, administered through the University of Alaska-Fairbanks looks at natural variability of and anthropogenic influences on the Bering Sea/Western Arctic ecosystems. A variety of research projects have been funded in the past, including those investigating the Bering Sea "green belt" (an area of high production near the shelf edge), arctic haze, ozone, and UV flux, and contaminant sources, transports and dispersion and effects on humans and ecosystems.

The US GLOBEC Northeast Pacific Program is charged with understanding the effects of climate variability and climate change on the distribution, abundance, and production of marine animals, particularly juvenile salmon and the dominant zooplankton relied on as prey. This research helps explain the role of climate in fish production changes, information that is valuable in differentiating between climate and human effects.

Ecosystem research on Alaska seabirds is ongoing through the USFWS Bering Sea/AI Ecosystem Action Plan. This plan outlines a monitoring approach of measuring bird abundance, reproductive success and food habits. The EVOS-funded APEX program had multiple projects relating seabird population trends in the Gulf of Alaska to forage fish and oceanography. The NVP (nearshore vertebrate predator) program of EVOS related marine mammal and bird population trends in Prince William Sound to oil pollution and availability of forage fish. USGS-BRD has looked at flight ranges and foraging, food versus reproductive success and trophic levels of marine birds.

NMFS Auke Bay Lab Habitat Section uses a combination of lab/field studies to examine effects of resource development on selected species and their habitats using an ecosystem perspective. This program has investigated food web tracers, effects of mine tailings on living marine resources, and importance of salmon buffer strips. The Auke Bay Ocean Carrying Capacity Program is working to understand the role of North Pacific ocean conditions in determining productivity of fish with emphasis on salmonid carrying capacity. It has been looking at salmonid energetics linked to behavior and habitat conditions and evaluating effects of temperature and predator/prey densities on growth and consumption.

OAR/NMFS joint Fisheries Oceanography Coordinated Investigations group works on understanding the influence of the environment on the abundance of various commercially important fish and shellfish stocks in Alaska waters and their role in the ecosystem. The group's focus has been on the early life stages of walleye pollock and their associated ecology.

ADFG and Game has performed several studies examining predator-prey relationships and climate factors on Alaska marine resource production. Recruitment patterns of crab and salmon have been examined with respect to physical oceanography. Pacific cod and shrimp predator prey interactions have also been studied.

Environmental assessments conducted under the National Environmental Policy Act also assess the effects of the fisheries on the environment.

Effects on listed species and critical habitat

Monitoring of the distribution, abundance, and status of the endangered whale species in the BSAI and GOA is based on observer reports from fishing vessels and the presence of scientific staff on the vessels that conduct groundfish surveys. The majority of information on these species is from past records of commercial whaling. Survey efforts in 1999 were sufficient to estimate abundance of fin and humpback whales, but not sufficient to estimate abundance of sei, northern right, blue, or sperm whales. Bowhead whales were considered to be north of the surveyed area at the time of the survey.

Most of the research related to fishery effects on listed species is related to the Steller sea lion. Such research includes population monitoring; long-term marking for estimation of vital rates; assessment of body morphometrics for population and individual health; assessment of physiological parameters for fitness and health; genetics for identification of population structure, movements, effects on the gene pool, and fitness; diet for predator/prey interactions and importance of prey types over time and space; foraging ecology including distribution and behavior; modeling for evaluation of population status and trends; and captive studies for physiology, growth, behavior, diet, and health.

The section 7 consultation process is an important management tool for assessing the effects of fisheries on listed species and critical habitat. NMFS conducts internal consultations for actions related to the species considered in this opinion, and consults with the USFWS for actions that may affect listed species or critical habitat under their jurisdiction.

3 ACTION AREA

The action area means "all areas to be affected directly or indirectly by the Federal action, and not merely the immediate area involved in the action" (50 CFR 402.02(d)). As such the action area for the Federally managed BSAI groundfish fisheries effectively covers all of the Bering Sea under U.S. jurisdiction, extending southward to include the waters south of the Aleutian Islands west of 170°W long. to the border of the U.S. EEZ (BSAI FMP, p. 20; Fig. 2.4). The GOA FMP (p. 7) applies to "the U.S. Exclusive Economic Zone of the North Pacific Ocean, exclusive of the Bering Sea, between the eastern Aleutian Islands at 170°W longitude and Dixon Entrance at 132°40' W longitude (Fig. 2.5)." These regions encompass those areas directly affected by fishing, and those that are likely affected indirectly by the removal of fish at nearby sites. The action area would also, necessarily, include state waters as they are areas that will be affected indirectly by the federal action of authorizing the EEZ fisheries pursuant to the FMP..

The action area, as described, includes the Alaska range of both the western (endangered) and eastern (threatened) populations of the Steller sea lion. However, the effects of the Federal FMPs on the Steller sea lions, generally occur within the range of the western population of that species. Therefore, for purposes of this consultation, the action area is further defined as those areas (as described in the above paragraph), but which occur west of 144˚ W long. (the defined boundary of the western population of Steller sea lions).

A review of areas fished by the groundfish fisheries (Fritz et al. 1998) suggests that virtually the entire Bering Sea and the GOA (from the continental slope shoreward) is utilized by one fishery or another; therefore, the action area for this consultation includes the entire Bering Sea. Of those fisheries identified in the FMPs, and which occur in the defined action area, several have been identified as likely to compete with Steller sea lions for available forage. These include the Atka mackerel fishery, the pollock fishery and the Pacific cod fishery. Additionally, state managed fisheries for salmon and herring have been identified in previous biological opinions (and discussed in Section 7.0 of this biological opinion) as fisheries that also likely interact with Steller sea lions.

The component of the action area that encompasses the Atka mackerel fishery extends from the eastern border of management area 541, which runs through the Islands of the Four Mountains, to the western border of area 543, just west of Stalemate Bank, or midway between Attu Island (U.S.) and Medney Island (Russia). The north and south borders of these management areas are 55°N lat. and the boundary of the EEZ south of the Aleutian Islands, respectively. Twenty Steller sea lion rookeries and 28 major haulouts are located in this region. Virtually all of the fishery occurs within these limits. Seventy percent or more of the fishery in 1995 through 1997 occurred within Steller sea lion critical habitat (i.e., within 20 nautical miles of these rookeries and haulouts or within the Seguam Pass foraging area designated as critical habitat).

However, the potential impacts of the fishery may extend beyond management areas 541, 542, and 543. First, sea lions may forage over relatively wide ranges (Merrick and Loughlin 1997), and sea lions from rookeries or haulouts adjacent to the management areas may, therefore, be affected if prey is reduced within their foraging range. Second, the Atka mackerel stock also may range beyond the areas fished. Lowe and Fritz (1997) suggest that Atka mackerel in the more western regions may constitute, at least to some degree, a source population for Atka mackerel found further east. If that is the case, then fishing may affect stock abundance in areas outside the three management areas.

The component of the action area that encompasses the pollock fishery includes both the BSAI and the western and central GOA. The action area for the BSAI pollock fishery can be estimated using a) the observed distribution of the fishery (Fritz 1993, Fritz *et al*. 1998) from the 1970s to the present; b) the estimated distribution of pollock stocks in the Bering Sea; and, c) the distribution of Steller sea lions that forage in areas where pollock stocks are fished or where pollock biomass is affected by fishing in other locations. The observed distribution of the fishery effectively encompasses the entire Bering Sea from about 62°N lat. to the shelf break south of the Aleutian Islands, from the eastern areas of Bristol Bay to the Aleutian Basin and Donut Hole, and along the Aleutian Islands at least as far west as the Semichi Islands. Areas of concentrated effort include the Eastern Bering Sea (EBS) shelf, along the shelf break from the Aleutian Islands to the U.S./Russian boundary, north of Umnak Island in the waters around of Bogoslof Island. The distribution of pollock in the BSAI region varies seasonally with spawning aggregations in the EBS and vicinity of Bogoslof Island, and then dispersion northward and westward to cover the Bering Sea and Aleutian Basin.

Twenty-eight Steller sea lion rookeries and 49 major haulouts occur in this region (50 CFR, Tables 1 and 2 for part 226.12). Thus, Steller sea lions that may be affected by the pollock fishery haulout at terrestrial sites from St. Matthew (haulout) and the Pribilof Islands (haulout and rookery sites) in the north, and all along the Aleutian Chain from Amak Island and Sea Lion Rock in the southeastern Bering Sea westward to the Commander Islands. Hill and DeMaster (1999) suggest a 1996 western population of 39,500, of which about 56%, or just over 22,000, occurred in the BSAI region. The extent to which sea lions from Russian territories (along the eastern shore of the Kamchatka peninsula) are affected by the pollock fishery is uncertain. With the exception of no-trawl zones, the distribution of the fishery and the distribution of foraging sea lions overlap extensively.

The action area for the GOA pollock fishery extends to the shelf break from the area south of Prince William Sound to west of Umnak Island in the Aleutian Islands. The fishery is divided into eastern, central, and western regions. The boundary between the eastern and central regions is at 147°W long., and essentially overlays the easternmost rookery and haulouts of the western population. The management areas of primary concern are, therefore, the central and western regions. The central and western regions are divided into three management areas, all of which extend from the 3-mile state boundary to the EEZ limit. Area 630 is delimited on the east by 147°W long. and on the west by 154°W long. Area 620 extends from 630 further west to 159°W long. and area 610 extends from 620 to 170°W long. Within these three management areas, fishing is concentrated south of Unimak Pass and Island (Davidson Bank), southeast and southwest of the Shumagin Islands, along the 200-fathom isobath running from the shelf break northeastward to Shelikof Strait, Shelikof Strait, and the canyon regions east of Kodiak Island.

The principle concern with the Pacific cod fishery in the BSAI and GOA is the possible competitive interaction with the endangered western population of Steller sea lions. Over the last 20 years, there has been a significant increase in the amount and relative percentage of Pacific cod removed by the fishery from the action area designated as critical habitat for the western population of Steller sea lions. This has been previously noted in two prior biological opinions on the groundfish fisheries (NMFS 1998 and 1999). In the BSAI, the harvest has occurred primarily in the winter period, and is especially true in the Aleutian Islands (AI). For the Bering Sea, between 42 and 46% of the annual catch is taken inside critical habitat. Of this about 35 to 36% has been taken in the winter period inside critical habitat, with little being taken in each of the other seasons. In the AI, between 80 and 95% of the catch is taken in critical habitat, of which about 60 to 75% is harvested inside critical habitat in the winter. In the GOA, over the last four years, between 40 and 70% of the annual catch has been taken in critical habitat. Of this about 47 to 68% has been taken in the winter period inside critical habitat. There is very little directed effort for cod outside the winter seasons.

Commercial groundfish fisheries that are managed by the State of Alaska in the action area are introduced in the *Environmental Baseline* section of this biological opinion. We expect those fisheries and their effects to continue in the action area and into the future. Herring, salmon, Pacific cod, and pollock, are fisheries that are managed entirely by the State of Alaska, or (in the case of Pacific cod) only a percentage of the fishery is managed by State authority, and are species found year-round in the diet of Steller sea lions. The Federal Pacific cod TACs in the GOA have been affected by a Pacific cod fishery managed in state waters by the State of Alaska since 1998. In 1998 and 1999, the State cod fishery occurred mostly in the winter and of that about 95% of the catch was in critical habitat. That is not surprising since the State fishery is limited to within 3 nm of land and critical habitat is extended to 20 nm from rookeries and haulouts. For species such as salmon and herring, they occur much more frequently in the summer as determined by analyses of scat samples from 1990-1998.

3.1 Critical Habitat in the Action Area

The proposed rule for establishment of critical habitat for the Steller sea lion was published on 1 April 1993 (58 FR 17181), and the final rule was published on 27 August 1993 (58 FR 45269). The following areas have been designated as critical habitat in the action area.

(a) Alaska rookeries, haulouts, and associated areas. In Alaska, all major Steller sea lion rookeries identified in 50 CFR, part 226.12, Table 1, and major haulouts identified in 50 CFR, part 226.12, Table 2, and associated terrestrial, air, and aquatic zones, have been designated as critical habitat for the Steller sea lion. Critical habitat includes a terrestrial zone that extends 3,000 feet (0.9 km) landward from the baseline or base point of each major rookery and major haulout in Alaska. Critical habitat includes an air zone that extends 3000 feet (0.9 km) above the terrestrial zone of each major rookery and major haulout in Alaska, measured vertically from sea level. Critical habitat includes an aquatic zone that extends 3,000 feet (0.9 km) seaward in State and Federally managed waters from the baseline or basepoint of each major haulout in Alaska that is east of 144˚ W long. Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in State and Federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144˚ W long.

(b) Three special aquatic foraging areas in Alaska, including the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area.

(1) Critical habitat includes the Shelikof Strait area in the GOA which . . . consists of the area between the Alaska Peninsula and Tugidak, Sitkinak, Aiaktilik, Kodiak, Raspberry, Afognak and Shuyak Islands (connected by the shortest lines): bounded on the west by a line connecting Cape Kumlik (56˚38″/157˚26´W) and the southwestern tip of Tugidak Island (56˚24′/154˚41′W) and bounded in the east by a line connecting Cape Douglas (58˚51´N/153˚15´W) and the northernmost tip of Shuyak Island

(58˚37´N/152˚22´W).

(2) Critical habitat includes the Bogoslof area in the Bering Sea shelf which . . . consists of the area between 170˚00´W and 164˚00´W, south of straight lines connecting 55˚00´N/170 00´W and 55˚00´N/168˚00´W; 55˚30´N/168˚00´W and 55˚30´N/166˚00´W; 56˚00´N/166˚00´W and 56˚00´N/164˚00´W and north of the Aleutian Islands and straight lines between the islands connecting the following coordinates in the order listed:

52˚49.2´N/169˚40.4´W; 52˚49.8´N/169˚06.3´W; 53˚23.8´N/167˚50.1´W; 53˚18.7´N/167˚51.4´W; 53˚59.0´N/166˚17.2´W; 54˚02.9´N/163˚03.0´W; 54˚07.7´N/165˚40.6´W; 54˚08.9´N/165˚38.8´W; 54˚11.9´N/165˚23.3´W; 54˚23.9´N/164˚44.0´W

(3) Critical habitat includes the Seguam Pass area which . . . consists of the area between 52˚00´N and 53˚00´N and between 173˚30´W and 172˚30´W.

Prey resources are the most important feature of marine critical habitat. Marine areas may be used for a variety of other reasons (e.g., social interaction, rafting or resting), but foraging is the most important sea lion activity that occurs when the animals are at sea. Two kinds of marine habitat were designated as critical. First, areas around rookeries and haulouts were chosen based on evidence that many foraging trips by lactating adult females in summer may be relatively short (20 km or less; Merrick and Loughlin 1997). Also, mean distances for young-of-the-year in winter may be relatively short (about 30 km; Merrick and Loughlin 1997). The availability of prey in the vicinity of rookeries and haulouts must be crucial to their transition to independent feeding after weaning. Similarly, areas around rookeries are likely to be important for juveniles. While the foraging patterns of juveniles have not been studied in the BSAI region, it is possible that they depend considerably on resources close to haulouts. Therefore, the areas around rookeries and haulouts must contain essential prey resources for at least lactating adult females, young-of-the-year, and juveniles, and those areas were deemed essential to protect.

Second, three areas were chosen based on 1) at-sea observations indicating that sea lions commonly used these areas for foraging, 2) records of animals killed incidentally in fisheries in the 1980s, 3) knowledge of sea lion prey and their life histories and distributions, and 4) foraging studies. In 1980, Shelikof Strait was identified as a site of extensive spawning aggregations of pollock in winter months. Records of incidental take of sea lions in the pollock fishery in this region provide evidence that Shelikof Strait is an important foraging site (Loughlin and Nelson 1986, Perez and Loughlin 1991). The southeastern Bering Sea north of the Aleutian Islands from Unimak Island past Bogoslof Island to the Islands of Four Mountains is also considered a site that has historically supported a large aggregation of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for sea lions (Fiscus and Baines 1966, Kajimura and Loughlin 1988). Finally, large aggregations of Atka mackerel are found in the area around Seguam Pass. These aggregations have supported a fishery since the 1970s, and are in close proximity to a major sea lion rookery on Seguam Island and a smaller rookery on Agligadak Island. Atka mackerel are an important prey of sea lions in the central and western Aleutian Islands. Records of incidental take in fisheries also indicate that the Seguam area is an important for sea lion foraging (Perez and Loughlin 1991).

Prey resources are not only the primary feature of Steller sea lion marine critical habitat, but they also appear to determine the carrying capacity of the environment for Steller sea lions. The term "environmental carrying capacity" is generally defined as the number of individuals that can be supported by the resources available. Therefore, the concepts of critical habitat and environmental carrying capacity are closely linked: critical habitat reflects the geographical extent of the environment needed to recover and conserve the species.

4 STATUS OF SPECIES

NMFS has determined that the actions being considered in this biological opinion may affect the following species[6] and critical habitat that have been provided protection under the ESA of 1973 (16 U.S.C. 1531 *et seq.*):

Listed Species	**Scientific Name**	**ESA Status**
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
Steller Sea Lion (Western Population)	*Eumetopias jubatus*	Endangered
Steller Sea Lion (Eastern Population)	*Eumetopias jubatus*	Threatened
Chinook Salmon (Puget Sound)	*Oncorhynchus tshawytscha*	Threatened
Chinook Salmon (Lower Columbia River)	*Oncorhynchus tshawytscha*	Threatened
Chinook Salmon (Upper Columbia River Spring)	*Oncorhynchus tshawytscha*	Endangered
Chinook Salmon (Upper Willamette River)	*Oncorhynchus tshawytscha*	Threatened
Chinook Salmon (Snake River Spring/Summer)	*Oncorhynchus tshawytscha*	Threatened
Chinook Salmon (Snake River Fall)	*Oncorhynchus tshawytscha*	Threatened
Sockeye Salmon (Snake River)	*Oncorhynchus nerka*	Endangered
Steelhead (Upper Columbia River)	*Onchorynchus mykiss*	Endangered
Steelhead (Middle Columbia River)	*Onchorynchus mykiss*	Threatened
Steelhead (Lower Columbia River)	*Onchorynchus mykiss*	Threatened
Steelhead (Upper Willamette River)	*Onchorynchus mykiss*	Threatened
Steelhead (Snake River Basin)	*Onchorynchus mykiss*	Threatened
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered
Steller's Eider[7]	*Polysticta stelleri*	Threatened
Short-tailed Albatross[*]	*Phoebaotria albatrus*	Endangered
Spectacled Eider[*]	*Somateria fishcheri*	Threatened
Northern Sea Otter[*]	*Enhydra lutris*	Candidate
Designated critical habitat		
Steller's Eider[*]		
Steller sea lion		

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[7] In its definition of species, the ESA of 1973, as amended, includes the traditional biological species concept of the biological sciences and "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature" (16 USC 1532). NMFS uses the term *evolutionarily significant unit* as synonymous with *distinct population segment* and lists Pacific salmon accordingly. For the purposes of section 7 consultations, these are all "species."

[*] The short-tailed albatross, spectacled eider, and Steller's eider are under the jurisdiction of the U.S. Fish and Wildlife Service. For these three species, critical habitat has been proposed only for the Steller's eider (65 FR 13262). The northern sea otter has been proposed by USFWS as a candidate species (November 9, 2000; 65 FR 67343).

The short-tailed albatross, spectacled eider, and Steller's eider are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). A letter dated December 2, 1998 from the USFWS to Steven Pennoyer, NMFS, Administrator, Alaska region, extends the USFWS 1997-1998 biological opinion covering these species until it is superseded by a subsequent amendment to that opinion. The USFWS issued a Biological Opinion on March 19, 1999 concluding that the GOA and BSAI hook-and-line fisheries for 1999 and 2000 were not likely to jeopardize the continued existence of the short-tailed albatross. In November 1999, NMFS requested that the USFWS affirm its determination that the ongoing groundfish fisheries (all gear types) of the BSAI and GOA do not adversely affect the spectacled eider or the Steller's eider. The USFWS has indicated the need for additional information regarding the relationship between the BSAI and GOA groundfish fisheries and eider habitat to address the NMFS request. Given that the Incidental Take Statement and Biological Opinion issued by the USFWS on March 19, 1999 will expire December 31, 2000, NMFS is reinitiating section 7 consultation with the USFWS on all ESA listed bird species.

NMFS also recognizes that gray whales (*Eschrichtius robustus*) migrate through the action area during their spring and fall migrations toward the Chukchi and Beaufort Seas. Although gray whales were removed from the list of threatened and endangered species in 1994 (59 FR 31094), NMFS has continued to monitor the status of this species purusant to Section 4(g) of the ESA and has conducted a monitoring program for gray whales along the U.S. coast and in Mexican waters in cooperation with the government of Mexico. This biological opinion will not assess whether the fisheries and FMPs are likely to jeopardize the continued existence of gray whales; however, this opinion will include a general assessment of the potential effects of the FMPs on gray whales as part of NMFS continuing efforts to monitor the status of the species.

The narratives that follow summarize information on the biology of these threatened and endangered species. More detailed information on the range–wide status and trends of these species and a critical habitat can be found in recent sea turtle status documents (NMFS and USFWS 1995), recovery plans for the blue whale (NMFS 1998a), humpback whale (NMFS 1991a), right whale (NMFS 1991b), Steller sea lion (NMFS 1992), and leatherback sea turtle (NMFS and USFWS 1998), draft recovery plan for the fin whale and sei whale (NMFS 1998b), the marine mammal stock assessment reports (Hill et al. 1997, Hill and DeMaster, 1999), a status review of bowhead whales (Sheldon and Rugh 1995), and a status report on six whale species that was prepared by Perry et al. (1999). Detailed information on range–wide status and trends of listed salmon can be found in Waples et al. (1991a, 1991b), Burgner (1991), Healey (1991), and Matthews and Waples (1991).

4.1 Blue Whale

4.1.1 Species description and distribution

Blue whales are the largest living mammal species. They may measure over 30 meters in length and weigh up to 160 metric tons (Mackintosh 1942). They are blue-gray in color with distinct gray and white mottling, while their ventral surface may be light pink in coloration. Their dorsal fin is relatively small. Like other baleen whales, they have fringed baleen plates instead of teeth, and ventral grooves which filter large quantities of water during feeding. Blue whales are found in all major oceans, including the continental shelf in coastal shelves and far offshore in pelagic environments of the North Pacific (Rice 1974, Donovan 1984).

At least three subspecies of blue whales have been designated, but only one (*B. m. musculus*) occurs in the northern hemisphere. In addition to these subspecies, the International Whaling Commision's (IWC) Scientific Committee has formally recognized one blue whale stock in the North Pacific (Donovan,1991), although there is increasing evidence that more than one stock occurs in the Pacific Ocean (Gilpatrick *et al*. 1997, Barlow *et al*. 1995, Mizroch *et al*. 1984a, Ohsumi and Wada 1974). In the action area, blue whales have been reported from the GOA to the Aleutian Islands, although blue whales have not been sighted in the action area since 1978. Blue whales calls have been recorded in Alaskan waters from 1995 to 1999 in every season although the whales have not been seen. Most of these calls occurred in fall and winter in the GOA suggesting that some blue whales remain in the action area (as opposed to migrating through it).

4.1.2 Life history information

Blue whale reproductive activities occur primarily in winter (see Yochem and Leatherwood 1985). Gestation takes 10–12 months, followed by a nursing period that continues for about 6–7 months. They reach sexual maturity at about 5 years of age (see Yochem and Leatherwood 1985). The age distribution of blue whales is unknown and little information exists on natural sources of mortality (such as disease) and mortality rates. Killer whales are known to attack blue whales, but the rate of these attacks or their effect on blue whale populations is unknown.

The species *Thysanoëssa inermis*, *Thysanoëssa longipes*, *Thysanoëssa raschii*, and *Nematoscelis megalops* have been listed as prey of blue whales in the North Pacific (Kawamura 1980; Yochem and Leatherwood 1985). Although some stomachs of blue whales have been found to contain a mixture of euphausiids and copepods or amphipods (Nemoto 1957; Nemoto and Kawamura 1977), it is likely that the copepods and amphipods were consumed adventitiously or incidentally. One exception to their near-total dependence on euphausiid prey is that blue whales have been observed feeding on pelagic red crabs, *Pleuroncodes planipes*, off Baja California (Rice 1974, 1986a), although these observations have not been confirmed by subsequent observations or other analyses (e.g., fecal analysis). Reports that blue whales feed on small, schooling fish and squid in the western Pacific (Mizue 1951; Sleptsov 1955) have been interpreted as suggesting that the zooplankton blue whales prefer are less available there (Nemoto 1957). Between February and April, blue whales in the Gulf of California, Mexico, have been observed feeding on euphausiid surface swarms (Sears 1990) consisting mainly of *Nyctiphanes simplex* engaged in reproductive activities (Gendron 1990, 1992). Sears (1990) regarded *Nyctiphanes simplex* as the principal prey of blue whales in the region, and results from recent fecal analyses confirmed this assertion (Gendron and Del Angel-Rodriguez 1997). However, this phenomenon appears to be strongly influenced by the occurrence of El Niño Southern Oscillation (ENSO) events (Gendron and Sears 1993).

Other baleen whales whose range overlaps with the range of blue whales could potentially compete with blue whales for food (Nemoto 1970). However, there is no evidence of competition and the highly migratory behavior of blue whales may help them avoid competition with other baleen whales (Clapham and Brownell 1996).

4.1.3 Listing status

Blue whales have been listed as endangered under the ESA since 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. The North Pacific stock is also listed as "low risk, conservation dependent" under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for blue whales.

4.1.4 Population status and trends

There are no reliable estimates of blue whale abundance in the North Pacific Ocean or the action area. Nevertheless, Gambell (1976) estimated there were about 4,900 blue whales in the North Pacific before whaling began. Gambell (1976) also estimated there were about 1,600 blue whales in the North Pacific in the 1990s (with a range of 1,400 to 1,900). Wade and Gerrodette (1993) and Barlow et al. (1997, as cited in Perry *et al*. 1999) estimated there were a minimum of 3,300 blue whales in the North Pacific Ocean in the 1990s.

4.1.5 Impacts of human activity on the species

From 1889 to 1965 approximately 5,761 blue whales were taken from the North Pacific Ocean (NMFS 1998a). Evidence of a population decline can be seen in the catch data from Japan. In 1912, 236 blue whales were caught, in 1913, 58 whales, in 1914, 123 whales, and from 1915 to 1965, the catch numbers declined continuously (Mizroch *et al*. 1984a). In the eastern North Pacific, 239 blue whales were taken off the California coast in 1926. And, in the late 1950s and early 1960s, Japan caught 70 blue whales per year off the Aleutian Islands (Mizroch *et al*. 1984a).

The IWC banned commercial whaling in the North Pacific in 1966, since that time there have been no reported blue whale takes. Nevertheless, Soviet whaling probably continued after the ban so Soviet catch reports under-represent the number of blue whales killed by whalers (as cited in Forney and Brownell 1996). Surveys conducted in these former whaling areas in the 1980s and 1990s failed to find any blue whales (Forney and Brownell 1996).

There are no reports of fisheries-related mortality or serious injury in any of the blue whale stocks. Blue whale interaction with fisheries may go undetected because the whales are not observed after they swim away with a portion of the net. However, fishers report that large blue and fin whales usually swim through their nets without entangling and with very little damage to the net (Barlow *et al*. 1997).

4.1.5.1 Vessel traffic and noise disturbance

In 1980, 1986, 1987, and 1993, ship strikes have been implicated in the deaths of blue whales off California (Barlow *et al*. 1997). In addition, several photo-identified blue whales from California waters were observed with large scars on their dorsal areas that may have been caused by ship strikes. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears *et al*. 1983). Within the St. Lawrence Estuary, blue whales are believed to be affected by large amounts of recreational and commercial vessel traffic. Blue whales in the St. Lawrence appeared more likely to react to these vessels when boats made fast, erratic approaches or sudden changes in direction or speed (Edds and Macfarlane 1987, Macfarlane 1981).

The number of blue whales struck and killed by ships is unknown because the whales do not always strand or examinations of blue whales that have stranded did not identify the traumas that could have been caused by ship collisions. In the California/Mexico stock, annual incidental mortality due to ship strikes averaged 0.2 whales during 1991–1995 (Barlow *et al*. 1997), but we cannot determine if this reflects the actual number of blue whales struck and killed by ships.

Blue whales do not appear to be disturbed by noise from seismic exploration. When noise pulses from air guns were produced off Oregon, blue whales continued vocalizing at the same rate as before the pulses, suggesting that at least their vocalization behavior was undisturbed by the noise (McDonald *et al*. 1993).

4.2 Bowhead Whale

4.2.1 Species description and distribution

Bowhead whales were historically found in all Arctic waters of the northern hemisphere. For management purposes, the IWC recognizes five stocks or populations of bowhead whales: Spitsbergen, Davis Strait, Hudson Bay, Okhtosk, and western Arctic (IWC 1992). This summary will focus on the two stocks that occur in the North Pacific Ocean: the Okhotsk Sea stock and western Arctic stocks.

The Okhotsk Sea stock occurs in the North Pacific off the western coast of Siberia near the Kamchatka Peninsula. The pre-exploitation size of this stock may have been 3,000–6,500 animals (Shelden and Rugh 1995), and may now number somewhere in the 300–400 range, although reliable population estimates are not currently available. This stock may mix with the Bering Sea stock (or may have mixed in the past), although the available evidence indicates the two stocks are essentially separate.

The western Arctic stock, which is also called the Bering Sea stock or Bering-Chukchi-Beaufort stock, has been studied more extensively than any other bowhead whale stock. From November to April, the Bering Sea stock of bowhead whales is widely distributed in the central and western Bering Sea in association with the marginal ice front and near the polynyas of St. Matthew Island, St. Lawrence Island, and the Gulf of Anadyr (Braham et al. 1982).

About April or May, most of the whales in this population begin moving north past St. Lawrence Island and through the Bering Strait into the southern Chukchi Sea, then north through nearshore lead systems to Point Barrow. Bowhead whales pass Point Barrow in several “pulses”: the first between late April and early May, a second about mid-May, and a third from late May through early June. Whaling crews also have noticed that some bowhead whales remain near Barrow during the summer and apparently do not migrate to the Canadian Beaufort Sea or waters off Siberia.

Most whales move eastward from Point Barrow through offshore lead systems of the central Beaufort Sea. Bowhead whales arrive in the Canadian Beaufort Sea from about mid-May through mid-June where they concentrate between Herschel Island and Amundsen Gulf . Whales begin moving back westward between late August and early October. The fall migration generally occurs south of the pack ice and closer inshore than the spring migration. Data are limited on the bowhead fall migration through the Chukchi Sea before they move south into the Bering Sea. After moving south through the Chukchi Sea, bowhead whales pass through the Bering Strait in late October through early November on their way to overwintering areas in the Bering Sea.

4.2.2 Life history information

Little is known about when bowhead whales become sexually mature, their mating behavior, and the timing of their reproductive activity. Most investigators have assumed that bowhead whales mate during late winter and spring, perhaps continuing through the spring migration. Most calves are born from April through early June during the spring migration, with a few calves born as early as March and as late as August (Koski et al. 1993). Calves are about 13 to 15 ft (4 to 4.5 m) at birth and reach 42 to 66 ft (13 to

20 m) as adults. Females produce a single calf, probably every 3 to 4 years .

Bowhead whales appear to feed primarily during the summer. Like other baleen whales, bowhead whales are filter-feeders that sieve prey from the water through baleen fibers in their mouths. They feed almost exclusively on zooplankton, with primary prey consisting of copepods (54%) and euphausiids (42%). Other prey include mysids, hyperiid and gammarid amphipods, other pelagic invertebrates, and small fish. Bowhead whales feed heavily in the Canadian Beaufort Sea and Amundsen Gulf area during summer and fall migration through the Alaskan Beaufort Sea. Carbon isotope analysis of bowhead baleen has indicated that a significant amount of feeding may occur in wintering areas of the Chukchi and Bering Seas. During the feeding season, bowhead whales consume about 3 or 4 percent of their body weight per day or about 2.0 tons of food (Lowry et al. 1982).

The summer distribution of bowhead whales within the Beaufort Sea is determined primarily by prey density and distribution, which in turn reflect variable current and upwelling patterns. Sub-adult bowhead whales were observed to feed in water depths less than 164 ft (50 m) in the Canadian Beaufort Sea. However, little is known about the feeding behavior of adult bowhead whales in the Canadian Beaufort Sea.

Little is known about disease and natural causes of death among bowhead whales. While certain viral agents are present in this stock, their contribution to natural mortality or reduced reproduction is unknown. Some bowhead whales appear to become trapped by ice and die as a result although the percentage of whales entrapped in ice is considered to be small, given that bowhead whales are so strongly associated with sea ice (Tomilin 1957). Bowhead whales are also killed by killer whales (*Orcinus orca*), which are the bowhead's only known natural predator. Of 195 whales examined during Alaskan subsistence harvests (1976-1992), 8 had been wounded by killer whales. Seven of the eight bowhead whales were greater than 13 m in length, suggesting either that scars are accumulated over time, or young animals do not survive a killer whale attack. Hunters on St. Lawrence Island reported two small (<9 m) bowhead whales found dead as a result of killer whale attacks.

4.2.3 Listing status

In 1964, the IWC began to regulate commercial whaling worldwide, which benefitted bowhead whales. Bowhead whales were listed as endangered in 1970 under the predecessor to the ESA of 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Critical habitat has not been designated in the action area, although NMFS is currently evaluating a petition to designate the U.S. Beaufort Sea as critical habitat for the bowhead whale.

4.2.4 Population status and trends

The Bering Sea stock of bowhead whales was reduced greatly by commercial whaling in the late 19th and early 20th centuries. The pre-whaling stock has been estimated at 10,400 to 23,000 (Woodby and Botkin 1993), but was reduced by whaling to a few thousand animals by 1910. Whales taken in the Bering Sea may have been representatives of a population that did not migrate. Based on shore-based surveys from 1978 through 1983, the bowhead whale population size was estimated to be between 3,500 to 5,300 animals (Zeh et al. 1993). The IWC Scientific Committee estimates the current size of the Bering Sea stock of bowhead whales as 7,992 whales (95% C.I.: 6,900–9,200; IWC 1995). A refined and larger sample of acoustic data from 1993 has resulted in an estimate of 8,200 animals and is considered a better estimate for this stock (Hill et al. 1997). The Bering Sea stock of bowhead whales is believed to be increasing at an annual rate of 3.1%.

4.2.5 Impacts of human activity on the species

The Bering Sea stock of bowhead whales is hunted by the Natives of the Alaskan Beaufort, Bering, and Chukchi Seas for cultural and subsistence purposes. Since 1978, the IWC has imposed a quota on the number of bowhead whales landed and/or struck by Alaskan natives. The IWC recently allocated the subsistence take of bowhead whales from the Alaska stock, establishing a 5-year block quota of 280 whales landed. For each of the years 1998–2002, the number of bowhead whales struck may not exceed 67 animals, except that unused quotas may be carried over to subsequent years. In addition, an annual quota of five bowhead whales has been granted to the Russian Federation for the Natives of Chukotka.

The number of whales landed in the subsistence harvest of bowhead whales from 1978–1991 ranged from a low of 8 in 1982 to a high of 30 in 1990 and averaged 18 whales per year. From 1991 to 1995, a combined average of 19 bowhead whales per year were taken by the communities of Barrow, Nuiqsut, and Kaktovik. In 1998, 41 bowhead whales were landed and 12 were struck and lost during the spring and fall harvests, while in 1999, 42 whales were landed and 5 were struck and lost.

Commercial fishing occurs in the Bering Sea and elsewhere within the range of this stock. Evidence of interactions between bowhead whales and fishing gear is rare, although bowhead whales have been reported with ropes caught in their baleen and with scarring caused by rope entanglement. We have no records of bowhead whales being captured, seriously injured, or killed by fishing gear in U.S. waters (Small and DeMaster 1995), although a young bowhead whale was apparently entrapped and killed in a fishing net in Japan (Nishiwaki and Kasuya 1970). Bowhead whales are also struck and injured by ships, although these incidents do not appear to be common (George et al. 1994). Man-made noise in the marine environment is increasing with industrialization of the Alaskan arctic, and may affect bowhead whales. Despite many years of study, the seriousness of those effects on bowhead whales is unknown.

4.3 Fin Whale

4.3.1 Species description and distribution

Fin whales are distributed widely in the world’s oceans. In the northern hemisphere, most migrate seasonally from high Arctic feeding areas in summer to low latitude breeding and calving areas in winter. Other groups may remain year-round in a particular area, depending on food supply. The IWC’s Scientific Committee recognizes two management stocks in the North Pacific: (1) the east China Sea, and (2) the rest of the North Pacific (Donovan,1991). Mizroch et al. (1984b) suggested five possible stocks within the North Pacific based on histological and tagging experiments (1) east and west Pacific that intermingle around the Aleutian Islands; (2) east China Sea; (3) British Columbia; (4) southern/central California to the GOA; and (5) Gulf of California (Rice 1974, Tershy et al. 1993). However, NMFS considers stock structure in the North Pacific to be equivocal, and recognizes three stocks: (1) Alaska (northeast Pacific), (2) California/Oregon/ Washington, and (3) Hawaii (Barlow et al. 1997, Hill and DeMaster 1998).

Fin whales were reported as occurring immediately offshore throughout the North Pacific from central Baja California to Japan and as far north as the Chukchi Sea (Rice 1974). Fin whales occurred in high densities in the northern GOA and southeastern Bering Sea from May to October, with some movement through the Aleutian passes into and out of the Bering Sea (Reeves et al. 1985). Fin whales were observed and taken by Japanese and Soviet whalers off eastern Kamchatka and Cape Navarin, both north and south of the eastern Aleutians, and in the northern Bering and southern Chukchi seas (Berzin and Rovnin 1966, Nasu 1974). In 1999, vessel surveys of the central Bering Sea reported 75 fin whale sightings (346 whales) clustered along the outer Bering Sea shelf break, primarily near the 200m isobath (Moore et al. 2000). In the GOA, fin whales appear to congregate in the waters around Kodiak Island and south of Prince William Sound.

In recent years, small numbers of fin whales have been observed south of the Aleutian Islands (Forney and Brownell 1996), in the GOA (including Shelikof Strait), and in the southeastern Bering Sea (Leatherwood et al. 1986). Their regular occurrence has also been noted in recent years around the Pribilof Islands in the northern Bering Sea (Baretta and Hunt 1994). Fin whale concentrations in the northern areas of the North Pacific and Bering Sea generally form along frontal boundaries, or mixing zones between coastal and oceanic waters, which themselves correspond roughly to the 200-m isobath (which is the shelf edge; Nasu 1974).

Acoustic data collected from 1995 to 1999 from hydrophone arrays showed fin whales vocalizing in Alaskan waters during all seasons, with a peak in occurrence in midwinter.

4.3.2 Life history information

Fin whales become sexually mature between six to ten years of age, depending on density-dependent factors (Gambell 1985b). Reproductive activities for fin whales occur primarily in the winter. Gestation lasts about 12 months and nursing occurs for 6-11 months (Perry et al. 1999). The age distribution of fin whales in the North Pacific is unknown.

Fin whales in the North Pacific feed on euphausiids, calanoid copepods, and schooling fish such as herring, pollock, Atka mackerel, and capelin (Calkins 1986; Nemoto 1957, 1970; Kawamura 1982). Euphausiids may be preferred prey, and competition may occur with other baleen whales or other consumers of these prey types.

Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggest annual natural mortality rates may range between 0.04 and 0.06 (based on studies of northeast Atlantic fin whales). The occurrence of the nematode, *Crassicauda boopis*, appears to increase the potential for kidney failure in fin whales and may be preventing some fin whale stocks from recovering from whaling (Lambertsen 1992, as cited in Perry et al. 1999). Killer whale or shark attacks may result in serious injury or death in very young and sick whales (Perry et al. 1999). NMFS has no records of fin whales being killed or injured by commercial fisheries operating in the North Pacific (Ferrero et al. 2000).

4.3.3 Listing status

In the North Pacific, the IWC began management of commercial whaling for fin whales in 1969; fin whales were fully protected from commercial whaling in 1976 (Allen 1980). Fin whales were listed as endangered under the ESA. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for fin whales.

4.3.4 Population status and trends

Prior to exploitation by whaling vessels, the North Pacific population consisted of an estimated

42,000–45,000 fin whales (Ohsumi and Wada 1974). Between 1914 and 1975, over 26,040 fin whales were harvested throughout the North Pacific (in Perry et al. 1999). Catches in the North Pacific and Bering Sea ranged from 1,000 to 1,500 fin whales annually during the 1950's and 1960's. However, not all Soviet catches were reported (cited in Ferrero et al. 2000). In the early 1970s, the entire North Pacific population had been reduced to between 13,620 and 18,630 fin whales (Ohsumi and Wada 1974). During the early 1970s, 8,520–10,970 fin whales were surveyed in the eastern half of the North Pacific (Braham 1991). If these historic estimates are statistically reliable, the population size of fin whales has not increased significantly over the past 20 years despite an international ban on whaling in the North Pacific.

The current status and trend of the fin whale population in the North Pacific is largely unknown. Based on the available information, it is feasible that the North Pacific population as a whole has failed to increase significantly over the past 20 years, despite an international ban on whaling in the North Pacific. The only contrary evidence comes from investigators conducting seabird surveys around the Pribilof Islands in 1975-1978 and 1987-1989. These investigators observed more fin whales in the second survey and suggested they were more abundant in the survey area (Baretta and Hunt 1994). A survey for whales in the central Bering Sea in 1999 tentatively estimated the fin whale population was about 4,951 animals (95% C.I.: 2,833-8,653).

4.3.5 Impacts of human activity on this species

As early as the mid-seventeenth century, the Japanese were capturing fin, blue, and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. The North Pacific and Antarctic whaling operations soon added this ‘modern’ equipment to their arsenal. After blue whales were depleted in most areas, the smaller fin whale became the focus of whaling operations and more than 700,000 fin whales were landed in the twentieth century.

In the North Pacific, there are no reports of fin whale deaths caused by fishery-related activities (Hill et al. 1997), although conflicts between fin whales and drift gillnet fisheries may occur (Barlow et al. 1997). Because of their size, strength, and distribution, it would probably be difficult to assess potential interactions between fin whales and fisheries; for example, fishermen have reported that large blue and fin whales usually swim through their nets without entangling and with very little damage to the net (Barlow et al. 1997).

4.4 Humpback Whale

4.4.1 Species description and distribution

NMFS recognizes four stocks of humpback whales in the North Pacific, two of which are pertinent to this consultation: one in the central North Pacific and one in the western North Pacific (Hill and DeMaster 1998). The primary distinguishing pattern for these two stocks is their wintering ground: the western North Pacific unit winters south of the Japanese archipelago, whereas the central North Pacific unit winters in the waters around Hawaii. The summer range of the western North Pacific unit is poorly studied, but almost certainly overlaps to some degree with that of the central North Pacific unit.

Humpback whales also summer throughout the central and western portions of the GOA, including Prince William Sound, around Kodiak Island (including Shelikof Strait and the Barren Islands), and along the southern coastline of the Alaska Peninsula. Japanese scouting vessels continued to observe high densities of humpback whales near Kodiak Island during 1965–1974 (Wada 1980). In Prince William Sound, during recent years [i.e., prior to 1991], humpback whales have congregated near Naked Islands, in Perry Passage, near Cheega Island, in Jackpot, Icy and Whale Bays, in Port Bainbridge and north of Montague Islands between Green Island and the Needle (Hall 1979, 1982; von Ziegesar 1984; von Ziegesar and Matkin 1986). The few sightings of humpback whales in offshore waters of the central GOA are usually attributed to animals migrating into coastal waters (Morris et al. 1983), although use of offshore banks for feeding is also suggested.

The continental shelf of the Aleutian Islands and Alaska Peninsula were once considered the center of the North Pacific humpback whale population (Berzin and Rovnin 1966; Nishiwaki 1966). The northern Bering Sea, Bering Strait, and the southern Chukchi Sea along the Chukchi Peninsula appear to form the northern extreme of the humpback whale's range (Nikulin 1946, Berzin and Rovnin 1966). However, sightings of humpback whales in the Bering Sea were most frequent south of Nunivak Island and east of the Pribilof Islands (Berzin and Rovnin 1966; Braham et al. 1977; Nemoto 1978; Braham et al. 1982; Leatherwood *et al*. 1983).

4.4.2 Life history information

Humpback whale reproductive activities occur primarily in winter. They become sexually mature at age four to six. Annual pregnancy rates have been estimated at about 0.40–0.42 (NMFS unpublished and Nishiwaki 1959) and female humpback whales are believed to become pregnant every two to three years. Cows will nurse their calves for up to 12 months. The age distribution of the humpback whale population is unknown, but the portion of calves in various populations has been estimated at about 4–12% (Chittleborough 1965, Whitehead 1982, Bauer 1986, Herman et al. 1980, and Clapham and Mayo 1987). The information available does not identify natural causes of death among humpback whales or their number and frequency over time, but potential causes of natural mortality are believed to include parasites, disease, predation (killer whales, false killer whales, and sharks), biotoxins, and entrapment in ice.

Humpback whales exhibit a wide range of foraging behaviors, and feed on a range of prey types including small schooling fishes, euphausiids, and other large zooplankton. Fish prey in the North Pacific include herring, anchovy, capelin, pollock, Atka mackerel, eulachon, sand lance, pollack, Pacific cod, saffron cod, arctic cod, juvenile salmon, and rockfish. In the waters west of the Attu Islands and south of Amchitka Island, Atka mackerel were preferred prey of humpback whales (Nemoto 1957). Invertebrate prey include euphausiids, mysids, amphipods, shrimps, and copepods.

4.4.3 Listing status

The IWC first protected humpback whales in the North Pacific in 1965. Humpback whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Critical habitat has not been designated for the species.

4.4.4 Population status and trends

An estimated 394 humpback whales constitute the western North Pacific stock (Calambokidis et al. 1997). Waite et al. (1999) identified 127 individual humpback whales in the Kodiak Island region between 1991 and 1994 and estimated there were 651 whales in this region (95% CI:356-1,523). Waite et al. (1999) also estimated that 200 humpback whales regularly feed in Prince William Sound. Subsequently, based on mark-recapture analysis of photo-identification studies, several investigators concluded that the central North Pacific stock consists of at least 4,000 humpback whales (Calambokidis et al. 1997, Ferrero et al. 2000). Other than these estimates of the size of the humpback whale population, the available information is not sufficient to determine population trends.

In the BSAI, the humpback whale population was dramatically reduced by commercial whaling (see the discussion of commercial whaling in the Environmental Baseline chapter). The humpback whale population is believed to have increased since whaling ceased, although the rate of increase is unknown. Brueggeman et al. (1987) did not sight humpback whales in the North Aleutian and St. George Basin Outer Continental Shelf planning areas to the north and west of the Alaska Peninsula. Similarly, Stewart et al. (1987) did not observe humpback whales during aerial surveys on or near areas hunted by vessels from the Akutan whaling station in the eastern Aleutians. Braham et al. (1977) saw 14 humpback whales in the northern Bering Sea in August 1976, and Braham et al. (1982) documented 25 humpback whales between 1958 and 1978 between Unimak Pass and the Pribilof Islands in the southern Bering Sea.

4.4.5 Impacts of human activity on the species

In the 1990s, no more than 3 humpback whales were killed annually in U.S. waters by commercial fishing operations in the Atlantic and Pacific Oceans. Between 1990 and 1997, no humpback whale deaths have been attributed to interactions with groundfish trawl, longline and pot fisheries in the BSAI, and GOA (Hill and DeMaster 1999). Humpback whales have been injured or killed elsewhere along the mainland U.S. and Hawaii (Barlow et al. 1997). In 1991, a humpback whale was observed entangled in longline gear and released alive (Hill et al. 1997). In 1995, a humpback whale in Maui waters was found trailing numerous lines (not fishery-related) and entangled in mooring lines. The whale was successfully released, but subsequently stranded and was attacked and killed by tiger sharks in the surf zone. In 1996, a humpback whale calf was found stranded on Oahu with evidence of vessel collision (propeller cuts; NMFS unpub. data). Also in 1996, a vessel from Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crabpot floats from the whale; the gear was traced to a recreational fisherman in southeast Alaska. No information is available on the number of humpback whales that have been killed or seriously injured by interactions with fishing fleets outside of U.S. waters in the North Pacific Ocean.

Humpback whales seem to respond to moving sound sources, such as whale-watching vessels, fishing vessels, recreational vessels, and low-flying aircraft (Beach and Weinrich 1989, Clapham et al. 1993, Atkins and Swartz 1989). Their responses to noise are variable and have been correlated with the size, composition, and behavior of the whales when the noises occurred (Herman et al. 1980, Watkins et al. 1981, Krieger and Wing 1986). Several investigators have suggested that noise may have caused humpback whales to avoid or leave feeding or nursery areas (Jurasz and Jurasz 1979b, Dean et al. 1985), while others have suggested that humpback whales may become habituated to vessel traffic and its associated noise. Still other researchers suggest that humpback whales may become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995). In Hawaii, regulations prohibit boats from approaching within 91 m of adult whales and within 274 m in areas protected for mothers with a calf. Likewise, in Alaska, the number of cruise ships entering Glacier Bay has been limited to reduce possible disturbance.

Many humpback whales are killed by ship strikes along both coasts of the U.S. On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow et al. 1997). On the Atlantic coast, 6 out of 20 humpback whales stranded along the mid-Atlantic coast showed signs of major ship strike injuries (Wiley et al. 1995). Almost no information is available on the number of humpback whales killed or seriously injured by ship strikes outside of U.S. waters.

4.5 Right Whale

4.5.1 Species description and distribution

Right whales have occurred historically in all the world's oceans from temperate to subarctic latitudes. The IWC currently recognizes two species of northern right whales: *Eubalaena glacialis* in the North Atlantic and *E. japonica* in the North Pacific. However, right whales in the North Atlantic, North Pacific, and the southern hemisphere of both oceans are currently listed under the ESA as one species: right whales (which includes *E. glacialis*, *E. japonica*, and *E. australis*). For the purposes of ESA Section 7(a)(2) consultations, NMFS recognizes three major populations of right whales: North Pacific, North Atlantic, and Southern Hemisphere. The available information is not sufficient to identify stocks in the North Pacific, although Scarff (1986) suggested a right whale stock may be associated with the GOA.

Very little is known of the size and distribution of right whales in the North Pacific and very few of these animals have been seen in the past 20 years. In 1996, a group of 3–4 right whales (which may have included a calf) were observed in the middle shelf of the Bering Sea, west of Bristol Bay and east of the Pribilof Islands (Goddard and Rugh 1998). In June 1998, a lone whale was observed on historic whaling grounds near Albatross Bank off Kodiak Island, Alaska (Waite and Hobbs 1999). Surveys conducted in July of 1997–2000 in Bristol Bay reported observations of lone animals or small groups of right whales in the same area as the 1996 sighting (Hill and DeMaster 1998, Perryman et al. 1999). Historical whaling records (Maury 1852, Townsend 1935, Scarff 1986) indicate the right whale ranged across the North Pacific above 35°N lat. They summered in the North Pacific Ocean and southern Bering Sea from April or May to September, with a peak in sightings in coastal waters of Alaska in June and July (Maury 1852, Townsend 1935, Omura 1958, Klumov 1962, Omura et al. 1969). Their summer range extended north of the Bering Strait (Omura *et al*. 1969). However, they were particularly abundant in the GOA from 145° to 151°W (Berzin and Rovnin, 1966), and apparently concentrated in the GOA, especially south of Kodiak Islands and in the Eastern Aleutian Islands and southern Bering Sea shelf waters (Braham and Rice, 1984).

The winter distribution patterns of right whales in the Pacific are virtually unknown, although some right whales have been sighted as far south as 27°N in the eastern North Pacific. They have also been sighted in Hawaii (Herman et al. 1980), California (Scarff 1986), Washington and British Columbia. Their migration patterns are unknown, but are believed to include north-south movements between summer and winter feeding areas.

The scarcity of right whales is the result of an 800-year history of whaling that continued into the 1960s (Klumov 1962). Of all of the large whales, right whales are believed to have the highest risk of extinction in the foreseeable future. Recent data suggest an estimated population of 300 in the North Atlantic and a small, unknown number of individuals in the North Pacific. The southern right whale, in contrast, has shown signs of a slow recovery over the past 20 years.

4.5.2 Life history information

In both northern and southern hemispheres, right whales have been observed in the lower latitudes and more coastal waters during winter, and then tend to migrate to higher latitudes during the summer. Calving may occur in winter months when their distribution is more coastal, but the lack of sighting information suggests that calving may occur farther offshore. In summer and fall in both hemispheres, the distribution of right whales appears linked to the distribution of their principal zooplankton prey (Winn et al.1986). Essentially no information is available on the calving grounds or feeding habits of right whales in the North Pacific. The western North Atlantic stock of right whales generally occurs in Northwest Atlantic waters west of the Gulf Stream and are most commonly associated with cooler waters (≤ 21°C). They are not found in the Caribbean and have been recorded only rarely in the Gulf of Mexico.

Right whales in the North Pacific are known to prey on a variety of zooplankton species including *Calanus plumchrus, C. cristatus, Euphausia pacifica, Metridia* spp., and copepods of the genus *Neocalanus*.. This is similar to the feeding habits of right whales in the Gulf of Maine, which feed on zooplankton (primarily copepods) (see NMFS 1991b, Murison and Gaskin 1989). Right whales may compete with sympatric sei whales and many other predators or consumers of zooplankton in the eastern North Pacific and Bering Sea. Killer whales are suspected as possible predators, but no data from the North Pacific support this speculation (Scarff 1986).

4.5.3 Listing status

Since 1949, the northern right whale has been protected from commercial whaling by the IWC. Right whales (both *E. glacialis* and *E. australis*) are listed as endangered under the ESA. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. NMFS designated critical habitat for the North Atlantic population of right whales on June 3, 1994 (59 FR 28793). Critical habitat has not been designated for right whales in the North Pacific Ocean.

4.5.4 Population status and trends

The population dynamics of right whales are unknown. The recovery plan for this species suggests that its pre-exploitation abundance was higher than 11,000, based on a known harvest of over 11,000 by U.S. whalers with additional numbers struck and lost (Brownell et al. 1986). Current population estimates range from a low of 100–200 (Braham and Rice 1984) to a high of 220–500 (Berzin and Yablokov 1978 [in Berzin and Vladimirov 1981]), but Hill and DeMaster (1998) argue that is it is not possible to produce a reliable estimate of population size or trends for the right whale in the North Pacific. No population projections are available.

Several researchers have suggested that the recovery of right whales in the northern hemisphere has been slowed by other whales that compete with right whales for food (Rice 1974, Scarff 1986). Mitchell (1975) analyzed trophic interactions among baleen whales in the western north Atlantic and noted that the foraging grounds of right whales overlapped with the foraging grounds of sei whales and both preferentially feed on copepods. Reeves et al. (1978) noted that several species of whales feed on copepods in the eastern north Pacific, so that the foraging pattern and success of right whales would be affected by other whales as well. Mitchell (1975) argued that the right whale population in the north Atlantic had been depleted by several centuries of whaling before steam-driven boats allowed whalers to hunt sei whales; from this, he hypothesized that the decline of the right whale population made more food available to sei whales and helped their population to grow. He then suggested that the larger sei whale population competes with the smaller right whale population and slows or prevents its recovery.

4.5.5 Impacts of human activity on the species

Before whaling began in the North Pacific Ocean, right whales were considered common or abundant in the North Pacific (Webb 1988). By 1900, observations of right whales in the North Pacific had become so rare, it was impossible to know their population status or trend. In the Atlantic Ocean, the major known sources of anthropogenic mortality and injury of right whales include entanglement in commercial fishing gear and ship strikes. Scarff (1986) concluded that entanglement in fishing gear, noise, or continued hunting by countries who are not members of the IWC were not serious threats to right whales in the North Pacific. However, Scarff (1986) concluded that right whales in the North Pacific are particularly vulnerable to ship strikes and marine pollution because of their habit of feeding at, or near, the water surface.

Undersea exploration and development of mineral deposits, and the dredging of major shipping channels are continued threats to the coastal habitat of the right whale in both the North Atlantic and North Pacific. Offshore oil and gas activities have been proposed off the coast of the mid- and south- Atlantic U.S. and are currently being conducted in the Bering Sea and in eastern North Pacific. In Russian waters, two fishery-related mortalities have been reported and offshore oil and gas development could potentially affect northern right whale habitat (Perry et al. 1999).

4.6 Sei Whale

4.6.1 Species description and distribution

Sei whales are distributed in all of the world's oceans, except the Arctic Ocean. The IWC's Scientific Committee groups all of the sei whales in the entire North Pacific Ocean into one stock (Donovan 1991). However, some mark-recapture, catch distribution, and morphological research indicated that more than one stock exists; one between 175°W and 155°W longitude, and another east of 155° W longitude (Masaki 1976, 1977). During the winter, sei whales are found from 20°–23° N and during the summer from 35°–50° N (Masaki 1976, 1977). Horwood (1987) reported that 75–85% of the total North Pacific population of sei whales resides east of 180° longitude.

In the North Pacific Ocean, sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the GOA, and inside waters of southeast Alaska (Nasu 1974, Leatherwood et al. 1982). Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and DeMaster 1998). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July through September, although other researchers question these observations because no other surveys have ever reported sei whales in the northern and western Bering Sea. Horwood (1987) evaluated the Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea.

4.6.2 Life history information

Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months and the calving interval is about 3 years (Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977). The age structure of the sei whale population is unknown. Rice (1977) estimated total annual mortality for adult females as 0.088 and adult males as 0.103. Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas.

Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95% of their diets (Calkins 1986). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollock, capelin, and Atka mackerel (Nemoto and Kawamura 1977). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries.

Endoparasitic helminths are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

4.6.3 Listing status

In the North Pacific, the IWC began management of commercial taking of sei whales in 1970, and fin whales were given full protection in 1976 (Allen 1980). Sei whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. They are listed as endangered under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for sei whales.

4.6.4 Population status and trends

Sei whale abundance prior to commercial whaling in the North Pacific has been estimated at 42,000 sei whales (Tillman 1977). Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968 and 1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). When commercial whaling for sei whales ended in 1974, the population of sei whales in the North Pacific had been reduced to between 7,260 and 12,620 animals (Tillman 1977).

Current abundance or trends are not known for stocks in the North Pacific. In California waters, only one confirmed and five possible sei whale sightings were recorded during 1991, 1992, and 1993 aerial and ship surveys (Carretta and Forney 1993, Mangels and Gerrodette 1994). No sightings were confirmed off Washington and Oregon during recent aerial surveys.

Several researchers have suggested that the recovery of right whales in the northern hemisphere has been slowed by other whales that compete with right whales for food. Mitchell (1975) analyzed trophic interactions among baleen whales in the western north Atlantic and noted that the foraging grounds of right whales overlapped with the foraging grounds of sei whales and both preferentially feed on copepods. Mitchell (1975) argued that the right whale population in the north Atlantic had been depleted by several centuries of whaling before steam-driven boats allowed whalers to hunt sei whales; from this, he hypothesized that the decline of the right whale population made more food available to sei whales and helped their population to grow. He then suggested that the larger sei whale population competes with the smaller right whale population and slows or prevents its recovery.

The patterns in the eastern north Pacific Ocean: right whales and sei whales have overlapping foraging areas; right whales feed almost entirely on copepods, which sei whales prefer; and whalers depleted the population of right whales almost a century before they began to hunt sei whales (Rice 1974, Scarff 1986). Reeves et al. (1978) noted that several species feed of copepods in the eastern north Pacific, so the foraging pattern of sei whales may affect the foraging success of right whales.

4.6.5 Impacts of human activity on the species

From 1910 to 1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Horwood 1987, Perry et al. 1999). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300–600 sei whales were killed per year from 1911 to 1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. In the eastern north Pacific, the sei whale population appeared to number about 40,000 animal until whaling began in 1963; by 1974, the sei whale population had been reduced to about 8,000 animals (Tilman 1977).

No recent reports indicate sei whales are being killed or seriously injured as a result of fishing activities in any eastern North Pacific fishery (Perry et al. 1999). However, Barlow et al. (1997) note that a conflict may exist in the offshore drift gillnet fishery.

4.7 Sperm Whale

4.7.1 Species description and distribution

Sperm whales are distributed in all of the world's oceans. Several authors have recommended three or more stocks of sperm whales in the North Pacific for management purposes (Kasuya 1991, Bannister and Mitchell 1980). However, the IWC's Scientific Committee designated two sperm whale stocks in the North Pacific: a western and eastern stock (Donovan 1991). The line separating these stocks has been debated since their acceptance by the IWC's Scientific Committee. For stock assessment purposes, NMFS recognizes three discrete population "centers" of sperm whales: (1) Alaska, (2) California/Oregon/Washington, and (3) Hawaii.

Sperm whales are found throughout the North Pacific and are distributed broadly from tropical and temperate waters to the Bering Sea as far north as Cape Navarin. Mature female and immature sperm whales of both sexes are found in more temperate and tropical waters from the equator to around 45°N throughout the year. These groups of adult females and immature sperm whales are rarely found at latitudes higher than 50°N and 50°S (Reeves and Whitehead 1997). Sexually mature males join these groups throughout the winter. During the summer, mature male sperm whales are thought to move north into the Aleutian Islands, GOA, and the Bering Sea.

Sperm whales are rarely found in waters less than 300 m in depth. They are often concentrated around oceanic islands in areas of upwelling, and along the outer continental shelf and mid-ocean waters. Because they inhabit deeper pelagic waters, their distribution does not include the broad continental shelf of the Eastern Bering Sea and these whales generally remain offshore in the eastern AI, GOA, and the Bering Sea.

4.7.2 Life history information

Female sperm whales take about 9 years to become sexually mature (Kasuya 1991, as cited in Perry et al. 1999). Male sperm whales take between 9 and 20 years to become sexually mature, but will require another 10 years to become large enough to successfully compete for breeding rights (Kasuya 1991). Adult females give birth after about 15 months gestation and nurse their calves for 2 –3 years. The calving interval is estimated to be about four to six years (Kasuya 1991). The age distribution of the sperm whale population is unknown, but sperm whales are believed to live at least 60 years (Rice 1978). Estimated annual mortality rates of sperm whales are thought to vary by age, but previous estimates of mortality rate for juveniles and adults are now considered unreliable (IWC 1980, as cited in Perry et al. 1999).

Sperm whales are known for their deep foraging dives (in excess of 3 km). They feed primarily on mesopelagic squid, but also consume octopus, other invertebrates, and fish (Tomilin 1967, Tarasevich

1968, Berzin 1971). Perez (1990) estimated that their diet in the Bering Sea was 82% cephalopods (mostly squid) and 18% fish. Fish eaten in the North Pacific included salmon, lantern fishes, lancetfish, Pacific cod, pollock, saffron cod, rockfishes, sablefish, Atka mackerel, sculpins, lumpsuckers, lamprey, skates, and rattails (Tomilin 1967, Kawakami 1980, Rice 1986b). Sperm whales taken in the GOA in the 1960s had fed primarily on fish. Daily food consumption rates for sperm whales ranges from 2 - 4% of their total body weight (Lockyer 1976b, Kawakami 1980).

Potential sources of natural mortality in sperm whales include killer whales and papilloma virus (Lambertson et al. 1987).

4.7.3 Listing status

Sperm whales have been protected from commercial harvest by the IWC since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). Sperm whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Critical habitat has not been designated for sperm whales.

4.7.4 Population status and trends

Current estimates for population abundance, status, and trends for the Alaska stock of sperm whales are not available (Hill and DeMaster 1999). Approximately 258,000 sperm whales in the North Pacific were harvested by commercial whalers between 1947 and 1987 (Hill and DeMaster 1999). In particular, the Bering Sea population of sperm whales (consisting mostly of males) was severely depleted (Perry et al. 1999). Catches in the North Pacific continued to climb until 1968, when 16,357 sperm whales were harvested. Catches declined after 1968 through limits imposed by the IWC.

4.7.5 Impacts of human activity on the species

In U.S. waters in the Pacific, sperm whales are known to have been incidentally taken only in drift gillnet operations, which killed or seriously injured an average of 9 sperm whales per year from 1991–95 (Barlow et al. 1997). Interactions between longline fisheries and sperm whales in the GOA have been reported over the past decade (Rice 1989, Hill and DeMaster 1999). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on longline-caught fish in the GOA. During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill and DeMaster 1998). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear.

In 2000, the Japanese Whaling Association announced that it proposed to kill 10 sperm whales in the Pacific Ocean for research purposes, which was the first time sperm whales have been taken since the international ban on commercial whaling took effect in 1987. Despite protests from the U.S. government and members of the IWC, the Japanese government plans to conduct this research. The implications of this action for the status and trend of sperm whales is uncertain.

4.8 Steller Sea Lion

4.8.1 Species description

The Steller sea lion (*Eumetopias jubatus*) is the only extant species of the genus *Eumetopias*, and is a member of the subfamily Otariinae, family Otariidae, superfamily Otarioidea, order Pinnipedia. The closest extant relatives of the Steller sea lion appear to be the other sea lion genera, including *Zalophus*, *Otaria*, *Neophoca*, and *Phocarctos*, and the fur seals of the genera *Callorhinus* and *Arctocephalus*. Loughlin *et al*. (1987) provide a brief but informative summary of the fossil record for *Eumetopias*. Repenning (1976) suggests that a femur dated 3 to 4 million years old may have been from an ancient member of the *Eumetopias* genus, thereby indicating that the genus is at least that old. *Eumetopias jubatus* likely evolved in the North Pacific (Repenning 1976).

4.8.2 Distribution

Steller sea lions are distributed around the North Pacific rim from the Channel Islands off Southern California to northern Hokkaido, Japan. The species' distribution extends northward into the Bering Sea and along the eastern shore of the Kamchatka Peninsula. The GOA and the Aleutian Islands are considered the geographic center of the sea lions' distribution (Kenyon and Rice 1961).

Within this distribution, land sites used by Steller sea lions are referred to as rookeries and haulout sites. In the Bering Sea, the northernmost major rookery is on Walrus Island (Pribilof Islands) and their northernmost major haulout is on Hall Island (off the northwestern tip of St. Matthew Island). Rookeries are used by adult males and females for pupping, nursing, and mating during the reproductive season (late May to early July). Haulouts are used by all size and sex classes but are generally not sites of reproductive activity. The continued use of particular sites may be due to site fidelity, or the tendency of sea lions to return repeatedly to the same site, often the site of their birth. Presumably, these sites were chosen and continue to be used because of their substrate and terrain, the protection they offer from terrestrial and marine predators, protection from severe climate or sea surface conditions, and the availability of prey resources.

Steller sea lion movement patterns from a land base (rookery or haulout) might be categorized into at least three types. First, sea lions move on and offshore for feeding excursions. Limited data are available to describe these movements (e.g., Gentry 1970, Sandgren 1970, Merrick and Loughlin 1997), but such descriptions are essential for understanding foraging patterns, nursing strategies, and energetics. Second, at the end of the reproductive season, some females may move with their pups to other haulout sites and males may disperse to distant foraging locations (Spaulding 1964, Mate 1973, Porter 1997). Some data indicate that animals do shift from rookeries to haulouts, but the timing and nature of these movements need further description (i.e., what distances are involved, are movements relatively predictable for individuals, do movements vary with foraging conditions, etc.). Description of these types of movements are essential for understanding seasonal distribution changes, foraging ecology, and apparent trends as a function of season. Third, sea lions may make semi-permanent or permanent one-way movements from one site to another (Chumbley et al. 1997, their Table 8; Burkanov et al. unpubl. report [cited in Loughlin 1997]). Calkins and Pitcher (1982) reported movements of up to 1500 km. They also describe wide dispersion of young animals after weaning, with the majority of those animals returning to the site of birth as they reach reproductive age.

The distribution of Steller sea lions at sea is not well understood. Their at-sea distribution is, however, a critical element to any understanding of potential effects of fisheries on Steller sea lions, and will be considered in greater detail below in the section on foraging patterns (see section 4.8.6).

4.8.3 Reproduction

Steller sea lions have a polygynous reproductive system where a single male may mate with multiple females. As mating occurs on land (or in the surf or intertidal zones), males are able to defend territories and thereby exert at least partial control over access to adult females and mating privileges. The pupping and mating season is relatively short and synchronous, probably due to the strong seasonality of the sea lions' environment and the need to balance aggregation for reproductive purposes with dispersion to take advantage of distant food resources (Bartholomew 1970). In May, adult males compete for rookery territories. In late May and early June, adult females arrive at the rookeries, where pregnant females give birth to a single pup. The sex ratio of pups at birth is approximately 1:1 or biased toward slightly greater production of males (e.g., Pike and Maxwell 1958, Lowry et al. 1982, NMFS 1992).

Mating occurs about one to two weeks later (Gentry 1970). The gestation period is probably about 50 to 51 weeks, but implantation of the blastocyst is delayed until late September or early October (Pitcher and Calkins 1981). Due to delayed implantation, the metabolic demands of a developing fetus are not imposed on the female until well into fall and early winter.

After parturition (birth), females nurse their pups over a period of months to several years. Merrick et al. (1995) compared pup sizes at different sites where Steller sea lion populations were either decreasing or increasing, to determine if pup size or growth may be compromised in decreasing populations. Their results were not consistent with that hypothesis; rather, they found that pups about two to four weeks of age were larger at sites in the Aleutian Islands and GOA than they were in southeast Alaska or Oregon. These observed differences indicate that at least this phase of reproduction may not be affected; that is, if females are able to complete their pregnancy and give birth, then the size of those pups does not appear to be compromised. Possible alternative explanations for the observed size differences are that pups were measured at different ages (i.e., pups in the GOA and Aleutian Islands may have been born earlier and therefore were older when weighed), or that over time, harsher environmental conditions in the Aleutian Islands of the GOA have selected for larger pup size.

The length of the nursing period may be an important indicator of the female's condition and ability to support her pup, and the pup's condition at weaning (and hence, the likelihood that the pup will survive the post weaning period). Thorsteinson and Lensink (1962) suggested that nursing of yearlings was common at Marmot Island in 1959. Pitcher and Calkins (1981) suggested that it is more common for pups to be weaned before the end of their first year, but they also observed nursing juveniles (aged 1 to 3). Porter (1997) distinguished metabolic weaning (i.e., the end of nutritional dependence of the pup or juvenile on the mother) from behavioral weaning (i.e., the point at which the pup or juvenile no longer maintains a behavioral attachment to the mother). He also suggested that metabolic weaning is more likely a gradual process occurring over time and more likely to occur in March–April, preceding the next reproductive season. The transition to nutritional independence may, therefore, occur over a period of months as the pup begins to develop essential foraging skills, and depends less and less on the adult female. The length of the nursing period may also vary as a function of the condition of the adult female. The nature and timing of weaning is important because it determines the resources available to the pup during the more demanding winter season and, conversely, the demands placed on the mother during the same period. The maintenance of the mother-offspring bond may also limit their distribution or the area used for foraging.

Relatively little is known about the life history of sea lions during the juvenile years between weaning and maturity. Pitcher and Calkins (1981) reported that females sampled in the late 1970s reached reproductive maturity between ages 2 and 8, and the average age of first pregnancy was 4.9 ±1.2 years. These results suggest a mean age of first birth of about 6 years. The available literature indicates an overall reproductive (birth) rate on the order of 55% to 70% or greater (Pike and Maxwell 1958, Gentry

1970, Pitcher and Calkins 1981, Pitcher *et al*. in review). York (1994) derived the age-specific fecundity rates in Table 4.1 based on data from Calkins and Pitcher (1982). Those rates illustrate a number of important points and assumptions. First, the probability of pupping is rare (about 10%) for animals 4 years of age or younger. Second, maturation of 100% of a cohort of females occurs over a prolonged period which may be as long as 4 years. Third, the reported constancy of fecundity extending from age 6 to 30 indicates that either senescence has no effect on fecundity, or our information on fecundity rates is not sufficiently detailed to allow confident estimation of age-specific rates for animals older than age 6. Given the small size of the sample taken, the latter is a more likely explanation for such constancy.

For mature females, the reproductive cycle includes mating, gestation, parturition, and nursing or post-natal care. The reproductive success of an adult female is determined by a number of factors within a cycle and over time through multiple cycles (Fig. 4.1). The adult female's ability to complete this cycle successfully is largely dependent on the resources available to her. While much of the effort to explain the Steller sea lion decline has focused on juvenile survival rates, considerable evidence suggests that decreased reproductive success may also have contributed to the decline.

- Young females collected in the 1970s were larger than females of the same age collected in the 1980s (Calkins *et al*. 1998). As size, as well as age, may influence the onset of maturity, females in the 1980s would also be more likely to mature and begin to contribute to population productivity at a later age.

- Pitcher *et al*. (1998) provide data from the 1970s and 1980s that suggests a high pregnancy rate after the mating season (97%; both periods), which declined to 67% for females collected in the 1970s and 55% for females collected in the 1980s. These changes in pregnancy rate suggest a high rate of fetal mortality that could be a common feature of the Steller sea lion reproductive strategy (i.e., may occur even when conditions are favorable and population growth is occurring), but is more likely an indication of stress (possibly nutritional) experienced by individual females.

- The observed differences in late pregnancy rates (67% in the 1970s and 55% in the 1980s) were not statistically significant. However, the direction of the difference is consistent with the hypothesis that reproductive effort in the 1980s was compromised.

- Pitcher *et al*. (1998) did observe a statistical difference in the late season pregnancy rates of lactating females in the 1970s (63%) versus lactating females in the 1980s (30%). This difference indicates that in contrast to lactating females in the 1970s, lactating females in the 1980s were less able to support a fetus and successfully complete consecutive pregnancies.

Males reach sexual maturity at about the same time as females (i.e., 3-7 years of age, reported in Loughlin *et al*. 1987), but generally do not reach physical maturity and participate in breeding until about 8 to 10 years of age (Pitcher and Calkins 1981). A sample of 185 territorial males from Marmot, Atkins, Ugamak, Jude, and Chowiet Islands in 1959 included animals 6 to 17 years of age, with 90% from 9 to 13 years old (Thorsteinson and Lensink 1962).

4.8.4 Survival

Much of the recent effort to understand the decline of Steller sea lions has been focused on juvenile survival, or has assumed that the most likely proximate explanation is a decrease in juvenile survival rates. This contention is consistent with direct observations and a modeling study, and is consistent with the notion that juvenile animals are less adept at avoiding predators and obtaining sufficient resources (prey) for growth and survival.

The direct observations consist of extremely low resighting rates at Marmot Island of 800 pups tagged and branded at that site in 1987 and 1988 (Chumbley et al. 1997) and observations of relatively few juveniles at Ugamak (Merrick et al. 1988). The low resighting rates do not themselves confirm that the problem was a corresponding drop in juvenile survival, but only that many of the marked animals were lost to the Marmot Island population. Migration to other sites where they were not observed is a possibility, but unlikely given the observations of relatively high site fidelity of animals returning to breed at their natal site. If the “loss” of these animals is viewed in the context of the overall sea lion decline in the central GOA (from 1976 to 1994 the number of non-pups counted at Marmot Island declined by 88.9% and by 76.9% at the 14 other trend sites in the Gulf; Chumbley et al. 1997), then a significant increase in juvenile mortality is a much more plausible conclusion.

Modeling by York (1994) provides evidence that the observed decline in sea lion abundance in the GOA may have been due to an increase in juvenile mortality. York used the estimated rate of decline between the 1970s and the 1980s, and the observed shift in the mean age of adult females ($\geq$3 years of age) to explore the effects of changes in adult reproduction, adult survival, and juvenile survival. While she pointed out that the observed decline did not rule out all other possible explanations, she concluded that the observed decline is most consistent with a decrease in juvenile survival on the order of 10 to 20% annually.

However, juvenile survival is not assumed to be the only factor influencing the decline of the western population of Steller sea lions. Evidence indicating a decline in reproduction was presented in the previous section. In addition, changes in adult survival may also have contributed to the decline. At present, survival rates for adult animals can not be determined with sufficient resolution to determine if those rates have changed over time or are somehow compromised to the extent that population growth and recovery are compromised.

4.8.5 Age distribution

Two life tables have been published with age-specific rates (Table 4.1). The first was from Calkins and Pitcher (1982) and was based on sea lions killed in the late 1970s. York (1994) created a second life table using a Weibull model and the data from Calkins and Pitcher (1982) and Calkins and Goodwin (1988). York’s analysis of these two data sets suggests a shift from the 1970s to the 1980s in the mean age of females older than 3 years of age. The shift was about 1.55 years, and provided the basis for her determination that increased juvenile mortality may have been an important proximate factor in the decline of Steller sea lions. That is, such a shift in mean age would occur as the adult population aged without expected replacement by recruitment of young females.

The most apparent limitations of these data and the resulting life tables are 1) the collected sea lions were not from the same locations and the relations between populations at different sites have not been described (e.g., were they experiencing similar trends and were their age structures comparable), 2) the data and estimated vital rates are also time-specific, and do not necessarily apply to the current population, 3) the assumption of a stable age distribution (or distributions) may be faulty even if trends at these different sites were consistent, and 4) the data set is relatively small and does not provide a basis for estimating age-specific survival rates for very young ages (0–2 years of age) or for possibly senescent older animals (say >12 years of age). Until senescence is assessed, longevity for Steller sea lions will be difficult to describe. The data reported in Pitcher and Calkins (1981) indicate that female sea lions may live to 30 years of age. A Weibull function fit to these data (York 1994) indicates, however, that fewer than 5% of females live to age 20.

The present age distribution may or may not be consistent with these life tables. Nevertheless, these tables provide the best available information on vital parameters, and the present age structure of sea lions may be similar if the immediate causes of the decline (e.g., low juvenile survival or low reproductive rates) have remained relatively constant.

4.8.6 Steller sea lion foraging behavior

The foraging patterns of Steller sea lions are central to the discussion of the interaction between this species and commercial fisheries. The two most important factors are Steller sea lion foraging locations and prey selectivity. A list of published foraging studies is provided in Table 4.2, together with notes on the sample sizes, locations, years, and primary findings of those studies.

4.8.6.1 Methods for researching sea lion foraging behavior

Current understanding of Steller sea lion foraging patterns are based on the following methods.

Observations

Foraging patterns can be discerned, in part, simply by observational studies. Observations can be useful for identifying areas that may be important foraging sites (e.g., Kajimura and Loughlin 1988, Fiscus and Baines 1966). The designation of critical habitat was based, in part, on observations that sea lions use those areas extensively for foraging. Similarly, under certain circumstances observations can be used for identifying prey items, particularly those that may be commercially important (e.g., Jameson and Kenyon 1977). In general, however, the power of observational studies is limited to situations where sea lions bring their prey to the surface and the prey can be identified, or where the sea lions can be observed diving repeatedly and the assumption that they are foraging is reasonable.

Stomach and intestinal contents

Stomach contents are generally considered to be the most reliable indication of foraging patterns. Nonetheless, biases may occur from a number of sources. Variable rates of digestion of soft tissues or variable retention of hard tissues (e.g., squid beaks) may result in misrepresentation of prey detection in the stomach. For example, Pitcher (1981) indicated that results from intestinal tracts may not correspond to results from stomachs. Stomach contents generally indicate prey items recently consumed, and may or may not be representative of prey items over a longer period of time. Results also may be biased by the evaluation method (e.g., use of frequency of occurrence may indicate how many animals ingested a prey type, but may not provide a good indicator of the importance of that prey; see Spalding 1964). Analyses of stomach contents have provided a large portion of our information on sea lion foraging (e.g., Calkins and Pitcher 1982, Calkins and Goodwin 1988), but under most conditions, killing for collection of stomach contents is no longer considered appropriate. Stomach and intestinal contents are now available only from dead animals found on beaches or live animals that are under sedation and can be lavaged or given an enema.

Scat analysis

Scats, or feces, are being used to study Steller sea lion prey selection, and have provided important information on the frequency of occurrence of various prey species in the sea lion diet (e.g., Merrick et al. 1997). Materials from scats, such as otoliths, can be used with additional information (e.g., size at age) to make inferences about the prey consumed (Pitcher 1981, Frost and Lowry 1986). As with stomach and intestinal contents, scats are known to be a biased index of prey selection because some prey may not have hard parts that resist digestion and can be identified in a scat, and the scat generally contains prey items consumed relatively recently (depending on the rate of passage through the digestive tract). Nevertheless, scat collections provide a non-lethal means of assessing diet and diet changes over time and space, and estimating relative frequency of occurrence of prey items in the sea lion diet. Since about 1990, NMFS has used scats as the primary tool for determining diet preferences for Steller sea lions in Alaska.

Telemetry

At least three types of telemetry are (or have been) used to study sea lion foraging. Very high frequency (VHF) telemetry can be used to determine presence or absence of an animal and, to some extent, animal location and whether it is on land or in the water. The use of VHF telemetry to determine the presence or absence of an animal can be used to infer the occurrence and length of foraging trips (e.g., Merrick and Loughlin 1997), and movement patterns between sites that can be monitored manually, remotely, or automatically by VHF receivers.

Satellite-linked telemetry is being used to determine animal location and diving patterns when coupled with time-depth recorders (e.g., Merrick et al. 1994). Satellite-linked telemetry provides an opportunity to gather information on animal location without having to recapture the animal to collect stored data. At present, satellite-linked telemetry is the most cost-effective means of assessing the distribution of foraging animals and thereby determining those regions that are critical for Steller sea lions.

Telemetry devices that record stomach temperature are being developed and offers an opportunity to determine when an animal has consumed prey, rather than requiring the investigator to infer feeding from diving behavior. This type of telemetry, in combination with satellite-linked telemetry, may provide greater understanding of foraging behavior and discrimination of at-sea activities that may or may not be related to foraging.

Physiology and captive studies

Studies of animals in captivity may be useful for understanding prey selection, diving and foraging physiology, and energetics. Various studies have examined assimilation efficiency, changes in weight as a function of prey type (Fadely et al. 1994, Rosen and Trites 1999, Rosen and Trites 2000), metabolic rates, the heat increment of feeding (Rosen and Trites 1998, 2000), and the metabolic effect of fasting (Rea et al. 2000). Energetic and nutritional studies on captive animals will likely form a basis from which dietary requirements of wild animals can be determined and understood. The issue of competition between groundfish fisheries and the Steller sea lion may be decided on the basis of demographic, ecological, or other information, but our understanding of such competition will ultimately depend on our ability to explain their energetic and nutritional needs and physiology.

Fatty acid analysis

Fish species vary in fatty acid composition and therefore carry their own "fatty acid signature." This signature is retained through ingestion and digestion of prey, and deposition of resulting fatty acids. Therefore, removal of small tissue (blubber) plugs from Steller sea lions and analysis for fatty acid composition can be used to identify prey types. This method of prey analysis is relatively new (e.g., Iverson 1993), but has been used successfully to identify prey types of harbor seals in different regions of Prince William Sound (Iverson et al. 1997). The NMFS laboratory at Auke Bay has developed the capability to conduct such analyses; this approach to prey determination will likely prove useful for providing a longer-term view of sea lion diets.

Isotope analysis

Isotope ratios for various elements differ in prey types in a manner that allows estimation of general prey category and trophic level. These analyses can be conducted using small amounts of tissue (e.g., vibrissae or whiskers) and may provide evidence of long term changes in general prey type, trophic level, or feeding strategy. For example, Hobson et al. (1997) examined carbon and nitrogen ratios in the hair and muscle of Steller sea lions and northern fur seals and were able to infer consumption of prey from different trophic levels for the two species. The results also indicated variation in prey by latitude.

4.8.6.2 Foraging distributions

At present, our understanding of Steller sea lion foraging distribution is based on sightings at sea or observations of foraging behavior (or presumed foraging behavior) in areas such as the southeastern Bering Sea (Fiscus and Baines 1966, Kajimura and Loughlin 1988), records of incidental take in fisheries (Perez and Loughlin 1991), and satellite-linked telemetry studies (e.g. Merrick et al. 1994, Merrick and Loughlin 1997).

Observations

The POP database provides our best overall view of the foraging range or distribution of Steller sea lions in the BSAI and the western/central GOA (Fig. 4.2a). This database and the locations of sea lions taken incidentally in groundfish fisheries (1973–1988, Perez and Loughlin 1991), indicate that sea lions disperse widely to forage throughout much of the BSAI and the GOA, at least as far out as the continental shelf break. Such broad dispersal may be essential to sea lion populations to take advantage of distant food resources and, as a consequence, limit intra-specific competition near rookeries and haulouts. However, this database should be viewed with some caution. The sightings in this database were collected over a period of four decades and do not reflect any natural changes that may have occurred in sea lion foraging patterns during that period. NMFS has prepared another database with just the observations from 1991-2000 which suggests similar trends (Fig. 4.2b). In the Bering Sea there have been many observations of Steller sea lions along the shelf-break as far north as 60N latitude throughout the year. Interestingly, the pattern of foraging (as determined from observations) seems to follow the continental shelf break (i.e. the 200 m isobath) suggesting the type of foraging locations preferred by some animals. However, many animals may remain within 20 nm because of the proximity to a nursing pup or because of the narrowness of the continental shelf (i.e. such as in the Aleutian Islands area).

The foraging range, as indicated by such sightings, would be expected to change over time due to the severe decline of the species in the last two decades. In addition, the database is biased as a reflection of overall foraging dispersion by the location of sighting effort. That is, a sighting at a particular location indicates sea lion presence at that site, but the lack of sightings at a site could mean that the site is not important for foraging or it could mean that there was insufficient sighting effort in that area. Also, it is not clear that each sighting represents a different animal, and it is possible that some sightings were of the same animal. Finally, the sighting database does not include information on the age and sex of the sighted animal. Nonetheless, the large number of sightings of Steller sea lions outside of critical habitat throughout the year, particularly in the eastern Bering Sea, suggests that this “outside” area is widely used by animals seeking forage.

Telemetry studies

Telemetry studies suggest that foraging distributions vary by individual, size or age, season, site, and reproductive status (Merrick and Loughlin 1997; NMFS unpublished data). NMFS has deployed 80 satellite-linked recorders since June 1990 from Puget Sound to the Kuril Islands. Unfortunately reliable data were available from only 53 of the 80 units. Some failed completely or provided questionable data, others fell off the animal prematurely. A summary of the number of deployments, sex and age, location and history of the deployments is summarized in Table 4.3. NMML has analyzed and published results for many of the early studies (e.g., Merrick and Loughlin 1997). Those reports have served as the basis for much of our understanding of Steller sea lion foraging ecology.

The range of deployment for the 80 SLTDRs ranges from 1 to 121 days with a mean of 37 days. Many of the early deployments failed because the epoxy got too hot and chemically burned the attachment fur; it took some experimentation to develop the correct mixture and brand of attachment epoxy. Recent deployments use a cooler-setting epoxy and the units are about 1/4 the size of the first units so deployments tend to last longer. However, Steller sea lion fur is quite brittle, when compared to other pinnipeds (e.g. northern fur seals) and deployments are much briefer. It is not uncommon for an instrument to stay on a fur seal for 3-8 months, where 3 months on a sea lion is considered a success. Experimentation with alternate epoxies and attachment methods continues.

The early deployments emphasized adult females with pups during the breeding season simply because at the time those animals were most accessible and their status and foraging ecology were of prime interest. Since then, the scientific community has recognized the need to focus on young animals because they are likely the ones suffering most from increased mortality rates. Thus, emphasis presently is on animals less than 4 years old during fall through early spring for both NMFS and ADFG deployments.

Merrick and Loughlin (1997)

The foraging patterns of adult females, as described by Merrick and Loughlin (1997), differed during summer months when females were with pups versus winter periods when considerable individual variation was observed, but may be attributable to the lactation condition of the females. Trip duration for females (n = 14) in summer was approximately 18 to 25 hours. For five of those females that could be tracked, trip length averaged 17 km and they dove approximately 4.7 hours per day. For five females tracked in winter months, mean trip duration was 204 hours, mean trip length was 133 km, and they dove 5.3 hours per day. The patterns exhibited by females in winter varied considerably, from which the investigators inferred that two of them may still have been supporting a pup. Those two females continued to make relatively shorter trips (mean of 53 km over 18 hours) and dove 8.1 hours per day, whereas the other three ranged further, dove 3.5 hours per day, and spent up to 24 days at sea. Five winter young-of-the-year exhibited foraging patterns intermediate between summer and winter females in trip distance (mean of 30 km), but shorter in duration (mean of 15 hours), and with less effort devoted to diving (mean of 1.9 hours per day). Estimated home ranges (mean ± 1 SE) were 319 ± 61.9 km^2 for adult females in summer, 47,579 ± 26,704 km^2 for adult females in winter, and 9,196 ± 6799 km^2 for winter young-of-the-year. The sea lions used in Merrick and Loughlin's (1997) study were from the GOA (Sugarloaf Island, Latax Rocks, Marmot Island, Long Island, Chirikof Island, Atkins Island, and Pinnacle Rock), and the BSAI region (Ugamak Island and Akun Island). This information is, therefore, directly pertinent to the action areas for both the GOA and BSAI fisheries, although it is perhaps most relevant to the GOA action area.

In general, there is substantial individual variation in distance traveled by Steller sea lions. For adult females, the information currently available suggests that they remain within 20 nm during the breeding season, as well as other seasons if they are nursing a pup. Once the breeding season ends (late July/early August) this general pattern may change. However, we have extremely limited telemetry data from the fall (October to December) to support any hypothesis for that season. Since most of the animals instrumented have been either females or pups, the data may not accurately represent the male portion of the population, which are believed to be much more likely to disperse over larger areas. This hypothesis is based on the POP database and limited telemetry data available.

Critical habitat

Based on the foraging distribution of Steller sea lions, NMFS designated critical habitat for the species on August 27, 1993 (58 FR 45269) . NMFS used both observations and incidental take of Steller sea lions to determine the appropriate area to list as critical habitat under the ESA (Loughlin and Nelson 1986, Perez and Loughlin 1991). The critical habitat boundary was not intended to include the entire geographic area used by foraging Steller sea lions. As required by the ESA, critical habitat must include only those areas necessary for the conservation of the species. When designating critical habitat in 1993, NMFS acknowledged that "other aquatic habitats within their range are essential to Steller sea lions for foraging." Three relatively large foraging areas were also listed as critical habitat in addition to the 20 nm boundaries around listed rookeries and haulouts (i.e., Seguam Pass, the Bogoslof Foraging Area in the southeastern Bering Sea, and Shelikof Strait Foraging Area).

Additionally, after the jeopardy Biological Opinion in 1998, for the BSAI and GOA pollock fisheries, NMFS took steps under the RFRPAs to protect foraging areas not previously listed as critical habitat (i.e., other non-listed haulouts). Presently, NMFS requires protection of core habitat areas in order to conserve listed species, but also allows for protection, generally at lesser degrees, outside of critical habitat. The goal of the ESA is to promote the recovery of listed species; therefore, such protections as implemented under the RFRPAs are consistent with the Act. Given the hypothesis that the population of Steller sea lions relies less upon areas outside of critical habitat for foraging, NMFS is likely to continue with less stringent protection measures outside of critical habitat. This does not mean that these areas outside of critical habitat are unimportant to Steller sea lions.

Overall, the available data suggest two types of foraging patterns: 1) foraging around rookeries and haulouts that is crucial for adult females with pups, pups, and juveniles, and 2) foraging that may occur over much larger areas where these and other animals may range to find the optimal foraging conditions once they are no longer tied to rookeries and haulouts for reproductive or survival purposes.

4.8.6.3 Foraging depths

In the discussion above in section 4.8.6.2 (Telemetry studies), we described the available data for location of Steller sea lions based on telemetry studies. Additional to the location information, the instruments also recorded time and depth. Over the years the transmitters have changed in size, data storage capabilities, and transmission power resulting in differences in the type and quality of data received. However, all provide information on dive depth and duration, the animal's location and the duration of time spent at sea and on land (e.g., Merrick et al. 1994, Merrick and Loughlin 1997, Loughlin et al 1998). A full description of the earlier units and their capabilities is in Merrick et al. (1994). The polar-orbiting satellite tracking system (Argos) is described in detail in Stewart et al. (1989). The SLTDRs record all dives and then summarize the data into a histogram plot prior to transmission. Time-depth recorders that require recapture of the animal and removal of the instrument were not an option because researchers were unable to revisit the rookery sites for recapture. The instruments were not recovered and were expected to be shed at or before the fall molt.

The SLTDR stored, summarized, and transmitted dive data as histograms. Software programming of the SLTDR required that each day be subdivided into four 6-h periods (2100-0300 hrs, 0300-0900 hrs, 0900-1500 hrs, 1500-2100 hrs local time). Histograms were separately summarized for dive depth and duration for each of the four time periods. The SLTDRs were programmed to record dive information into six separate bins (eight in the more recent versions). The dive-depth bins were 4-10 m, 10-20 m, 20-50 m, 50-100 m, 100-250 m, and >250 m.

NMML uses 4 m as the minimum depth for a dive based on Merrick et al. (1994). Dive-duration bins were 0-60 sec, 60-120 sec, 120-240 sec, 240-480 sec, 480-960 sec, and >960 sec. Locations were estimated based on the Service-Argos classification scheme where class 3 is accurate to 150 m, class 2 to 350 m, class 1 to 1 km, and class 0, A, and B have no accuracy assigned. All location data are used to estimate location but estimated trip distance uses all but class 0, A, and B. Trip distance was estimated for individual trips as the straight-line distance from the capture site to the farthest location offshore.

The information is collected and stored in the unit until the animal surfaces for a preset amount of time; a salt water switch on the unit turns it off and off when submerged or on the surface. Depending on the position of the Argos satellite at the time the animal surfaces, all or portions of the stored information is transmitted to the satellite; the information is then sent to land-based stations where it is collated and available to the user. The transmitted information contains dive data as described above; locations at sea are determined from the Doppler shift of the frequencies of a series of signals received by the satellite. If the satellite is directly overhead and the animal surfaces for a few seconds, then two or more quality hits are obtained and good location data are available along with the transmitted dive data. However, Steller sea lions often surface for only short periods, or when surfacing the satellite is not overhead, resulting in no transmission or poor quality location information and partial transmission of dive data. Dive data that are not transmitted while at sea are stored until the animal is on land or is dumped in favor of more recently collected data.

The sea lions in the Merrick and Loughlin (1997) study tended to make relatively shallow dives, with few dives recorded at greater than 250 m (Fig. 4.3). Maximum depth recorded for each of the five summer adult females was in the range from 100 to 250 m, and maximum depth for the five winter adult females was greater than 250 m. The maximum depth measured for winter young-of-the-year was 72 m. These results suggest that sea lions are generally shallow divers, but are capable of deeper dives (i.e., greater than 250 m).

The instruments used to record diving depths do not determine the purpose of a dive, and many of the recorded dives (Fig. 4.3) may not be indicative of foraging effort. Dives between 4 and 10 m depth may be for foraging, or they may be related to other behaviors such as social interactions or transiting between locations. For example, animals transiting to and from foraging locations during rough sea surface conditions may transit in a series of long, shallow dives to avoid such conditions. The relatively large number of dives recorded between 4 and 10 m may therefore bias the assessment of “foraging” depths for these sea lions.

The results from this study also may not be indicative of diving depths and patterns for other sea lions at other times of year or in other locations. The winter young-of-the-year were instrumented in the period from November to March, when they were about five to nine months old and may have still been nursing. At this age, they are just beginning to develop foraging skills. The diving depths and patterns exhibited by these young-of-the-year are not indicators of the foraging patterns of older juveniles (one- to three-year-olds). For example, Swain and Calkins (1997) report dives of a 2-year-old male sea lion to 252 m, and regular dives of this animal and a yearling female to 150 m to 250 m (Fig. 4.4). Clearly, if young-of-the-year are limited to relatively shallow depths, and older animals are capable of diving to much greater depths, then those younger animals are just beginning to develop the diving and foraging skills necessary to survive. The rate at which they develop those skills and begin to dive to greater depths or take prey at greater depths is unknown, but probably occurs rapidly after weaning to take advantage of otherwise unavailable prey resources. ADFG is currently studying the ontogeny of dive behavior in young Steller sea lions.

4.8.6.4 Prey species

Historically, pinniped diet studies were based on the remains of prey in stomach contents. Stomach contents have been collected from Steller sea lions (*Eumetopias jubatus*) killed or found dead on rookeries, haulout sites and at sea from the North Pacific Coast, the Gulf of Alaska and the Aleutian Islands since 1902. Early studies contained primarily narrative summaries of prey occurrence but reported little quantitative information on prey occurrence (Table 4.2). As early as the late 1950's, some studies used the percent frequency of occurrence as a comparative measure of the incidence of prey species in the stomachs of Steller sea lions. To summarize historical information on the prey of Steller sea lions, based on stomach contents, data on the occurrence of prey taxa from ten studies conducted between 1956 and 1986 were pooled. Comparisons of prey species consumed were made between the eastern and western range of sea lions and between the 1950-90's (Table 4.2).

Stomach analyses

Percent frequency of occurrence was calculated from a pooled sample of 781 stomachs containing prey remains (Figure 4.5, Table 4.4). Gadids increased both in the eastern and western stocks from the 1950's through 1970s and the 1980s. Pollock accounted for much of the increase in Gadids in both the eastern and western regions. Pacific cod and flatfish also increased in both regions while cephalopods showed a slight decrease in both regions between the two time periods. Other demersal fish may have decreased in the 1980s, however, this could be due to a small sample size (n = 14) in the eastern region. In the western region, capelin (6.3% to 0%) and sandlance (4.8% to 2.8%) decreased from the early period to the 1980s, although small forage fish as a whole increased during this time period primarily due to an increase in Pacific herring (4.1% to 7.9%).

Scat analyses

Currently, the primary method of identifying prey species consumed by pinnipeds is through analysis of bony remains in scat (fecal) collections. The interpretation of predator diet through the use of scat was first developed for terrestrial studies and has been adapted for use in marine mammal trophic studies over the past two decades. All methods of diet evaluation in marine mammals have their own set of biases. For instance, stomach contents from an individual animal may represent an accumulation of a number of meals over an extended period of time since certain prey parts such as squid beaks or large fish bones get trapped in stomach folds where they digest very slowly, or accumulate until regurgitated. The scat remains from that same animal however, typically represent meals eaten 12 - 72 hours prior and tend to underepresent the size of prey consumed since small items pass through the digestive tract much more readily than large items. A recent analysis of prey remains from stomachs and colons of northern fur seals (Sinclair, unpubl. analyses) illustrates the potential bias in basing diet studies on either stomachs or scats alone. Scat is a valuable tool for quantifying trends in predator diets, but is limited in terms of discrete evaluation of absolute volumes or biomass of prey eaten. Nonetheless, scat is a reliable tool for monitoring seasonal and temporal trends in predator diets and eliminates the need to euthenize the animal.

The relative "importance" of an individual prey species in the diet of Steller sea lions is based on the number of scats that contain that prey species and is referred to as "percent frequency of occurrence" (%FO), or "percent occurrence". The FO is calculated by dividing the number of scats in which a prey item occurred by the total number of scats that contained identifiable prey.

The scat data were analyzed site by site across the Gulf of Alaska and Aleutian Islands. Then for comparative purposes, rookery and haulout sites were grouped into regions based on population trends (York et al. 1996): (i) western Gulf of Alaska (WGOA); (ii) eastern Gulf of Alaska (EGOA); (iii) eastern Aleutian Islands (EAI); (iv) western Aleutian Islands (WAI). The data were also compared seasonally: December - April collections (winter); May - September collections (summer). FO was then calculated for each species within each region-season grouping.

Prey species and relative importance to Steller sea lions

A total of 3,852 scats collected between 1990 and 1998 contained identifiable prey remains. Of those scats, 2,168 were collected between May and September (summer) and 1,684 were collected between December and April (winter). Winter scat collections occurred only after 1993.

Year-round, all regions combined, walleye pollock and Atka mackerel are the two dominant prey followed by Pacific salmon (Salmonidae) and Pacific cod (Fig. 4.6). The occurrence of walleye pollock is highest in the Gulf of Alaska and eastern Aleutian Islands, becoming less important moving west along the Aleutian Islands chain where it is replaced by Atka mackerel.

When FO is examined seasonally by region, several trends appear (Table 4.5). Pacific cod consumption is highest during winter months within the Gulf of Alaska area (FO = 29%, CGOA; FO = 37%, WGOA). Pacific cod also occurs during summer months, but at lower frequencies overall. In contrast, the FO values for salmon range between 34 - 46% in the eastern regions (CGOA,WGOA and EAI) during summer months, decreasing to 10 - 18% FO during the winter. The occurrences of Pacific sand lance (*Ammodytes hexapterus*) and Pacific herring (*Clupea pallasi*) are also highest in the eastern regions however, frequencies of occurrence values are comparable between winter and summer. Arrowtooth flounder (*Atheresthes stomias*) is most prevalent in scats in the CGOA region (winter FO = 20.4; summer FO = 35.1) and cephalopods (squid and octopus) are most prevalent in the CAI region (winter FO = 13.1; summer FO = 21.8).

Inter-island comparisons of diet on a seasonal basis demonstrates that some "minor" prey species have consistently high FO values on particular islands, yet when FO values are averaged across a region these same species may not rank among the top prey (Fig. 4.7). Examples of fish species occurring among the top three prey items only on select islands during winter include: snailfish (Liparididae) on Atkins and Sequam islands; rock greenling (*Hexagrammos lagocephalus*) on Ulak Island; kelp greenling (*Hexagrammos decagrammus*) on Adugak Island; sandfish (*Trichodon trichodon*) on Ugamak Island; and rock sole (*Lepidopsetta bilineata*) on Clubbing Rocks. Species occurring among the top three prey only on specific islands during the summer include: sandlance (*Ammodytes hexapterus*) on Atkins and nearby Pinnacle Rocks; and northern smoothtongue (*Leuroglossus schmidti*) on Bogoslof Island (data are, however, limited to summer only on Bogoslof). Relative values among the primary prey species also demonstrates wide variation in relative importance between islands. Pacific cod, for instance is a significant prey item during the winter in the Gulf of Alaska, however percent FO values range as low as 0 and as high as 62 between sites there (Fig. 4.7).

The current diet of Steller sea lions based on year-round scat collections from the Gulf of Alaska and Aleutian Island rookeries consists primarily of groundfish species walleye pollock, Atka mackerel, and Pacific cod. Other groups that are important overall include the flatfishes (Pleuronectidae) and sculpins (Cottidae), pelagic salmonidae, and cephalopods. Other species such as sand lance and herring are present in the overall diet, but currently occur at relatively low frequencies overall. When seasonal and spatial patterns are taken into account, the importance of still other prey species, as measured by their frequencies of occurrence, becomes apparent. Seemingly minor prey species may play a very important role in the foraging success of regional populations of Steller sea lions and their young.

The results of this analysis differ significantly from those conducted prior to the mid-1970s. Studies conducted in the Gulf of Alaska between 1958 and 1968 did not identify pollock as a significant component of Steller sea lion diet (Mathisen et al., 1962; Thorsteinson and Lensink, 1962; Fiscus and Baines, 1966). The most common prey items in these earlier studies included: cephalopods, greenlings (Hexagrammidae), rockfishes, smelts, capelin, and sand lance. Capelin, which were important in Steller sea lion diet through the 1970's (Fiscus and Baines, 1966; Pitcher, 1981) do not have an occurrence greater than 5% in this study. Salmon was present in early studies but, not at the frequencies found across the range during the summer in this study. The occurrence of flatfish, especially arrowtooth flounder, in the CGOA region is substantially higher in this study than any previous studies have shown. Cephalopods were among the top prey items found in Steller stomachs in many early studies (Mathisen et al., 1962; Thorsteinson and Lensink, 1962; Pitcher, 1981; Merrick and Calkins, 1996) sometimes ranking as the most frequently occurring prey item (Fiscus and Baines, 1966). Cephalopod occurrence was primarily limited to the CAI and WAI regions and highest during the summer months, but never reached the high frequencies of the 1960s.

The high occurrence of pollock in the diet in this study is comparable to diet studies conducted between 1975 and 1993 (Pitcher, 1981; Merrick & Calkins, 1996; Merrick et al., 1997). This study also highlights the importance of Pacific cod in Steller sea lion diet during the winter months. Prior to this work, relatively few papers have focused on winter diet, so it is difficult to assess whether this is a recent trend. Pacific cod was shown to be a top prey item (FO =12%) in stomachs collected in the Gulf of Alaska 1973 - 1975 (Pitcher, 1981).

Prey size

Prey size was initially estimated based on subjective comparisons with museum reference collections. In order to quantify prey body size, special studies were conducted for each of the three primary prey species; Pacific cod (*Gadus macrocephalus*), Atka mackerel *(Pleurogrammus monopterygius*) and walleye pollock (*Theragra chalcogramma*). NMFS has previously developed a summary of studies used to develop regression analyses to quantify the body size of Pacific cod, Atka mackerel, and walleye pollock. Regression formulae were then developed based on a size-stratified series of selected bones. Ultimately, up to five measurable bone types providing a high degree of correlation with total fish length (r^2 ranging 0.966 - 0.990) were selected for each species. The 10 year database was then re-analyzed with application of these new techniques. The results of these studies indicate that there is an overlap between the size of prey consumed by Steller sea lions and the size of the fish taken by the commercial fisheries although the extent of overlap could not be quantified in a manner that resulted in a precise statement of overlap other than it does occur.

4.8.6.5 Prey availability and foraging success

The foraging success of a sea lion clearly depends on the availability of prey. For a given sea lion, the availability of prey is determined by, among other things, the types of prey within the foraging distribution of the sea lion, their standing biomasses, their characteristics, and their spatial and temporal distributions. The diversity of prey selected by sea lions may also be a determinant of their foraging success.

Prey species or types

A description of the prey species for Steller sea lions is described above in section 4.8.6.4.

Prey biomasses

Total prey biomass is determined by the sum of the biomasses of each different prey type in the foraging distribution of a sea lion. For any particular prey type, available biomass changes as a function of reproduction and recruitment, and physical growth of individual prey. Biomass decreases as a function of natural and fisheries mortality, and as a function of life history events such as spawning. At present, our best estimates of prey biomasses are derived from surveys of groundfish stocks. These surveys generally provide “global” as opposed to “local” estimates of biomass at a given point in time (summer) for large areas such as the eastern Bering Sea shelf or the GOA. Although some efforts are now being made to derive prey biomass estimates at seasonal scales inside and outside of critical habitat (NMFS 2000, in Appendix 3).

Prey characteristics

Examples of important prey characteristics include tissue or body composition, individual size (mass), depth in the water column, degree of association with the bottom, and reproductive physiology and behavior. Body composition determines the relative nutritional and energetic value of a particular prey type, and individual prey size will determine the absolute gain in nutrients and energy from predation on that prey (and whether such predation is feasible). Depth in the water column determines whether the prey is accessible to sea lions. Degree of association with the bottom may determine the vulnerability of prey to sea lions, and the type of foraging strategy (or behavior) necessary for capturing such demersal prey. Reproductive physiology may determine prey condition and nutritional value (e.g., pollock ripe with roe must be more valuable to sea lions than pollock spent after the reproductive season). Taken together, these (and other) characteristics determine the complicated and poorly understood predator-prey dynamics of Steller sea lions and their fish prey which, in turn, determine the foraging success of sea lions.

Spatial and temporal distributions

The spatial and temporal distributions of prey types also must be a critical determinant of their availability to sea lions. Many sea lion prey (Atka mackerel, cod, herring, pollock, and salmon) occur in patchily distributed aggregations, particularly for reproduction. Important patch characteristics may include their size, location, persistence, composition (e.g., prey sizes), density (number of patches per area), and seasonality. Sea lions may alter their foraging strategy as different prey species aggregate for reproduction or other purposes, filling the interim periods with the best available prey. That is, they may exhibit pulses in foraging that allow them to take advantage of the seasonal changes in availability of schools of Atka mackerel, cod, herring, pollock, salmon, and other prey. These seasonal pulses may be essential for regaining good condition or preparation for periods when desirable prey are less available and less desirable prey must constitute the staple of their diet. Unfortunately, the information available to characterize such prey patches and evaluate their potential importance to sea lions is limited. For many species (e.g., pollock, cod), the available information is limited to trawl and hydroacoustic surveys that generally provide a single broad-scale snapshot of prey distribution on an annual or less frequent basis.

Prey diversity

The quality of the sea lion diet may be determined not only by the individual components (species) of the diet, but also by the mix or diversity of prey in the diet. Merrick et al. (1997) found a correlation between a measure of diet diversity in different geographic regions of the western population and population trends in those regions. Their conclusions were that reliance on a single prey type may not be conducive to population growth; a diversity of prey may be necessary for recovery of the western population. Trites (unpubl. data) evaluated the diet and population growth data for Steller sea lions in southeast Alaska and found results consistent with those of Merrick et al. (1997). However, diet diversity is a function not only of prey selection, but of the diversity of prey available. To the extent that pollock or Atka mackerel currently dominate the prey field, sea lions survive on those prey. In addition, the analysis reported by Merrick et al. (1997) and Trites did not account for the confounding factor that species diversity of marine fish may decline from the eastern Gulf of Alaska to the western Aleutians. This is an important caveat that remains to be fully analyzed.

4.8.6.6 Foraging - integration and synthesis

While much remains to be learned about Steller sea lions, the available information is sufficient to begin a description of their foraging patterns. The emerging picture appears to be that:

- Steller sea lions are land-based predators but their attachment to land and foraging patterns/distribution may vary considerably as a function of age, sex, site, season, reproductive status, prey availability, and environmental conditions;

- foraging sites relatively close to rookeries may be particularly important during the reproductive season when lactating females are limited by the nutritional requirements of their pups;

- Steller sea lions appear to be relatively shallow divers but are capable of (and apparently do) exploit deeper waters (e.g., to beyond the shelf break);

- at present, pollock and Atka mackerel appear to be their most common or dominant prey, but Steller sea lions consume a variety of demersal, semi-demersal, and pelagic prey;

- the availability of prey to an individual sea lion is determined by a range of factors, including prey types within the foraging distribution of the sea lion, total prey biomass, characteristics of the different prey types, and their spatial and temporal distributions;

- diet diversity may also be an important determinant of foraging success and growth of Steller sea lion populations; and

- the broad distribution of sea lions sighted in the POP database indicates that sea lions forage at sites distant from rookeries and haulouts; the availability of prey at these sites may be crucial in that they allow sea lions to take advantage of distant food sources, thereby mitigating the potential for intraspecific competition for prey in the vicinity of rookeries and haulouts.

The question of whether competition exists between the Steller sea lion and BSAI or GOA groundfish fisheries is a question of sea lion foraging success. For a foraging sea lion, the net gain in energy and nutrients is determined, in part, by the availability of prey or prey patches it encounters within its foraging distribution. Competition occurs if the fisheries reduce the availability of prey to the extent that sea lion condition, growth, reproduction, or survival are diminished, and population recovery is impeded. The question of whether competition occurs will be addressed in the Effects of the Action, Section 6.

4.8.7 Physiology

Studies of Steller sea lion physiology were initiated in the early 1990s in an effort to determine causes for the observed declines and to provide indices of sea lion health. These studies were designed to compare populations in decline areas to stable areas as well as to initiate captive studies to form a baseline of physiological functions. An additional suite of captive studies have sought to explore the nutritional limitation hypothesis by examining nutritional physiology. A summary of these studies follow, part of which is excerpted from a Steller Sea Lion Recovery Team sponsored workshop on physiology held in Seattle, Washington, on February 8-10, 1999.

4.8.7.1 Captive studies

The Steller sea lion captive research program at the University of British Columbia uses a bioenergetic paradigm to empirically test hypotheses related to the population decline. Various studies have examined the effect of prey type and intake rate on assimilative and digestive efficiencies, body mass, metabolic rates, and the heat increment of feeding (Rosen and Trites 1997, 1999, 2000a, 2000b), and other studies examined the metabolic effect of fasting (Rea et al. 2000). Growth data, including body mass, multiple girth measurements, body length, and blubber depth have been collected to document growth patterns, compose energy budgets, and to evaluate the accuracy of using condition indices with wild sea lions.

Measurements of resting metabolism suggests a rapid decrease in mass-corrected metabolism within the pup's first year, followed by a much more gradual decrease. This latter period is characterized by increasing seasonal variation associated with changes in food intake and activity, and critical life history phases (breeding and molting periods). Controlled fasting experiments were conducted on captive Steller sea lion pups and juveniles to determine if sea lions exhibit biochemical adaptation to fasting, and to determine if blood chemistry profiles can be reliably used to judge nutritional condition of free-ranging Steller sea lions. These studies suggest an age-related difference in how body reserves are utilized during fasting or how the resulting products are circulated and used (Rea et al . 1998b; 2000). Four Steller sea lion pups were fasted for 2.5 days to determine how pups mobilize energy reserves during short periods of fasting similar to those experienced in the wild. Six-week-old Steller sea lion pups showed evidence of rapid metabolic adaptation to fasting but were not able to sustain a protein-sparing metabolism for a prolonged period at this age. These data suggest that pups were reverting to protein metabolism after only 2.5 days of fasting, which infers a decrease in lipid catabolism possibly due to depletion of available lipid resources.

To calculate the net energy available from different meal types and sizes, the heat increment of feeding (HIF) and digestive (and assimilation) efficiency have been measured (see also Fadely et al. 1994 for similar studies on California sea lions). Digestive efficiencies were found to be positively related to prey energy content (Rosen and Trites 2000a), but unrelated to meal size or feeding frequency (Rosen et al. 2000). For similarly sized meals, the energy lost through HIF (as a percent of gross energy intake) was 11.9% for herring, 15.7% for pollock, and 19.4% for squid (Rosen and Trites 1997, 1999), and increased with meal size (Rosen and Trites 1997). The results indicate that the net energy difference in prey items is greater than that calculated solely from gross energy density measurements (Rosen and Trites 2000b).

Short-term diet switches (2-3 weeks) from herring to a lower energy density prey (salmon, squid, pollock) have also been carried out (Rosen and Trites, 2000b). Despite being fed ad libitum, the sea lions failed to significantly increase ingested food mass when eating the lower energy diet, resulting in significantly lower gross energy intakes and increased body mass loss (-1.1 kg/d squid diet, - 0.6 kg/d pollock diet). Concurrent with the loss in body mass was progressive metabolic depression indicating that the animal was entering a physiological state of increased energy conservation. These metabolic adjustments were also seen in experimentally fasted sea lions (Rea et al. 2000). A similar diet study at the Alaska Sea Life Center is currently attempting to extend this short-term diet study by examining the effects of varying diet on sea lion health over an annual time frame and by using a diet regime more closely linked to the sea lion diet in the Gulf of Alaska.

4.8.7.2 Free-ranging studies

Body condition, blood chemistry and hematology have been examined in over 200 free-ranging Steller sea lion pups to test the hypothesis that pups less than one month of age were nutritionally or physiologically compromised such that they may be unable to survive the nursing period. The results of these studies suggest that blood chemistry and body morphology show no indication that sea lions less than one month of age from areas of population decline were nutritionally compromised (Rea et al.1998).

Biochemical and physiological profiles also have been used to assess nutritional status and body condition (M.A. Castellini, Institute of Marine Science, University of Alaska Fairbanks, unpublished data). The study attempted to apply models of mammalian fasting and starvation to compare Steller sea lions from declining and stable populations using morphometrics and blood chemistry. By these measures, animals from the declining population were expected to be both distinct and compromised. Measurements of body girth and length were taken, and body mass was projected using the volumetric methods. Hematocrit, percentage body water, and a variety of blood chemistry parameters were measured from animals sampled during the breeding season. For comparison, blood chemistry profiles were also obtained from three captive juvenile sea lions. Results did not match expectations. Animals from the western population were generally rounder, longer, and heavier. Body water percentages were significantly lower for the western group, implying the presence of more body fat. Hematocrit values were not significantly different. Similarly, blood chemistry values did not provide evidence of nutritional stress, especially when compared with captive animals, for sea lions during the breeding season. However, Zenteno-Savin et al. (1997) did find elevated plasma concentrations of haptoglobin (an acute phase protein that increases in concentration in response to chronic stress) in sea lions sampled from the Aleutian Islands, Gulf of Alaska and Prince William Sound relative to those sampled from Southeast Alaska or captivity.

Studies to assess maternal investment and energy metabolism of lactating females and pups have been conducted by researchers at Texas A&M University. These studies attempted to compare milk and energy intake rates for pups in areas of decline with those in a stable population. Between 1991 and 1997, blood samples were obtained from 40 newborn pups at five rookeries. The results of this study showed no significant differences in milk or energy intake among declining or stable populations. She concluded that in early lactation when the pup's mass is small relative to maternal mass, a lactating female's ability to adequately provision her young may not be influenced by prey availability unless she experiences severe malnutrition. However, the capacity of lactating females to "buffer" their young by mobilizing body reserves into milk is limited and as the energetic demands of the pup increase, females will need to increase food intake. During mid to late lactation, when the milk consumption by the pup is at a peak, females may be unable to adequately provision their offspring if they do not have access to sufficient prey. Interestingly, the milk content of lactating females from declining and stable Steller sea lion populations was also examined and found no significant differences among locations in any milk component except protein, which may be explained by the small sample sizes.

Another important component of Steller sea lion physiology is their ability to regulate body temperatures in both aquatic and terrestrial environments (thermoregulation) which has been studied by T. Williams at the University of California, Santa Cruz. Steller sea lions are highly specialized mammals that spend much of their lives at sea. To counterbalance the high thermal conductivity of water, Steller sea lions, like many marine mammals, have developed a thick insulating blubber layer that encases the body. Maintenance of this insulating layer depends on an appropriate diet for the deposition of lipids that comprise the blubber. Williams' study compared thermal profiles and quality of insulation for Steller sea lions from declining (Chirikof Island, Aleutian Islands, Marmot Island) and stable (Lowrie Island) populations in Alaska. Preliminary results suggest that blubber thickness in adult females is comparatively lower for animals in the declining areas. Pups showed similar trends for blubber thickness; however, differences in heat flow and insulation quality between the areas of decline and stability were not as distinct as observed for the adults. These results indicate subtle differences in insulation between Steller populations. Interestingly, these differences were not apparent with courser morphological measurements such as length-girth relationships and body mass.

4.8.7.3 Direction for physiological studies

The review panel convened by the Steller Sea Lion Recovery Team provided recommendations for future physiological efforts on Steller sea lions. These recommendations included development of a research framework under which the recovery of Steller sea lions can be considered in a broader ecological context, including the development of a multidisciplinary bioenergetics model. The panel also suggested that the NMFS Steller sea lion research coordinator implement both a Strategic Plan for research and an external peer review process for that plan to provide better coordination and accountability for Steller sea lion research. The panel felt that it was now time to move into a phase of more manipulative experimental designs involving free-ranging Steller sea lions. In this context, it was felt important to reconcile what researchers can do now with what they should be doing in the future to promote Steller sea lion recovery. Although initial studies have been completed, the panel recommended investigations into the responses of Steller sea lions to starvation and limited diets using physiological studies on captive animals. The panel also felt that improved imaging technology may enhance age structure analysis of populations, and lastly, the panel highly recommended the development of a reliable, inexpensive index of body condition. Body composition (protein + fat) is the best measure of body condition, but it is also the most expensive to measure. Pitcher et al. (unpubl) evaluated various morphometric measures as indices of fatness for Steller sea lions, and found that, though such indices could account for up to 75% of the variation in sea lion fatness and were useful for population-level comparisons, such indices were not adequate to evaluate the condition of an individual. A quick and reliable way to assess condition is required. Both NMFS, ADFG, and other parties are presently addressing this and the other recommendations provided by the review panel.

Direct detection of stressed or nutritionally limited individual sea lions in the wild is difficult. Though thousands of mortalities occur annually, very few carcasses are found to necropsy, precluding a direct determination of cause of death. Also, animals breeding at rookeries (and thus available for sampling) are perhaps less likely to be in poor health since they are in sufficient condition to attempt territorial defense (males) or carry a pup to term (females). This does not mean, however, that differences in condition between entire populations or areas can not be detected using health and body condition methods, as such differences have been detected between areas and over time (Calkins et al. 1998).

According to the York (1994) model, only a 10-20% change in juvenile survival is required to account for the decline. Since there may then only be a small increase in post-weaned juvenile mortality, the statistical power to differentiate these potentially compromised individuals from the ‘normal’ population is uncertain. Because only a relatively few individuals may be compromised, the likelihood of sampling one from the general population is low. The likelihood of detecting a compromised animal if one were to be sampled must also be considered. Blood chemistry profiling and body condition measurements can detect severely or clinically compromised animals, and can also be useful for broad spatial or temporal comparisons. Though subclinical differences in health or condition can be detected, the relationship between these indices and fecundity or survival has not been quantified. Pitcher et al. (unpubl) found that body condition was positively related to the probability that a female would be pregnant during late gestation.

4.8.8 Natural predators

The Recovery Plan for the Steller Sea Lion (NMFS 1992) states: “Steller sea lions are probably eaten by killer whales and sharks, but the possible impact of these predators is unknown. The occurrence of shark predation on other North Pacific pinnipeds has been documented, but not well quantified (Ainley et al., 1981).” A major increase in sharks in the GOA has been documented in recent years. Killer whales are likely predators in the waters of British Columbia and Alaska (Frost et al. 1992; Barrett-Lennard et al., unpubl. rep.). Regarding predation by killer whales on Steller sea lions, Frost et al. (1992) reported that an unusual number of killer whales appeared inshore in waters of the southeastern Bering Sea in the summers of 1989 and 1990. Multiple sightings of killer whales were reported from Bristol Bay and the Kuskokwim Bay, where killer whales had been seen only rarely in previous years. Of the 27 reported sightings in 1989 and 1990, one sighting of 4 whales near Round Island involved chasing of a Steller sea lion. A more detailed discussion on the impacts of killer whale predation on Steller sea lions is presented in the Baseline (see section 5.2).

4.8.9 Natural competitors

Competition may take several forms. For exploitative competition to occur, the potential competitors must use the same resource, the availability of that resource must be limited relative to the needs of at least one of the potential competitors, and use of the available resource by one competitor must impede availability to the other, to its detriment (Krebs 1985). Interference competition can occur even when resources are not limited if the use of the resource by one potential competitor harms another. With respect to other (nonhuman) species, Steller sea lions are most likely to compete for food, although they may also compete for habitat (e.g., potential competition with northern fur seals for rookery or haulout space).

Steller sea lions forage on a variety of marine prey that are also consumed by other marine mammals (e.g., northern fur seals, harbor seals, humpback whales), marine birds (e.g., murres and kittiwakes), and marine fishes (e.g., pollock, cod, arrowtooth flounder). To some extent, these potential competitors may partition the prey resource so that little direct competition occurs. For example, harbor seals and northern fur seals may consume smaller pollock than Steller sea lions (Fritz et al. 1995). Competition may still occur if the consumption of smaller pollock limits the eventual biomass of larger pollock for sea lions, but the connection would be difficult to demonstrate. Such competition may occur only seasonally if, for example, fur seals migrate out of the area of competition in the winter and spring months. Similarly, competition may occur only locally if prey availability or prey selection varies geographically for either potential competitor. Finally, competition between sea lions and other predators may be restricted to certain age classes, as diet may change with age or size.

4.8.10 Disease

Parasites known to infect sea lions include cestodes of the genera *Diplogonoporus*, *Diphyllobothrium*, *Anophryocephalus*, *Adenocephalus*, and *Pyramicocephalus*; trematodes of the genera *Pricetrema*, *Zalophotrema*, and *Phocitrema*; acanthocephalans of the genera *Bulbosoma* and *Corynosoma*; and nematodes of the genera *Anisakis*, *Contracaecum*, *Parafilaroides*, *Uncinaria*, and *Phocanema* (Hill 1968, Dailey and Brownell 1972, Daily 1975, Fay *et al*. 1978, Geraci 1979, Dieterich 1981, Hoover 1988). In addition, Thorsteinson and Lensink (1962) reported two types of parasites: Body louse (*Antarctophthirus michrochir*) severely infesting pups and nose mites *(Orthohalarachne diminuta*) invariably found on adults. And Scheffer (1946) reported ascarid worms (*Porocaecum decipiens*) nearly always found in adult stomachs.

Sea lion exposure to disease has been documented by evidence of leptospirosis (Fay et al. 1978), chlamydiosis (Goodwin and Calkins 1985), and San Miguel sea lion virus (Goodwin and Calkins 1985, Barlough et al. 1987). Barlough et al. (1987) also present evidence of eight types of calici virus (including seven types of San Miguel sea lion virus and Tillamook [bovine] virus). And recent tests, indicate exposure to brucellosis (pers. comm., K. Pitcher, ADFG). Disease may have contributed to the high fetal mortality rate observed in animals collected in 1975–1978 and 1985–1986 (Pitcher et al. in review) but, again, that hypothesis is not substantiated by available data.

While a range of different parasites, diseases, and maladies have been documented for Steller sea lions, the available evidence is not sufficient to demonstrate that these have played or are playing any significant part in the decline of the western population.

4.8.11 Population distribution

The breeding range of the Steller sea lion covers virtually all of the North Pacific Rim from about 34° N to 60°N lat. Within this range, sea lions are found in hundreds of rookeries and haulouts. These rookery and haulout sites can be grouped in rookery/haulout clusters on the basis of politics, geography, demographic patterns, genetics, foraging patterns, or other reasons related to scientific study or management. Political divisions are drawn to separate animals that are found off Japan or the Republic of Korea, in Russian territories, in Alaska, British Columbia, or along the western coast of Washington, Oregon, and California. These divisions are largely for the purpose of management or jurisdiction, but may be related to sea lion population dynamics because of differing management strategies or objectives.

Geographic distinctions are frequently made on the basis of variable habitat or ecosystem characteristics in differing parts of the range. For example, rookeries and haulouts in the Aleutian Islands are often separated from those in the GOA, and these two areas are again separated from southeastern Alaska and British Columbia. These distinctions may have demographic significance because of the important variability in ecosystem features such as prey resources.

Sea lion rookeries and haulouts are also grouped on the basis of observed demographic trends (York et al. 1996). Many, if not most, descriptions of the decline of Steller sea lions begin with the statement that the decline was first witnessed in the eastern Aleutian Islands in the mid 1970s and then spread westward to the central Aleutian Island and eastward to the western GOA in the late 1970s and early 1980s. Similarly, counts are frequently presented for the area from Kenai to Kiska Island, which is considered to enclose the center of abundance for the species. Genetic studies (Bickham et al. 1996, Loughlin 1997) provided the basis for distinguishing western and eastern management stocks of the sea lion, and additional work may allow further differentiation of stocks. The relation between diet diversity and population trend was studied using rookery groups identified by geographic location and rates of change. The rookery groups were those identified by York et al. (1996). These examples indicate that, depending on the purpose at hand, the total sea lion population may be split meaningfully into subpopulations in any number of ways.

However, if the purpose is to study or understand the natural (i.e., without human influence) population structure of the Steller sea lion, then the biogeography of the species must be defined more narrowly. Genetic studies may provide the best description of the result of biogeographic patterns, as they are likely the least influenced by human interaction. Demographic trends and foraging patterns may be influenced by human activities and, clearly, the artificial boundaries determined for political purposes should not have an influence on the natural biogeography of sea lions.

Natural factors that determine their biogeography include climate and oceanography, avoidance of predators, distribution and availability of prey, the reproductive strategy of the species, and movement patterns between sites. The marine habitat of the Steller sea lion tends to reduce variation in important environmental or climatic features, allowing the sea lion to disperse widely around the rim of the North Pacific Ocean. The decline of Steller sea lions off California may indicate a contraction in their range, depending on the explanation for that decline. Avoidance of terrestrial predators must clearly be an important factor, as rookeries and haulouts are virtually all located at sites inaccessible to such predators. Distribution and availability of prey are likely critical determinants of sea lion biogeography, and probably determine the extent of their dispersion during the non–reproductive season. The reproductive strategy of the species, on the other hand, requires aggregation at rookery sites, and therefore likely places important limits on the species' movement patterns and dispersion. Finally, movement patterns between sites determine, in part, the extent to which such groups of sea lions at different rookeries and haulout sites are demographically independent. Steller sea lions are generally not described as migrators. Adult males, for example, are described as dispersing widely during the non-reproductive seasons, and juveniles are described as dispersing widely after weaning and not returning to the reproductive site until they are approaching reproductive age (Calkins and Pitcher 1982).

4.8.12 Population Status and Trends

Assessments of the status and trends of Steller sea lion populations are based largely on (a) counts of nonpups (juveniles and adults) on rookeries and haulouts, and (b) counts of pups on rookeries in late June and early July. Both kinds of counts are indices of abundance, as they do not necessarily include every site where animals haul out, and they do not include animals that are in the water at the time of the counts. Population size can be estimated by standardizing the indices (e.g., with respect to date, sites counted, and counting method), by making certain assumptions regarding the ratio of animals present versus absent from a given site at the time of the count, and by correcting for the portion of sites counted. Population estimates from the 1950s and 1960s (e.g., Kenyon and Rice 1961; see also Trites and Larkin 1992, 1996) are used with caution because counting methods and dates were not standardized, and the results contain inconsistencies that indicate the possibility of considerable measurement error at some sites in some years. Efforts to standardize methods began in the 1970s (Braham *et al*. 1980); as a result, counts conducted since the late 1970s are the most reliable index of population status and trends.

For the western U.S. population (i.e., west of 144°W long.), index counts of adults and juveniles fell from 109,880 animals in the late 1970s to 22,223 animals in 1996, a decline of 80% (Fig. 4.8; Table 4.6; NMFS 1995, Strick et al. 1997, Strick et al. *in press*). In 2000, that number has further declined to 18,193 animals, an 18% decrease. In the GOA, from the late 1970s to 1996, index counts dropped from 40,042 to 9,789 (76%), and for the BSAI region dropped from 70,412 to 12,434 (82%). In the GOA, from 1996 to 2000, index counts dropped from 9,789 to 7,853 (20%), and for the BSAI region counts dropped from 12,434 to 10,340 (17%).

Counts in Russian territories (to the west of the action area for the BSAI and GOA groundfish fisheries) have also declined and are currently estimated to be about one-third of historic (i.e., 1960s) levels (NMFS 1992). Counts conducted in 1989, 1994, and 1999 indicate that the recent trends in counts in Russia may vary considerably by area (V. Burkanov, pers. comm.). Counts have increased in the northern part of the Sea of Okhotsk and at Sakhalin Island, but decreased at Kamchatka, Bering Island, and the northern half of the Kurils. Whether these changes were due to births and deaths, or immigration and emigration (i.e., a shift in distribution) is unknown. The data suggest that the number of pups born may have increased over the last ten years at 2.7% annually. The sum of the counts conducted in 1989, 1994, and 1999 has increased over the last ten years, but counts at repeated sites have decreased, indicating that trends in Russia can not yet be described with confidence. Nonetheless, relative to the 1960s, counts in Russia are depressed to a degree similar to that observed for the western population in the U.S.

For the western population, the number of animals lost appears to have been far greater from the late 1970s to the early 1990s. Nevertheless, the rate of decline in the 1990s has remained relatively high: the 1996 count was 27% lower than the count in 1990, and the 2000 count was 18% lower than in 1996. Review of counts by region also indicate a continued sharp rate of decline in some areas (Table 4.6). In the eastern GOA, 7,241 nonpups were counted in 1989 and 2,133 were counted in 1996 – a loss of 71%

over a 7-year period, which is equivalent to a loss of about 15% annually. In the central GOA, counts declined by 86% between 1976 and 1998; 55% from 1985 to 1989 (approximately 18% annually); and 61% from 1989 to 1998 (approximately 13% or more annually).

Counts of pups from the 2000 survey did not decline to the extent as nonpup counts. NMFS counted sea lion pups at four rookeries in the eastern Aleutian Islands (Yunaska, Adugak, Bogoslof, Akun) and five rookeries in the Gulf of Alaska (Pinnacle, Atkins, Chirikof, Outer I., and Fish I.) during 20 June to 6 July 2000. From 1998 to 2000, three rookeries decreased by a combined loss of 125 pups, two rookeries increased by a combined total of 47 pups, and four rookeries showed no change. For these areas, the numbers declined by about 3% to 4% between 1998 and 2000. However, the counters overall impression was of no appreciable change in pup counts at these sites over the past two years, and they considered the pups to appear relatively "healthy."

In addition, the portion of (non-pup) sea lions counted on rookeries versus haulouts appears to have declined considerably during the 1990s (Sease and Loughlin 1999, their Table 7). From 1998 to 2000, non-pup counts declined by 13.8% as an average of all sea lion sites (John Sease, personal communication, 2000) This decline could occur for a number of reasons: a decrease in reproductive rate for females, a decrease in number of males on the rookeries, a shift in the age distribution from relatively more mature animals to relatively fewer mature animals (such as might occur with greater juvenile survival), or a shift in the timing of reproduction relative to the timing of the counts.

For the eastern population (east of 144°W long.), counts of nonpups (adults and juveniles) have increased overall from just under 15,000 in 1982 to just over 20,000 in 1994 (Hill and DeMaster 1998). Counts of nonpups in California/Oregon were essentially unchanged from 1982 to 1996 at about 3,300. In California alone, the counts during this period represent a decline of over 50% since the first half of this century (NMFS 1995). Counts of nonpups in British Columbia increased from 4,700 in 1982 to 8,100 in 1994. P. Olesiuk (pers. comm.) reports that the overall population trend in British Columbia over the last 30 years has been an annual increase of 2% to 3%. The increase in British Columbia likely represents partial recovery from the effects of "control" programs in the earlier part of the century. In 1913, after sea lion numbers had already been reduced, 10,000–12,000 animals (including pups) were counted. In 1965, after continued efforts to reduce sea lion numbers, 4,000 were counted (Bigg, 1988). More recently, counts of non-pups at trend sites in southeast Alaska have increased from 6,400 in 1979 to 8,700 in 1998 (NMFS 1995, Sease and Loughlin 1999). The number of pups born in southeast Alaska increased from ca. 2,200 in 1979 to ca. 3,700 in 1994 (NMFS 1995). Pup production increased at Hazy and Forrester Islands. Forrester Island has become the largest rookery for the entire species, with just under 3,300 pups born there in 1991 (NMFS 1995).

4.8.13 Population Variability and Stability

Populations change as a function of births, deaths, immigration, and emigration. During the nonreproductive season, some sea lions may move between the western and eastern populations (Calkins and Pitcher 1981), but net migration out of the western population is not considered a factor in the decline. Over the past two decades, the amount of growth observed in the eastern population is equivalent to only a small fraction of the losses in the western population. Thus, the decline must be due primarily to changes in birth and death rates. As mentioned above, computer modeling (York 1994) and mark-recapture experiments (Chumbley et al. 1997) indicate that the most likely problem leading to the decline is decreased juvenile survival, but lower reproductive success is almost certainly a contributing factor. Finally, adult survival has not been characterized and even small changes in the survival rate of adult females may be contributing significantly to past or current population trends.

These changes in vital rates would likely lead to changes in the age structure which, in turn, may tend to destabilize populations. With declining reproductive effort or juvenile survival, populations tend to become top heavy with more mature animals (e.g., the increase in mean age of adult females described by York [1994]), followed by a drop in population production as mature animals die without replacement through recruitment of young females. The extent to which the age structure is destabilized and the effect on population growth rate depends, in part, on the length of time that reproduction and/or juvenile survival remain suppressed. Increased mortality of young adult females may have the strongest effect on population growth and potential for recovery, as these females have survived to reproductive age but still have their productive years ahead of them (i.e., they are at the age of greatest reproductive potential).

Vital rates and age structures may change as a function of factors either extrinsic or intrinsic to the population. This biological opinion addresses the question of potential effects of fishery actions (i.e., extrinsic factors) on the Steller sea lion. However, the potential effects will be determined, in part, by the sensitivity of the western population to extrinsic influence, its resilience, and its recovery rate. The Steller sea lion fits the description of a "K-selected" species of large-bodied, long-lived individuals with delayed reproduction, low fecundity, and considerable postnatal maternal investment in the offspring. These characteristics should make sea lion populations relatively tolerant of large changes in their environment. Thus, the observed decline of the western population over the past two to three decades is not consistent with the description of the species as K-selected, and suggests that the combined effect of those factors causing the decline has been severe. The ability of the population to recover (i.e., its resilience) and the rate at which it recovers will be determined by the same K-selected characteristics (longevity, delayed reproduction, and low fecundity), as well as its metapopulation structure. Its maximum recovery rate will likely be limited to no more than 8% to 10% annually (based on its life history characteristics and observed growth rates of other Otariids), which means that recovery could require 20 to 30 years, even under optimal conditions. The metapopulation structure of the western population may enhance or deter recovery. Dispersal of populations provides some measure of protection for the entire species against relatively localized threats of decline or extinction. And rookeries that go extinct may be more likely recolonized by seals migrating between sites. On the other hand, the division of the whole population into smaller demographic units may exacerbate factors that accelerate small populations toward extinction (e.g., unbalanced sex ratios, allee effects, inbreeding depression). Such acceleration has been referred to as an "extinction vortex" (Gilpin and Soulé 1986).

Finally, any description of population stability for the Steller sea lion should be written with caution. Over the past three decades (or perhaps longer), we have witnessed a severe decline of the western population throughout most of its range. Our inability to anticipate those declines before they occurred, our limited ability to explain them now, and our limited ability to predict the future suggests the difficulty of describing the stability of Steller sea lion populations.

4.8.14 Population Projections

Based on recent trends in southeast Alaska and British Columbia, prospects for recovery of the eastern population are encouraging. Population viability analyses have been conducted for the western population by Merrick and York (1994) and York et al. (1996). The results of these analyses indicated that the next 20 years would be crucial for the western population of Steller sea lions, if the rates of decline observed at that time were to continue. Within this time frame, they determined the possibility that the number of adult females in the Kenai-to-Kiska region could drop to less than 5000. Extinction rates for rookeries or clusters of rookeries could also increase sharply in 40 to 50 years, and extinction for the entire Kenai-to-Kiska region could occur within 100–120 years. These projections have not been updated since 1994, however, given the continued decline of sea lions at about 4-7% annually, we consider the next 15years to be an important time period for Steller sea lions.

Further analysis of population projections is presented in the Baseline (see section 5.4.4).

4.8.15 Listing status

On 26 November 1990, the Steller sea lion was listed as threatened under the ESA. In 1997; the species was split into two separate stocks on the basis of demographic and genetic dissimilarities (Bickham et al. 1996, Loughlin 1997); the status of the western stock was changed to endangered; and the status of the eastern stock was left unchanged (62 FR 30772).

4.9 Chinook Salmon

Chinook salmon are the largest of the Pacific salmon and historically ranged from the Ventura River in California to Point Hope, Alaska in North America, and in northeastern Asia from Hokkaido, Japan to the Anadyr River in Russia (Healey 1991). In addition, chinook salmon have been reported in the Mackenzie River area of northern Canada (McPhail and Lindsey 1970). Six threatened or endangered species of chinook salmon are known to occur in the action area for this consultation. Because of similarities in the life history and threats to the survival and recovery of these six chinook salmon covered in this biological opinion, we will begin this section by summarizing the general life history and threats to chinook salmon. Then we will separately discuss specific information on their listing status, population status and trends, and impacts that are not shared for each species.

Life history information

Chinook salmon exhibit diverse and complex life history strategies. Two generalized freshwater life-history types were initially described by Gilbert (1912): "stream-type" chinook salmon reside in freshwater for a year or more following emergence, whereas "ocean-type" chinook salmon migrate to the ocean within their first year. For the purposes of this opinion, we will refer to chinook salmon (spring and summer runs) that spawn upriver from the crest of the Cascade Range as "stream-type"; we will refer to chinook salmon that spawn down-river of the crest of the Cascade Range (including in the Willamette River) as "ocean-type."

The generalized life history of Pacific salmon involves incubation, hatching, and emergence in freshwater; migration to the ocean until they reach sexual maturity; and a migration to freshwater to complete the maturation process and spawn. Juvenile salmon rear in freshwater for various lengths of time and some male chinook salmon do not migrate to the ocean and mature in freshwater. The timing and duration of these stages will be determined by genetics and the environment.

Impacts of human activity on chinook salmon

Over the past few decades, the size and distribution of chinook salmon populations have declined because of natural phenomena and human activity. The following discussions briefly summarize the effect of the hydropower system, harvests, hatcheries, and habitat degradation on the status of chinook salmon in the Columbia and Snake River basins.

Hydropower

The network of dams, reservoirs, and diversions that comprise the hydropower system in the Columbia

River and Snake River basins has substantially reduced or eliminated populations of chinook salmon. The hydropower system has increased water temperatures, changed the structure of freshwater fish communities, and depleted flows necessary for salmon migration, spawning, rearing by flushing sediment from spawning gravels, altering gravel recruitment, and eliminating the transport of large woody debris. Physical features of dams, such as turbines and sluiceways, have increased the mortality of both adult and juvenile salmon in the Columbia River basin. In some cases, the dams block access to spawning and rearing habitat and have a direct effect on populations of chinook salmon. In other cases, the dams have indirect effects on these salmon by increasing the number of adults and juveniles that are killed during downstream and upstream migrations; changing natural flow regimes; de-watering or reduce flows to downstream areas; and disrupting the movement of gravel necessary to maintain spawning sites.

Reservoirs associated with the hydropower system in the Columbia River Basin create ecological conditions that are ideal for native, predatory fish and non-native fish species. The result has been increased predation of juvenile chinook salmon. Predators such as northern pikeminnow (*Ptychocheilus oregonensis*), walleye (*Stizostedion vitreum*), smallmouth bass (*Micropterus dolomieui*), and channel catfish (*Ictalurus punctatus*) consume between 9 and 19 percent of the juvenile salmon entering reservoirs, with northern pikeminnow accounting for about 78 percent of this loss.

Harvests

Many stock of chinook salmon were threatened by fishing pressure before their habitat was degraded. Even after watersheds of western United States, were destroyed or degraded many populations of chinook salmon were still being exploited at unsustainable rates. As a result of these threats, many chinook salmon runs became extinct.

Between 1982 and 1989, total exploitation rates for chinook salmon in the Columbia River and Snake River region averaged 68 percent, with ocean exploitation rates averaging 39 percent. After listing, chinook salmon were still harvested, although at lower levels; ocean harvest rates were 11.5 percent in 1995 and 23 percent in 1996 (PFMC 1996). Because of their life history, ocean fisheries pose a significant threat to salmon; even small ocean harvests of adult salmon can significantly reduce a salmon population's likelihood of surviving and recovering in the wild. Nevertheless, threatened and endangered salmon are caught in groundfish fisheries off Alaska, Washington, Oregon, and California.

Hatcheries

About 80 percent of the annual adult salmon that now return to the Columbia River Basin to spawn come from a hatchery. Nearly all of the 100 or more hatcheries in the Columbia River basin were constructed to compensate for the loss of fish and fish habitat that was caused by the hydropower system; together they produce about 150 million salmon each year.

Hatcheries benefit native salmon by conserving natural populations in areas where habitat conditions can no longer support natural spawning or where the numbers of returning adults are so low that a population has an immediate risk of extinction. At the same time, hatcheries hurt natural populations of salmon through interbreeding between hatchery and wild salmon (which can adversely affect the health of wild salmon populations), predation by larger hatchery salmon on smaller wild salmon, competition between hatchery and wild salmon for food and space, disease transmission, and by supporting mixed-stock fisheries that target large populations of hatchery salmon may overharvest smaller populations of wild salmon.

Habitat

Forestry, agriculture, mining, urbanization, grazing, flood control, dredging, water pollution, water withdrawals, hydropower, road construction, and recreational activities have destroyed and degraded aquatic and riparian ecosystems throughout the Columbia and Snake River basins. Examples of habitats that have been destroyed in the region include riparian and aquatic ecosystems (in 1988, about 95% of streams surveyed in Oregon has been moderately or severely degraded by excessive sedimentation, high water temperatures, bank instability and other problems related to logging and removal of large woody debris; FEMAT 1993), wetlands (reduced by 30 percent in Washington and Oregon; NMFS 1998), and forests, which experienced significant changes in structure and composition after 50 years of even-age timber management. In addition, water throughout large portions of the Pacific Northwest has been diverted for agriculture, flood control, and domestic uses. Combined with the effects of the hydropower system in the Columbia River basin, these habitat losses have had devastating effects on populations of chinook salmon in Pacific Northwest.

Federal, state, and local governments in the Columbia River basin are undertaking several efforts to slow or reverse the decline of chinook salmon populations that include the Northwest Forest Plan, PACFISH, Lower Columbia River National Estuary Program, Lower Columbia Steelhead Conservation Initiative, Oregon Plan for Salmon and Watersheds, Washington Wild Stock Restoration Initiative, and Washington Wild Salmonid Policy.

Natural phenomena

Natural variations in freshwater and marine environments have substantial effects on the abundance of salmon populations. Of the various natural phenomena that affect most populations of Pacific salmon, changes in ocean productivity are generally considered most important. Recent evidence suggests that the survival of Pacific salmon in the marine environment fluctuates in response to long-term cycles of climatic conditions and ocean productivity (20–30 years); these fluctuations cause salmon survival to be either above-average or below-average (Cramer 1999). These long-term, climactic fluctuations have been referred to as the Pacific Decadal Oscillation. For many years, ocean conditions and resulting productivity appear to have produced below-average marine survival rates for Pacific salmon, which has reduced the size of salmon populations throughout the Pacific Northwest.

At the same time, the long-term survival of Pacific salmon depends on the productivity of freshwater ecosystems, which determines the number of salmon that enter the ocean. During the early 1990s, freshwater ecosystems throughout the Pacific coast were affected by a series of very dry years, which adversely affected the survival of adult and juvenile salmon in those areas. More recently, severe flooding throughout the Pacific Northwest has reduced the spawning success of salmon populations in the region.

Chinook salmon are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Ocean predation probably contributes to significant natural mortality, although the levels of predation are largely unknown. In general, chinook are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that increasing size of tern, seal, and sea lion populations in the Pacific Northwest has dramatically reduced the survival of adult and juvenile salmon in the Columbia River estuary.

4.9.1 Puget sound chinook salmon

4.9.1.1 Species description and distribution

Puget Sound chinook salmon include all runs of chinook salmon in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula. Chinook salmon in this area generally have an "ocean-type" life history. Thirty-six hatchery populations were included as part of the species and five were considered essential for recovery and listed including spring chinook from Kendall Creek, the North Fork Stillaguamish River, White River, and Dungeness River, and fall run fish from the Elwha River.

4.9.1.2 Listing status

Puget Sound chinook salmon were listed as threatened under the ESA in 1999. Critical habitat has not been designated for these salmon.

4.9.1.3 Population status and trends

The largest recorded harvest of this species occurred in 1908, when the run-size for Puget Sound chinook salmon was estimated at 690,000 fish (in 1908, both ocean harvests and hatchery production were negligible). Between 1992 and 1996, the average run-size of natural chinook salmon runs in North Puget Sound was about 13,000 fish. With few exceptions, these runs represented short- and long-term declines.

4.9.1.4 Impacts of human activity on this species

Hatchery production sustains about 10 of 29 stocks of Puget Sound chinook salmon (WDF *et al*. 1993). Since the 1950s, nearly 2 billion salmon have been released from hatcheries into Puget Sound tributaries; most of these chinook salmon were produced from local, fall-run, chinook salmon. Since artificial propagation programs began, hatchery returns have accounted for more than 57% of the total spawning escapement of this species.

The status of naturally-spawning, Puget Sound chinook salmon varies by stock. Of the 29 chinook stocks identified by WDF et al. (1993) 10 were classified as healthy, 8 as depressed, 4 as critical, and 3 as unknown. The critical stocks are all spring-run chinook stocks. Although problems associated with habitat degradation and hatchery influence are common to all stocks, at least some stocks appear to be in reasonably good shape: in 1998 returns of adult, Snohomish River chinook salmon exceeded escapement goals; returns to the Skagit River were very close to escapement goals, and returns to the Stillaguamish, were the largest in seven years. These increased returns can be attributed to recent reductions in harvest in Canadian and U.S. fisheries.

Habitat throughout the range of Puget Sound chinook salmon has been blocked or degraded. In general, upper tributaries have been damaged by forest practices and lower tributaries and mainstem rivers have been damaged by agriculture, urbanization, or both. Dikes constructed for flood control, water diversions, dams, destruction and modification of freshwater and estuarine wetlands, and sedimentation caused by forest practices and urban development threaten Puget Sound chinook salmon (WDF et al. 1993). All of these habitat changes have reduced levels of escapement in Puget Sound chinook salmon.

4.9.2 Lower Columbia River chinook salmon

4.9.2.1 Species description and distribution

Lower Columbia River chinook salmon includes all native populations from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls. The Cowlitz, Kalama, Lewis, White Salmon, and Klickitat Rivers are the major river systems on the Washington side, and the lower Willamette and Sandy Rivers are foremost on the Oregon side. The eastern boundary for this species occurs at Celilo Falls, which corresponds to the edge of the drier Columbia Basin Ecosystem and historically may have been a barrier to salmon migration at certain times of the year.

Fall-run fish form the majority of these chinook salmon, whose stocks tend to migrate north once they reach the ocean. This is supported by recoveries of coded-wire-tags for lower Columbia River chinook salmon, which tend to be recovered off the British Columbia and Washington coasts, with a small proportion recovered in Alaskan waters.

Stream-type spring-run chinook salmon found in the Klickitat River are not included in this species (they are considered Mid-Columbia River spring-run chinook salmon) or the introduced Carson spring-chinook salmon strain. "Tule" fall chinook salmon in the Wind and Little White Salmon Rivers are included in this species, but not introduced "upriver bright" fall-chinook salmon populations in the Wind, White Salmon, and Klickitat Rivers.

There is some question whether any natural-origin spring chinook salmon remain in this species. Fourteen hatchery stocks were included in the species; one was considered essential for recovery (Cowlitz River spring chinook) but was not listed.

4.9.2.2 Listing status

Lower Columbia River chinook salmon were listed as threatened under the ESA in 1999. Critical habitat has not been designated for these salmon.

4.9.2.3 Population status and trends

There are no reliable estimates of the historic abundance of Lower Columbia River chinook salmon, but experts generally agree that naturally-spawning populations of this species have declined dramatically over the last century. By the 1990s, spawning runs of this species have been sustained by hatchery production. For example, between 1991 and 1995, estimated escapements of this species have included 29,000 natural spawners and 37,000 hatchery spawners and about 68% of the natural spawners were first-generation hatchery strays (PFMC 1996).

4.9.2.4 Impacts of human activity on this species

All basins in the range of Lower Columbia River chinook salmon have been adversely affected by habitat degradation. Major habitat problems are related primarily to blockages, forest practices, urbanization in the Portland and Vancouver areas, and agriculture in flood plains and low-gradient tributaries. Substantial chinook salmon spawning habitat has been blocked (or passage substantially impaired) in the Cowlitz (Mayfield Dam 1963, RKm 84), Lewis (Merwin

Dam 1931, RKm 31), Clackamas (North Fork Dam 1958, RKm 50), Hood (Powerdale Dam 1929, RKm 7), and Sandy (Marmot Dam 1912, RKm 48; Bull Run River dams in the early 1900s) rivers (WDF et al. 1993, Kostow 1995).

Hatchery programs in the lower Columbia River began in the 1870s, expanded rapidly, and have continued throughout this century. Although the majority of the stocks have come from within the range of this species, over 200 million fish from outside the range of this species have been released since 1930. A particular concern noted at the time of listing related to the straying by Rogue River fall-run chinook salmon, which are released into the lower Columbia River to augment harvest opportunities. The release strategy has since been modified to minimize straying, but it is too early to assess the effect of the change. Available evidence indicates a pervasive influence of hatchery fish on most natural populations throughout the range of this species, including both spring- and fall-run populations (Howell et al. 1985, Marshall et al. 1995). In addition, the exchange of eggs between hatcheries in this species has led to the extensive genetic homogenization of hatchery stocks (Utter et al. 1989).

4.9.3 Upper Columbia River spring chinook salmon

4.9.3.1 Species description and distribution

The Upper Columbia River spring chinook salmon include stream-type chinook salmon that inhabit tributaries upstream from the Yakima River to Chief Joseph Dam. They currently spawn in only three river basins above Rock Island Dam: the Wenatchee, Entiat, and Methow Rivers. Several hatchery populations are also listed including those from the Chiwawa, Methow, Twisp, Chewuch, and White rivers, and Nason Creek.

Adults of this species return to the Wenatchee River from late March to early May, and from late March to June in the Entiat and Methow rivers. Most adults return after spending two years in the ocean, while 20%-40% return after three years at sea. Like the Snake River spring/summer chinook, Upper Columbia River spring chinook are subject to very little ocean harvest.

4.9.3.2 Listing status

Upper Columbia River chinook salmon were listed as endangered under the ESA in 1999. Critical habitat has not been designated for these salmon.

4.9.3.3 Population status and trends

There are no historical estimates of the size of Upper Columbia chinook salmon populations. Adult escapements of this species throughout its range continue to be critically low and redd counts are still declining severely.

Upper Columbia River chinook salmon have been reduced to small populations in three watersheds. Population viability analyses for this species (using the Dennis Model) suggest that these chinook salmon face a significant risk of extinction: a 75 to 100 percent probability of extinction within 100 years (given return rates for 1980 to present).

4.9.3.4 Impacts of human activity on this species

Historical artificial propagation efforts have had a significant impact on spring-run populations of this chinook salmon. Extensive introductions of spring-run chinook salmon from outside this species and egg transfers within the species have affected the genetics of Upper Columbia River chinook salmon. In addition, despite their small population size and high risk of extinction, Upper Columbia River chinook salmon are still taken in fisheries; although harvest rates for this species are estimated to be less than 10 percent (ODFW and WDFW 1998).

4.9.4 Upper Willamette River Chinook Salmon

4.9.4.1 Species description and distribution

Upper Willamette River chinook salmon occupy the Willamette River and tributaries upstream of Willamette Falls. Historically, access above Willamette Falls was restricted to the spring when flows were high. In autumn, low flows prevented fish from ascending past the falls. The Upper Willamette spring chinook are one of the most genetically distinct chinook groups in the Columbia River Basin. Fall chinook salmon spawn in the Upper Willamette but are not considered part of the species because they are not native. None of the hatchery populations in the Willamette River were listed although five spring-run hatchery stocks were included in the species.

The ocean distribution of Upper Willamette River chinook salmon is consistent with an ocean-type life history with the majority of chinook being caught off the coasts of British Columbia and Alaska. Spring chinook from the Willamette River have the earliest return timing of chinook stocks in the Columbia Basin with freshwater entry beginning in February. Historically, spawning occurred between mid-July and late October. However, the current spawn timing of hatchery and wild chinook in September and early October has probably been changed through introgression with hatchery salmon.

4.9.4.2 Listing status

Upper Willamette River chinook salmon were listed as threatened under the ESA in 1999. Critical habitat has not been designated for these salmon.

4.9.4.3 Population status and trends

Populations of naturally-produced Upper Willamette River spring chinook are substantially smaller than they were historically, when escapement levels may have been as high as 200,000 fish per year. The Willamette River's ability to produce salmon has been reduced by extensive dam construction and habitat degradation. In response, chinook salmon populations in the Willamette River have declined. From 1946 to 1950, geometric mean counts of spring chinook was 31,000 fish, primarily naturally-produced salmon (Myers *et al*. 1998). From 1995 to 1999, geometric mean counts of spring chinook salmon was 27,800 fish, primarily hatchery-produced salmon.

4.9.4.4 Impacts of human activity on this species

Historically, five rivers produced spring chinook in the Willamette River basin, including the Clackamas, North and South Santiam Rivers, McKenzie, and the Middle Fork Willamette. However, between 1952-1968 dams were built on all of the major rivers in the basin that supported spring chinook, preventing these salmon from reaching more than half of the most important spawning and rearing habitat in the Willamette River basin. Dams on the South Fork Santiam and Middle Fork Willamette eliminated wild spring chinook in those systems (ODFW 1997). Populations in several smaller tributaries that also used to support spring chinook are believed to be extinct (Nicholas 1995).

Mitigation hatcheries were built to offset the effects of the dams in the Willamette River basins. As a result, 85 to 95% of the chinook salmon in the basin originated in a hatchery.

4.9.5 Snake River Spring/summer Chinook Salmon

4.9.5.1 Species description and distribution

Snake River spring/summer chinook salmon are primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon Rivers in the Snake River basin. Most adult Snake River spring/summer chinook salmon enter these rivers to spawn from May through September. Juvenile Snake River spring/summer chinook salmon emerge from spawning gravels from February through June. After rearing in nursery streams for about one year, smolts begin migrating seaward in April and May. After reaching the mouth of the Columbia River, spring/summer chinook salmon probably inhabit nearshore areas before migrating to the northeast Pacific Ocean where they will remain for two to three years.

4.9.5.2 Listing status

Snake River spring-summer chinook salmon were listed as endangered under the ESA in 1992. Critical habitat for these salmon was designated in 1993. This critical habitat encompasses the waters, waterway bottoms, and adjacent riparian zones of specified lakes and river reaches in the Columbia River that are or were accessible to listed Snake River salmon (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams) and is well beyond the area that is likely to be directly or indirectly affected by the proposed action.

4.9.5.3 Population status and trends

In the late 1800s, the population of wild, adult Snake River spring/summer chinook salmon was estimated at more than 1.5 million adults. By the 1950s, the population had declined to an estimated 125,000 adults and continued to decline through the 1970s. Returns were variable through the 1980s, but declined further in the 1990s. Record low returns were observed in 1994 and 1995. Dam counts were modestly higher from 1996–1998, but declined in 1999.

In 2000, 134,000 Snake River spring chinook salmon were expected to return to the Snake River, which would be the highest return in over 30 years. Only a small portion of these returning salmon (5,800) are expected to be natural-origin spring chinook destined for the Snake River. Expected returns to the Tucannon River (500 listed hatchery and wild fish), Imnaha River (800 wild and 1,600 listed hatchery fish), and Sawtooth Hatchery (368 listed hatchery fish) all represent substantial increases over past years.

In 2000, 33,300 Snake River summer chinook salmon were expected to return to the Snake River, which is the second highest return in over 30 years, but only a small portion of these animals (2,000) are expected to be natural-origin salmon. The return of natural-origin fish is slightly more than half of the five-year average (3,466).

In 1999, NMFS conducted an analysis referred to as Cumulative Risk Initiative, which estimated the Snake River spring/summer chinook salmon's probability of extinction for 10- and 100-year periods (NWFSC 1999). For some of the index stocks of this species, the risk analysis estimated the Marsh River subpopulation had a 90 percent probability of extinction within 100 years; the Imnaha River subpopulation had a 74 percent probability of extinction within 100 years; the Bear Creek and Sulphur River subpopulations had 50 percent probabilities of extinction; and the remaining three subpopulations had extinction probabilities that ranged between 30 and 40 percent.

4.9.5.4 Impacts of human activity on this species

Recent analyses conducted through the Plan for Analyzing and Testing Hypotheses (called PATH) considered this species' likelihood of surviving and recovering given several future management options for the Columbia River hydrosystem and other causes of mortality. That analysis indicated that Snake River spring/summer chinook salmon had a good chance of surviving, but full recovery was unlikely except under a very limited range of assumptions (unless drawdowns were implemented for at least the four lower Snake River dams operated by the U.S. Army Corps of Engineers). If the four, lower Snake River dams were drawn down, Snake River spring/summer chinook salmon had a high likelihood of surviving and recovering in the wild.

The Northwest Fisheries Science Center has recently considered the extinction risk for Snake River spring/summer chinook as part of their Cumulative Risk Initiative, which was based on seven "index" populations of Snake River spring/summer chinook salmon (out of a total of 35 to 40 populations). Two populations have a 10 percent risk of declining to one individual in ten years, four populations have 56 to 88 percent probability of declining to one individual in 100 years that range between 56 and 88 percent, and the remaining three populations have more than 30 percent probability of declining to this level within 100 years if nothing changes.

4.9.6 Snake River fall chinook salmon

4.9.6.1 Species description and distribution

The present range of spawning and rearing habitat for naturally-spawned Snake River fall chinook salmon is primarily limited to the Snake River below Hells Canyon Dam and the lower reaches of the Clearwater, Grand Ronde, Salmon, and Tucannon Rivers.

Although Snake River fall chinook have been recovered in North Pacific Fishery Management Council groundfish fisheries, several upper Columbia River fall chinook (known as upriver brights) have been recovered in GOA groundfish fisheries. The presence of upriver brights in Gulf of Alaska fisheries suggests that Snake River fall chinook probably occur in North Pacific Fishery Management Council groundfish fisheries.

4.9.6.2 Life history information

Unlike many other listed salmon, Snake River fall chinook is probably represented by only a single population that spawns in parts of the mainstem of the river and lower reaches of tributaries. Adult Snake River fall chinook salmon enter the Columbia River in July and migrate into the Snake River from August through October. Fall chinook salmon generally spawn from October through November and fry emerge from March through April. Downstream migration generally begins within several weeks of emergence (Becker 1970, Allen and Meekin 1973), and juveniles rear in backwaters and shallow water areas through mid-summer prior to smolting and migrating to the ocean—thus they exhibit an "ocean" type juvenile history. Once in the ocean, they spend one to four years (usually three) before beginning their spawning migration. Fall returns in the Snake River system are typically dominated by four-year-old fish.

4.9.6.3 Listing status

Snake River fall chinook salmon were listed as endangered under the ESA in 1992. Critical habitat for these salmon was designated in 1993. This critical habitat encompasses the waters, waterway bottoms, and adjacent riparian zones of specified lakes and river reaches in the Columbia River that are or were accessible to listed Snake River salmon (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams) and is well beyond the area that is likely to be directly or indirectly affected by the proposed action.

4.9.6.4 Population status and trends

There are no reliable estimates of historical population sizes of Snake River fall chinook salmon. The mean number of adult Snake River fall chinook salmon was estimated to have declined from 72,000 in the 1930s and 1940s to 29,000 during the 1950s. In spite of these declines, the Snake River was the most important area natural production of fall chinook in the Columbia River basin through the 1950s. The number of adults counted at the uppermost Snake River mainstem dams averaged 12,720 total spawners from 1964 to 1968, 3,416 spawners from 1969 to 1974, and 610 spawners from 1975 to 1980 (Waples, *et al*. 1991). Counts of adult fish of natural-origin continued to decline through the 1980s when they reached a low of 78 individuals in 1990. Since 1990, returns of natural-origin fish to Lower Granite Dam have been variable, but increasing. They reached a high of 797 in 1997 only to decline to 306 in 1998.

The Lyons Ferry Hatchery population of Snake River fall chinook, which was included in this species' listing, helps buffer this species from natural declines. In recent years, several hundred adult fall chinook salmon have returned to Lyons Ferry Hatchery and smolt from the 1995 brood-year were outplanted to accelerate rebuilding this species. Nevertheless, supplementation will not substitute for habitat restoration to recover this species because of this species' ecology.

4.9.6.5 Impacts of human activity on the species

Irrigation and hydroelectric projects on the Snake River probably had a greater impact on fall chinook than any other species of salmon, because fall chinook spawn in the mainstem of the river. Recent analyses conducted through the Plan for Analyzing and Testing Hypotheses considered the prospects for survival and recovery given several future management options for the hydro system and other mortality sectors (Peters et al. 1999). That analysis indicated that the prospects of survival for Snake River fall chinook were good, but that full recovery was relatively unlikely except under a very limited range of assumptions, or unless draw down was implemented for at least the four lower Snake River dams operated by the U.S. Army Corps of Engineers. Consideration of the draw down options led to a high likelihood that both survival and recovery objectives could be achieved.

The Northwest Fisheries Science Center recently considered the extinction risk for Snake River fall chinook as part of their Cumulative Risk Initiative. The results of these analyses indicate that the probability of extinction for Snake River fall chinook over the next ten years is near zero while the risk of extinction over 100 years is between 6–17% (depending on whether 1980 is included in the baseline analysis).

4.10 Snake River Sockeye Salmon

4.10.1 Species description and distribution

Sockeye salmon occur in the North Pacific and Arctic oceans and associated freshwater systems. This species ranges south as far as the Klamath River in California and northern Hokkaido in Japan, to as far north as far as Bathurst Inlet in the Canadian Arctic and the Anadyr River in Siberia. Sockeye salmon were an important food source for aboriginal people who either ate them fresh or dried them for winter use. Today sockeye salmon remain an important mainstay of many subsistence users and support one of the most important commercial and recreational fisheries on the Pacific coast of North America.

Sockeye salmon can be distinguished from chinook, coho, and pink salmon by the lack of large, black spots and from chum salmon by the number and shape of gill rakers on the first gill arch. Sockeye salmon have 28 to 40 long, slender, rough or serrated closely set rakers on the first arch. Chum salmon have 19 to 26 short, stout, smooth rakers.

Immature and pre-spawning sockeye salmon are elongate, fusiform, and somewhat laterally compressed. They are metallic green blue on the back and top of the head, iridescent silver on the sides, and white or silvery on the belly. Some fine black speckling may occur on the back, but large spots are absent. Juveniles, while in fresh water, have the same general coloration as immature sockeye salmon in the ocean, but are less iridescent. Juveniles also have dark, oval parr marks on their sides. These parr marks are short-less than the diameter of the eye-and rarely extend below the lateral line. Breeding males develop a humped back and elongated, hooked jaws filled with sharp caniniform teeth. Both sexes turn brilliant to dark red on the back and sides, pale to olive-green on the head and upper jaw, and white on the lower jaw.

Snake River sockeye salmon is one of three stock of sockeye salmon that remain in the Columbia River basin. This species includes sockeye populations from the Snake River Basin, Idaho, although the only remaining populations of this species occur in the Stanley River Basin of Idaho.

4.10.2 Life history information

Adult Snake River sockeye salmon enter the Columbia River during June and July. Their arrival at Redfish Lake, which now supports the only remaining run of Snake River sockeye salmon, peaks in August; spawning occurs primarily in October. Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for three to five weeks, emerge from April through May and move immediately into the lake. Once there, juvenile sockeye salmon feed on plankton for one to three years before they migrate to the ocean. Migrants leave Redfish Lake from late April through May and smolts migrate almost 900 miles to the Pacific Ocean.

Smolts pass Lower Granite Dam (the first dam on the Snake River downstream from the Salmon River) from late April to July with peak passage from May to late June (Fish Passage Center 1992). Once in the ocean, Snake River sockeye salmon smolts remain inshore or within the Columbia River influence during the early summer. Later, they migrate through the northeast Pacific Ocean where they remain for two to three years (Hart 1973, Hart and Dell 1986). Snake River sockeye salmon usually begin the spawning migration in their fourth or fifth year of life.

4.10.3 Listing status

Snake River sockeye salmon were listed as endangered under the ESA in 1991. Critical habitat for these salmon was designated in 1993. This critical habitat encompasses the waters, waterway bottoms, and adjacent riparian zones of specified lakes and river reaches in the Columbia River that are or were accessible to listed Snake River salmon (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams) and is well beyond the area that is likely to be affected by the proposed action.

4.10.4 Population status and trends

Historically, the largest numbers of Snake River sockeye salmon returned to headwaters of the Payette River, where 75,000 were taken in one year by a single fishing operation on Big Payette Lake (Bevan et al. 1994). During the early 1880s, returns of Snake River sockeye salmon to the headwaters of the Grande Ronde River in Oregon were estimated between 24,000 and 30,000 at a minimum. During the 1950s and 1960s, adult returns to Redfish Lake numbered more than 4,000 fish. By 1985, the number of adults arriving at Redfish Lake, Idaho, had fallen below 20 animals. Between 1990 and 1998, only 16 “wild” Snake River sockeye salmon returned to Redfish Lake or the nearby Sawtooth Hatchery (including one in 1998 and none in 1999).

Since 1991, all returning adults Snake River sockeye salmon have been spawned in a hatchery to prevent the species’ extinction. The first adults produced by this program (from the 1991 returns) were released into Redfish Lake to spawn in 1993 and their progeny were expected to outmigrate in the spring of 1995. Sixteen sockeye were observed at Lower Granite Dam in 1999, seven of which return to the Sawtooth Hatchery weir. By Aug. 8 of 2000, 149 four-year-old sockeye adults had made the 900-mile journey from the ocean to Redfish Lake or Sawtooth Hatchery. Most are products of either sockeye adults produced in the hatchery program and released to spawn in 1996 or year-old smolts released near the hatchery or in Redfish Creek. All are progeny of eight, lone returning "wild" sockeye salmon that had been taken into the program as broodstock in 1993.

Given the extremely low sockeye salmon population size, this species’ likelihood of surviving in the wild remains fairly low. Snake River sockeye will remain below the threshold escapement level of 150 fish (which applies only to naturally-produced spawners) until natural production is sufficiently re-established. This species’ likelihood of recovering in the wild (which only applies to spawners at least two generations removed from captive broodstock) is even less certain.

4.10.5 Impacts of human activity on the species

The following discussion briefly summarizes the combined effect of the natural phenomena and human activities, including hydropower systems, harvests, hatcheries, and habitat degradation, on the status of Snake River sockeye salmon.

4.10.5.1 Hydropower

The network of dams, reservoirs, and diversions that comprise the hydropower system in the Columbia River and Snake River basins has substantially reduced or eliminated populations of sockeye salmon. The hydropower system has increased water temperatures, changed the structure of freshwater fish communities, and depleted flows necessary for salmon migration, spawning, rearing by flushing sediment from spawning gravels, altering gravel recruitment, and eliminating the transport of large woody debris. Physical features of dams, such as turbines and sluiceways, have increased the mortality of both adult and juvenile salmon in the Columbia River basin. In some cases, the dams block access to spawning and rearing habitat and have a direct effect on populations of sockeye salmon. In other cases, the dams have indirect effects on these salmon by increasing the number of adults and juveniles that are killed during downstream and upstream migrations; changing natural flow regimes; de-watering or reduce flows to downstream areas; and disrupting the movement of gravel necessary to maintain spawning sites.

Reservoirs associated with the hydropower system in the Columbia River Basin create ecological conditions that are ideal for native, predatory fish and non-native fish species. The result has been increased predation of juvenile sockeye salmon. Predators such as northern pikeminnow (*Ptychocheilus oregonensis*), walleye (*Stizostedion vitreum*), smallmouth bass (*Micropterus dolomieui*), and channel catfish (*Ictalurus punctatus*) consume between 9 and 19 percent of the juvenile salmon entering reservoirs, with northern pikeminnow accounting for about 78 percent of this loss.

4.10.5.2 Harvests

Many stock of sockeye salmon were threatened by fishing pressure before their habitat was degraded. Even after watersheds of western United States, were destroyed or degraded many populations of sockeye salmon were still being exploited at unsustainable rates. As a result of these threats, many sockeye salmon runs became extinct.

The State of Idaho conducts a fishery for kokanee salmon in Redfish Lake, the last known spawning area for sockeye salmon, from January through August. Pettit Lake and Alturas Lakes are also open to kokanee fishing throughout the year, despite stocking programs for endangered sockeye salmon in those lakes. Between 1995 and 1998, about 59, listed, sockeye salmon have been taken in these fisheries. These lakes are also stocked with trout to support a year-around, recreational fishery. The State of Idaho has applied for a permit to release rainbow trout into Redfish Lake to support a put-and-take fishery in the lake, but the permit has not been authorized.

In addition, Snake River sockeye salmon are captured in winter-, spring-, and summer-season fisheries in the Columbia River Basin conducted by the Columbia River treaty tribes (the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakama Indian Nation). The tribes generally manage their fisheries to prevent harvest rates on upriver summer chinook stocks and sockeye from exceeding 5%, but actual harvest rates on Snake River summer chinook and Snake River sockeye have averaged 1.5% (range 0.4 - 3.1) and 4.3% (range 2.6 - 6.0) since 1990.

4.10.5.3 Hatcheries

About 80 percent of the annual adult salmon that return to the Columbia River Basin to spawn came from a hatchery. Nearly all of the 100 or more hatcheries in the Columbia River basin were constructed to compensate for the loss of fish and fish habitat that was caused by the hydropower system; together they produce about 150 million salmon each year.

Hatcheries benefit native salmon by conserving natural populations in areas where habitat conditions can no longer support natural spawning or where the numbers of returning adults are so low that a population has an immediate risk of extinction. At the same time, hatcheries hurt natural populations of salmon through interbreeding between hatchery and wild salmon (which can adversely affect the health of wild salmon populations), predation by larger hatchery salmon on smaller wild salmon, competition between hatchery and wild salmon for food and space, disease transmission, and by supporting mixed-stock fisheries that target large populations of hatchery salmon may overharvest smaller populations of wild salmon.

4.10.5.4 Habitat

Forestry, agriculture, mining, urbanization, grazing, flood control, dredging, water pollution, water withdrawals, hydropower, road construction, and recreational activities have destroyed and degraded aquatic and riparian ecosystems throughout the Columbia and Snake River basins. Examples of habitats that have been destroyed in the region include riparian and aquatic ecosystems (in 1988, about 95% of streams surveyed in Oregon has been moderately or severely degraded by excessive sedimentation, high water temperatures, bank instability and other problems related to logging and removal of large woody debris; FEMAT 1993), wetlands (reduced by 30 percent in Washington and Oregon; NMFS 1998), and forests, which experienced significant changes in structure and composition after 50 years of even-age timber management. In addition, water throughout large portions of the Pacific Northwest has been diverted for agriculture, flood control, and domestic uses. Combined with the effects of the hydropower system in the Columbia River basin, these habitat losses have had devastating effects on populations of sockeye salmon in Pacific Northwest.

Federal, state, and local governments in the Columbia River basin are undertaking several efforts to slow or reverse the decline of sockeye salmon populations that include the Northwest Forest Plan, PACFISH, Lower Columbia River National Estuary Program, Lower Columbia Steelhead Conservation Initiative, Oregon Plan for Salmon and Watersheds, Washington Wild Stock Restoration Initiative, and Washington Wild Salmonid Policy.

4.10.5.5 Natural Phenomena

Natural variations in freshwater and marine environments have substantial effects on the abundance of salmon populations. Of the various natural phenomena that affect most populations of Pacific salmon, changes in ocean productivity are generally considered most important. Recent evidence suggests that the survival of Pacific salmon in the marine environment fluctuates in response to long-term cycles of climatic conditions and ocean productivity (20–30 years); these fluctuations cause salmon survival to be either above-average or below-average. These long-term, climactic fluctuations have been referred to as the Pacific Decadal Oscillation. For many years, ocean conditions and resulting productivity appear to have produced below-average marine survival rates for Pacific salmon, which has reduced the size of salmon populations throughout Pacific Northwest.

At the same time, the long-term survival of Pacific salmon depends on the productivity of freshwater ecosystems, which determines the number of salmon that enter the ocean. During the early 1990s, freshwater ecosystems throughout the Pacific coast were affected by a series of very dry years, which adversely affected the survival of adult and juvenile salmon in those areas. More recently, severe flooding throughout the Pacific Northwest has reduced the spawning success of salmon populations in the region.

Like other species of salmon, sockeye salmon are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Ocean predation probably contributes to significant natural mortality, although the levels of predation are largely unknown. In general, sockeye salmon are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that increasing size of tern, seal, and sea lion populations in the Pacific Northwest has dramatically reduced the survival of adult and juvenile salmon in the Columbia River estuary.

Recent analyses conducted through the Plan for Analyzing and Testing Hypotheses considered the prospects for survival and recovery given several future management options for the hydro system and other mortality sectors (Marmorek, et al. 1998, Peters, et al. 1999). That analysis indicated that the prospects of survival for Snake River sockeye were not optimistic and full recovery was relatively unlikely except under a very limited range of assumptions, or unless draw down was implemented for at least the four lower Snake River dams operated by the U.S. Army Corps of Engineers. Consideration of the draw down options led to a high likelihood that both survival and recovery objectives could be achieved.

4.11 Steelhead

Unlike Pacific salmon, steelhead are capable of spawning more than once before death (iteroparity). However, steelhead rarely spawn more than twice before dying; most that do so are females (August 9, 1996, 61 FR 41542). Biologically, steelhead can be divided into two basic run-types: the stream-maturing type, or summer steelhead, enters fresh water in a sexually immature condition and requires several months in freshwater to mature and spawn and the ocean-maturing type, or winter steelhead, enters fresh water with well-developed gonads and spawns shortly after river entry (August 9, 1996, 61 FR 41542; Burgner et al. 1992). Variations in migration timing exist between populations. Some river basins have both summer and winter steelhead, while others only have one run-type.

Five threatened or endangered species of steelhead are known to occur in the action area for this consultation. Because of similarities in their life history and the threats to their survival and recovery in the wild, these issues will be addressed for all six of these species below. Specific information on their Listing Status, Population Status and Trends, and Impacts that are not shared will be discussed further for each of these six species.

General life history information

Summer steelhead enter freshwater between May and October in the Pacific Northwest (Busby et al. 1996). They require cool, deep holding pools during summer and fall, prior to spawning. They migrate inland toward spawning areas, overwinter in the larger rivers, resume migration in early spring to natal streams, and then spawn (Meehan and Bjornn 1991).

Winter steelhead enter freshwater between November and April in the Pacific Northwest (Busby et al. 1996), migrate to spawning areas, and then spawn in late winter or spring. Some adults, however, do not enter coastal streams until spring, just before spawning. Steelhead typically spawn between December and June (Bell 1991), and the timing of spawning overlaps between populations regardless of run type

(Busby et al. 1996).

Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity. Intermittent streams may also be used for spawning (Barnhart 1986; Everest 1973). Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months (August 9, 1996, 61 FR 41542) before hatching. Juveniles rear in fresh water from one to four years, then migrate to the ocean as smolts (August 9, 1996, 61 FR 41542). Winter steelhead populations generally smolt after two years in fresh water (Busby et al. 1996).

Steelhead typically reside in marine waters for two or three years before migrating to natal their streams to spawn as four- or five-year olds (August 9, 1996, 61 FR 41542). Populations in Oregon and California have higher frequencies of age-1-ocean steelhead than populations to the north, but age-2-ocean steelhead generally remain dominant (Busby et al. 1996). Age structure appears to be similar to other west coast steelhead, dominated by four-year-old spawners (Busby et al. 1996).

4.11.1 Upper Columbia River Steelhead

4.11.1.1 Species description and distribution

Upper Columbia River steelhead occupy the Columbia River Basin upstream from the Yakima River, Washington, to the border between the United States and Canada. This area includes the Wenatchee, Entiat, and Okanogan Rivers. All upper Columbia River steelhead are summer steelhead. Steelhead primarily use streams of this region that drain the northern Cascade Mountains of Washington State. This species includes hatchery populations of summer steelhead from the Wells Hatchery because it probably retains the genetic resources of steelhead populations that once occurred above the Grand Coulee Dam. This species does not include the Skamania Hatchery stock because of its non-native genetic heritage.

4.11.1.2 Listing status

Upper Columbia River steelhead were listed as endangered under the ESA in 1997. Critical habitat for these salmon was designated in 2000. This critical habitat includes all river reaches accessible to listed steelhead in Columbia River tributaries upstream of the Yakima River, Washington, and downstream of Chief Joseph Dam. This critical habitat is well beyond the area that is likely to be directly or indirectly affected by the proposed action.

4.11.1.3 Population status and trends

Returns of Upper Columbia River natural-origin steelhead to Priest Rapids dam have declined from a 4-year average of 2,900 (beginning in 1986-1987) to 900 (present) although escapements appear to have stabilized at a range of 800-900, over the past six years. Hatchery populations of Upper Columbia River steelhead are included in the species and are also listed as endangered. The hatchery component is relatively abundant and usually, exceeds hatchery supplementation program needs by a substantial margin.

The naturally spawning population of Upper Columbia River steelhead has been augmented for a number of years by stray hatchery fish that have spawned naturally. Replacement ratios for naturally spawning fish (natural-origin and hatchery strays) are quite low, on the order of 0.3. This very low return rate suggests that the productivity of the river basin is so low hatchery strays have been supporting the population.

4.11.1.4 Impacts of human activity on this species

When this species was listed, the Biological Review Team that reviewed the status of this species concluded that Upper Columbia steelhead are presently in danger of extinction. While total abundance of populations within this Evolutionary Significant Unit (ESU) has been relatively stable or increasing, this appears to be occurring only because of major hatchery supplementation programs. Estimates of the proportion of hatchery fish in spawning escapement are 65% (Wenatchee River) and 81% (Methow and Okanogan Rivers). Their major concern for this species was the clear failure of natural stocks to replace themselves. They were also concerned about problems of genetic homogenization due to hatchery supplementation within the species and about the apparent high harvest rates on steelhead smolts in rainbow trout fisheries and the degradation of freshwater habitats within the region, especially the effects of grazing, irrigation diversions, and hydroelectric dams.

4.11.2 Middle Columbia River Steelhead

4.11.2.1 Species description and distribution

Middle Columbia steelhead occupy the Columbia River Basin from Mosier Creek, Oregon, upstream to the Yakima River, Washington, inclusive (61 FR 41541; August 9, 1996). Steelhead from the Snake River Basin (described elsewhere) are excluded. This species includes the only populations of inland winter steelhead in the United States, in the Klickitat River and Fifteenmile Creek (Busby et al. 1996). Two hatchery populations are considered part of this species, the Deschutes River stock (ODFW stock 66) and the Umatilla River stock (ODFW stock number 91); listing for neither of these stocks was considered warranted.

Most Middle Columbia River steelhead smolt at 2 years and spend 1 to 2 years in salt water (i.e., 1-ocean and 2-ocean fish, respectively) prior to re-entering fresh water, where they may remain up to a year prior to spawning (Howell *et al*., 1985). Within this species, the Klickitat River is unusual in that it produces both summer and winter steelhead, and the summer steelhead are dominated by 2-ocean steelhead, whereas most other rivers in this region produce about equal numbers of both 1-and 2-ocean steelhead.

4.11.2.2 Listing status

Middle Columbia River steelhead were listed as endangered under the ESA in 1999. Critical habitat for Middle Columbia River steelhead was designated in 2000 and includes all river reaches accessible to listed steelhead in Columbia River tributaries (except the Snake River) between Mosier Creek in Oregon and the Yakima River in Washington (inclusive). This critical habitat is well beyond the area that is likely to be affected by the proposed action.

4.11.2.3 Population status and trends

Populations of Middle Columbia River steelhead in the Yakima, Umatilla and Deschutes River basins appear to be increasing. Part of the reason for listing this species as threatened were low returns to the Yakima River, low estimates of winter steelhead abundance in Klickitat River and Fifteenmile Creek, and an overall decline of naturally-producing stocks.

4.11.2.4 Impacts of human activity on this species

Middle Columbia River steelhead occupy the intermontane region which includes some of the driest areas of the Pacific Northwest, generally receiving less than 40 cm of rainfall annually. Vegetation is of the shrub-steppe province, reflecting the dry climate and harsh temperature extremes. Because of this habitat, occupied by the species, factors contributing to the decline include agricultural practices, especially grazing, and water diversions and withdrawals. In addition, hydropower development has impacted the species by preventing these steelhead from migrating to habitat above dams, and by killing them in large numbers when they try to migrate through the Columbia River hydroelectric system.

4.11.3 Lower Columbia River Steelhead

4.11.3.1 Species description and distribution

Lower Columbia River steelhead include naturally-produced steelhead returning to Columbia River tributaries on the Washington side between the Cowlitz and Wind rivers in Washington and on the Oregon side between the Willamette and Hood rivers, inclusive. In the Willamette River, the upstream boundary of this species is at Willamette Falls. This species includes both winter and summer steelhead. Two hatchery populations are included in this species, the Cowlitz Trout Hatchery winter-run stock and the Clackamas River stock (ODFW stock 122) but neither was listed as threatened.

4.11.3.2 Listing status

Lower Columbia River steelhead were listed as threatened under the ESA in 1998. Critical habitat for Lower Columbia River steelhead was designated in 2000 and includes all river reaches accessible to listed steelhead in Columbia River tributaries between the Cowlitz and Wind Rivers in Washington and the Willamette and Hood Rivers in Oregon, inclusive. This critical habitat is well beyond the area that is likely to be directly or indirectly affected by the proposed action.

4.11.3.3 Population status and trends

There are no historical estimates of this species' abundance. Because of their limited distribution in upper tributaries and urbanization in the lower tributaries (e.g., the lower Willamette, Clackamas, and Sandy Rivers run through Portland or its suburbs), habitat degradation appears to have threatened summer steelhead more than winter steelhead. Steelhead populations in the lower Willamette, Clackamas, and Sandy Rivers appear stable or slightly increasing although sampling error limits the reliability of this trend. Total annual run size data are only available for the Clackamas River (1,300 winter steelhead, 70% hatchery; 3,500 wild summer steelhead).

4.11.4 Upper Willamette River steelhead

4.11.4.1 Species description and distribution

Upper Willamette River steelhead occupy the Willamette River and its tributaries upstream of Willamette Falls. This is a late-migrating winter group that enters fresh water in March and April (Howell *et al*. 1985). Only the late run was included is the listing of this species, which is the largest remaining population in the Santiam River system.

4.11.4.2 Listing status

Upper Willamette River steelhead were listed as threatened under the ESA in 1999. Critical habitat for Willamette River steelhead was designated in 2000 and includes all river reaches accessible to listed steelhead in the Willamette River and its tributaries above Willamette Falls upstream to, and including, the Calapooia River. This critical habitat is well beyond the area that is likely to be affected by the proposed action.

4.11.4.3 Population status and trends

No estimates of abundance prior to the 1960s are available for this species. Recent run size can be estimated from redd counts, dam counts, and counts at Willamette Falls (late stock). Recent total-basin run size estimates exhibit general declines for winter steelhead. The majority of winter steelhead populations in this basin may not be self-sustaining.

4.11.4.2 Impacts of human activity on this species

A major threat to Willamette River steelhead results from artificial production practices. Fishways built at Willamette Falls in 1885 have allowed Skamania-stock summer steelhead and early-migrating winter steelhead of Big Creek stock to enter the range of Upper Willamette River steelhead. The population of summer steelhead is almost entirely maintained by hatchery salmon, although natural-origin, Big Creek-stock winter steelhead occur in the basin (Howell et al. 1985). In recent years, releases of winter steelhead are primarily of native stock from the Santiam River system.

4.11.5 Snake River Basin Steelhead

4.11.5.1 Species description and distribution

Snake River basin steelhead are an inland species that occupy the Snake River basin of southeast Washington, northeast Oregon, and Idaho. The historic spawning range of this species included the Salmon, Pahsimeroi, Lemhi, Selway, Clearwater, Wallowa, Grande Ronde, Imnaha, and Tucannon Rivers.

4.11.5.2 Life history information

Snake River Basin steelhead, like most inland steelhead, are “summer-run” which means they enter freshwater nine or ten months before spawning. Snake River Basin steelhead enter fresh water from June to October and spawn in the following spring from March to May. The two components, A-run and B-run, are distinguished by their size, the timing of their respective adult migrations, and ocean-age. Because of these timing differences, the A-run component of the Snake River Basin steelhead is most affected by the winter, spring, and summer season fisheries in the Columbia River.

4.11.5.3 Listing status

Snake River steelhead were listed as threatened under the ESA in 1997. Critical habitat for Snake River steelhead was designated in 2000 and includes all river reaches accessible to listed steelhead in the Snake River and its tributaries in Idaho, Oregon, and Washington and is well beyond the area that is likely to be directly or indirectly affected by the proposed action.

4.11.5.4 Population status and trends

No estimates of historical (pre-1960s) abundance specific to Snake River steelhead are available. An estimated 80% of the total Columbia River Basin steelhead that run above Bonneville Dam (summer and winter steelhead combined) are hatchery fish. Total recent 5-year average escapement above Lower Granite Dam was approximately 71,000, with a natural component of 9,400 (7,000 A-run and 2,400 B-run).

4.11.5.5 Impacts of human activity on this species

When this species was listed, the Biological Review Team that reviewed the status of this species concluded that Snake River Basin steelhead were not presently in danger of extinction, but were likely to become endangered in the foreseeable future (although some members of the team concluded that there was little likelihood that this ESU will become endangered). Although the total (hatchery + natural) run size has increased since the mid-1970s, Snake River Basin steelhead recently experienced severe declines in natural run sizes. The majority of natural stocks of this species have been declining. Parr densities in natural production areas have been substantially below estimated capacity in recent years. Downward trends and low parr densities indicate a particularly severe problem for B-run steelhead, whose loss would substantially reduce life history diversity of Snake River basin steelhead.

4.12 Leatherback Sea Turtle

4.12.1 Species Description and Distribution

The leatherback is the largest living turtle. Leatherback sea turtles are widely distributed throughout the oceans of the world, and are found throughout waters of the Atlantic, Pacific, Caribbean, and the Gulf of Mexico (Ernst and Barbour 1972). In the Pacific Ocean, they range as far north as Alaska and the Bering Sea and as far south as Chile and New Zealand. In Alaska, leatherback turtles are found as far north as 60.34 N, 145.38W and as far west as the Aleutian Islands (Hodge 1979, Stinson 1984). Leatherback turtles have been found in the Bering Sea along the coast of Russia (Bannikov et al. 1971).

Leatherback turtles undertake the longest migrations of any other sea turtle and exhibit the broadest thermal tolerances (NMFS and USFWS 1998). Leatherback turtles are able to inhabit intensely cold waters for a prolonged period of time because leatherbacks are able to maintain body temperatures several degrees above ambient temperatures. Leatherback turtles are typically associated with continental shelf habitats and pelagic environments, and are sighted regularly in offshore waters (>328 ft). Leatherback turtles regularly occur in deep waters (>328 ft), and an aerial survey study in the Northeast found that leatherbacks were sighted in water depths ranging from 3 to 13,618 ft, with a median sighting depth of 131.6 ft (CeTAP 1982). This same study found leatherbacks in waters ranging from 7 to 27.2 ºC.

Leatherback turtles are uncommon in the insular Pacific Ocean, but individual leatherback turtles are sometimes encountered in deep water and prominent archipelagoes. To a large extent, the oceanic distribution of leatherback turtles may reflect the distribution and abundance of their macroplanktonic prey, which includes medusae, siphonophores, and salpae in temperate and boreal latitudes (NMFS and USFWS 1996). There is little information available on their diet in subarctic waters.

4.12.2 Life History Information

Although leatherbacks are a long lived species (> 30 years), they are somewhat faster to mature than loggerheads, with an estimated age at sexual maturity reported as about13-14 years for females, and an estimated minimum age at sexual maturity of 5-6 years, with 9 years reported as a likely minimum (Zug and Parham 1996).

Leatherback sea turtles are predominantly distributed pelagically where they feed on jellyfish such as *Stomolophus, Chryaora,* and *Aurelia* (Rebel 1974). Leatherbacks are deep divers, with recorded dives to depths in excess of 1000 m, but they may come into shallow waters if there is an abundance of jellyfish nearshore. They also occur annually in places such as Cape Cod and Narragansett bays during certain times of the year, particularly the fall.

Some of the largest nesting populations of leatherback turtles in the world border the Pacific Ocean, but no nesting occurs on beaches under U.S. jurisdiction. However, the Pacific coast of Mexico is generally regarded as the most important breeding ground for nesting leatherback turtles in the world. Leatherback turtles do not generally nest in the insular Central and North Pacific (except the Solomon Islands, Vanuatu, and Fiji). Nesting is widely reported from the western Pacific, including China, southeast Asia, Indonesia, and Australia.

4.12.3 Listing status

The leatherback was listed as endangered on June 2, 1970 and a recovery plan was issued in 1998. Leatherback turtles are included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which effectively bans trade. Critical habitat has not been designated for leatherback turtles in the U.S. Pacific, largely because nesting is not known to occur in U.S. territory and important foraging areas have not been identified.

4.12.4 Population status and trends

Globally, leatherback turtle populations have been decimated worldwide. The global leatherback turtle population was estimated to number approximately 115,000 adult females in 1980 (Pritchard 1982), but only 34,500 in 1995 (Spotila et al. 1996). The decline can be attributed to many factors including fisheries as well as intense exploitation of the eggs (Ross, 1979). On some beaches nearly 100% of the eggs laid have been harvested (Eckert, 1996). Eckert (1996) and Spotila et al. (1996) record that adult mortality has also increased significantly, particularly as a result of driftnet and longline fisheries.

The Pacific population appears to be in a critical state of decline. The East Pacific leatherback population was estimated to be over 91,000 adults in 1980 (Spotila 1996), but is now estimated to number less than 3,000 total adult and subadult animals (Spotila 2000). Leatherback turtles have experienced major declines at all major Pacific basin rookeries. At Mexiquillo, Michoacan, Mexico, Sarti *et al*. (1996) reported an average annual decline in nesting of about 23% between 1984 and 1996. The total number of females nesting on the Pacific coast of Mexico during the 1995-1996 season was estimated at fewer than 1,000. Less than 700 females are estimated for Central America (Spotila 2000). In the western Pacific, the decline is equally severe. Current nestings at Terengganu, Malaysia represent 1% of the levels recorded in the 1950s (Chan and Liew 1996).

The status of the Atlantic population is less clear. In 1996, it was reported to be stable, at best (Spotila 1996), but numbers in the Western Atlantic at that writing were reported to be on the order of 18,800 nesting females. According to Spotila (pers.comm.), the Western Atlantic population currently numbers about 15,000 nesting females, whereas current estimates for the Caribbean (4,000) and the Eastern Atlantic (i.e. off Africa, numbering ~ 4,700) have remained consistent with numbers reported by Spotila et al. in 1996. Between 1989 and 1995, marked leatherback returns to the nesting beach at St. Croix averaged only 48.5%, but that the overall nesting population grew (McDonald, et. al, 1993). This is in contrast to a Pacific nesting beach at Playa Grande, Costa Rica, where only 11.9% of turtles tagged in 1993-94 and 19.0% of turtles tagged in 1994-95 returned to nest over the next five years. Characterizations of this population suggest that it has a very low likelihood of survival and recovery in the wild under current conditions.

Spotila et al. (1996) describe a hypothetical life table model based on estimated ages of sexual maturity at both ends of the species' natural range (5 and 15 years). The model concluded that leatherbacks maturing in 5 years would exhibit much greater population fluctuations in response to external factors than would turtles that mature in 15 years. Furthermore, the simulations indicated that leatherbacks could maintain a stable population only if both juvenile and adult survivorship remained high, and that if other life history stages (i.e. egg, hatchling, and juvenile) remained static, "stable leatherback populations could not withstand an increase in adult mortality above natural background levels without decreasing.

4.12.5 Impacts of human activity on the species

The primary threats to leatherback turtles are entanglement in fishing gear (e.g., gillnets, longlines, lobster pots, weirs), boat collisions, and ingestion of marine debris (NMFS and USFWS 1997). The foremost threat is the number of leatherback turtles killed or injured in fisheries. Spotila (2000) states that a conservative estimate of annual leatherback fishery-related mortality (from longlines, trawls and gillnets) in the Pacific during the 1990s is 1,500 animals. He estimates that this represented about a 23% mortality rate (or 33% if most mortality was focused on the East Pacific population). Spotila (2000) asserts that most of the mortality associated with the Playa Grande nesting site was fishery related. As noted above, leatherbacks normally live at least 30 years, usually maturing at about 12-13 years. Such long-lived species can not withstand such high rates of anthropogenic mortality.

Based on recent modeling efforts, the leatherback turtle population cannot withstand more than a 1% human-related mortality level which translates to 150 nesting females (Spotila et al. 1996; Spotila pers. comm.). As noted previously, there are many human-related sources of mortality to leatherbacks; every year, 1,800 leatherback turtles are expected to be captured or killed as a result of federally-managed activities in the U.S. (this total includes both lethal and non-lethal take). An unknown number of leatherbacks are captured or killed in fisheries managed by states. Spotila et al. (1996) recommended not only reducing fishery-related mortalities, but also advocated protecting eggs and hatchlings. Zug and Parham (1996) point out that a combination of the loss of long-lived adults in fishery-related mortalities and a lack of recruitment stemming from elimination of annual influxes of hatchlings because of intense egg harvesting has caused the sharp decline in leatherback populations.

4.13 Steller Sea lion Critical Habitat

The term "critical habitat" is defined in the ESA (16 U.S.C. 1532(5)(A) to mean:

> *(i) the specific areas within the geographic area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of this Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management consideration or protection; and (ii) the specific areas outside of the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential to the conservation of the species.*

The ESA also states that "Except in those circumstances determined by the Secretary, critical habitat shall not include the entire geographical area which can be occupied by the threatened or endangered species."

By this definition, critical habitat includes those areas that are essential to the "conservation" of a threatened or endangered species. The ESA defines the term "conservation" as: ". . . to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary." That is, the status of the species would be such that it would be considered "recovered." Therefore, the area designated as critical habitat should contain the physical and biological resources necessary to support and sustain a population of a threatened or endangered species that is sufficiently large and persistent to be considered recovered.

4.13.1 Establishment of Steller sea lion critical habitat

The areas designated as critical habitat for the Steller sea lion were determined on the basis of the available information on life history patterns of the species, with particular attention paid to land sites where animals haul out to rest, pup, nurse their pups, mate, and molt, and to marine sites considered to be essential foraging areas. The foraging areas were determined on the basis of sightings of sea lions at sea, incidental catch data (Loughlin and Nelson 1986, Perez and Loughlin 1991), and foraging studies using satellite-linked tracking systems. Critical habitat areas were determined with input from NMFS scientists and managers, the Steller Sea Lion Recovery Team, independent marine mammal scientists invited to participate in the discussion, and the public. The proposed rule for establishment of critical habitat for the Steller sea lion was published on 1 April 1993 (58 FR 17181), and the final rule was published on 27 August 1993 (58 FR 45269). The following areas have been designated as critical habitat in the action area of one or more of the proposed fisheries (Fig. 4.9).

4.13.1.1 Alaska rookeries, haulouts, and associated areas

In Alaska, all major Steller sea lion rookeries identified in Table 1 [their Table 1] and major haulouts identified in Table 2 [their Table 2] and associated terrestrial, air, and aquatic zones. Critical habitat includes a terrestrial zone that extends 3,000 feet (0.9 km) landward from the baseline or base point of each major rookery and major haulout in Alaska. Critical habitat includes an air zone that extends 3,000 feet (0.9 km) above the terrestrial zone of each major rookery and major haulout in Alaska, measured vertically from sea level. Critical habitat includes an aquatic zone that extends 3,000 feet (0.9 km) seaward in State and Federally managed waters from the baseline or basepoint of each major haulout in Alaska that is east of

144˚ W long. Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in State and Federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144˚ W long.

4.13.1.2 Three special aquatic foraging areas in Alaska

Three special aquatic foraging areas in Alaska, including the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area.

Shelikof Strait Foraging Area

Critical habitat includes the Shelikof Strait area in the Gulf of Alaska which . . . consists of the area between the Alaska Peninsula and Tugidak, Sitkinak, Aiaktilik, Kodiak, Raspberry, Afognak and Shuyak Islands (connected by the shortest lines): bounded on the west by a line connecting Cape Kumlik (56˚38″/157˚26´W) and the southwestern tip of Tugidak Island (56˚24′/154˚41′W) and bounded in the east by a line connecting Cape Douglas (58˚51´N/153˚15´W)and the northernmost tip of Shuyak Island (58˚37´N/152˚22´W).

Bogoslof Foraging Area

Critical habitat includes the Bogoslof area in the Bering Sea shelf which . . . consists of the area between 170˚00´W and 164˚00´W, south of straight lines connecting 55˚00´N/170 00´W and 55˚00´N/168˚00´W; 55˚30´N/168˚00´W and 55˚30´N/166˚00´W; 56˚00´N/166˚00´W and 56˚00´N/164˚00´W and north of the Aleutian Islands and straight lines between the islands connecting the following coordinates in the order listed:

52˚49.2´N/169˚40.4´W; 52˚49.8´N/169˚06.3´W; 53˚23.8´N/167˚50.1´W; 53˚18.7´N/167˚51.4´W; 53˚59.0´N/166˚17.2´W; 54˚02.9´N/163˚03.0´W; 54˚07.7´N/165˚40.6´W; 54˚08.9´N/165˚38.8´W; 54˚11.9´N/165˚23.3´W; 54˚23.9´N/164˚44.0´W

Seguam Pass Foraging Area

Critical habitat includes the Seguam Pass area which ... consists of the area between 52˚00´N and 53˚00´N and between 173˚30´W and 172˚30´W.

4.13.2 Physical and biological features of Steller sea lion critical habitat

For the Steller sea lion, the physical and biological features of its habitat that are essential to the species' conservation are those that support reproduction, foraging, rest, and refuge. Land or terrestrial habitat is relatively easy to identify on the basis of use patterns and because land use patterns are more easily observed. The areas used are likely chosen because they offer refuge from terrestrial predators (e.g., are inaccessible to bears), include suitable substrate for reproductive activities (pupping, nursing, mating), provide some measure of protection from the elements (e.g., wind and waves), and are in close proximity to prey resources.

Prey resources are the most important feature of marine critical habitat. Marine areas may be used for a variety of other reasons (e.g., social interaction, rafting or resting), but foraging is the most important sea lion activity that occurs when the animals are at sea. Two kinds of marine habitat were designated as critical. First, areas around rookeries and haulouts were chosen based on evidence that lactating, adult females took only relatively short foraging trips during the summer (20 km or less; Merrick and Loughlin 1997). These areas were also important because young-of-the-year sea lions took relatively short foraging trips in the winter (about 30 km; Merrick and Loughlin 1997) and are just learning to feed on their own, so the availability of prey in the vicinity of rookeries and haulouts appeared crucial to their transition to feeding themselves.

Similarly, areas around rookeries are likely to be important for juvenile sea lions. While the foraging patterns of juveniles are only now being studied in the BSAI region, they probably depend considerably on prey resources close to haulouts. Evidence indicates that decreased juvenile survival may be an important proximate cause of the sea lion decline (York 1994, Chumbley *et al*. 1997), and that the growth rate of individual young seals was depressed in the 1980s. These findings are consistent with the hypothesis that young animals are nutritionally stressed. Furthermore, young animals are almost certainly less efficient foragers and probably have relatively greater food requirements which, again, suggests that they may be more easily limited or affected by reduced prey resources or greater energetic requirements associated with foraging at distant locations. Therefore, the areas around rookeries and haulouts must contain essential prey resources for at least lactating adult females, young-of-the-year, and juveniles, and those areas were deemed essential to protect.

Second, three additional areas were chosen based on (1) at-sea observations indicating that sea lions commonly used these areas for foraging, (2) records of animals killed incidentally in fisheries in the 1980s, (3) knowledge of sea lion prey and their life histories and distributions, and 4) foraging studies. In 1980, Shelikof Strait was identified as a site of extensive spawning aggregations of pollock in winter months. Records of incidental take of sea lions in the pollock fishery in this region provide evidence that Shelikof Strait is an important foraging site (Loughlin and Nelson 1986, Perez and Loughlin 1991). The southeastern Bering Sea north of the Aleutian Islands from Unimak Island past Bogoslof Island to the Islands of Four Mountains is also considered a site that has historically supported a large aggregation of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for sea lions (Fiscus and Baines 1966, Kajimura and Loughlin 1988). Finally, large aggregations of Atka mackerel are found in the area around Seguam Pass. These aggregations have supported a fishery since the 1970s, and are in close proximity to a major sea lion rookery on Seguam Island and a smaller rookery on Agligadak Island. Atka mackerel are an important prey of sea lions in the central and western Aleutian Islands. Records of incidental take in fisheries also indicate that the Seguam area is an important area for sea lion foraging (Perez and Loughlin 1991).

While many of the important physical and biological elements of Steller sea lion critical habitat can be identified, most of those features (particularly biological features) cannot be described in a complete and quantitative manner. For example, prey species within critical habitat can not be described in detail or with a demonstrated measure of confidence, and the lack of such information is an important impediment to the analysis of fishery effects. Walleye pollock, Atka mackerel, Pacific cod, rockfish, herring, capelin, sand lance, other forage fish, squid, and octopus are important prey items found in Steller sea lion critical habitat but for most (if not all) of these species, we are not able to reliably describe their abundance, biomass, age structure, or temporal and geographic distribution within critical habitat with sufficient clarity and certainty to understand how they interact with Steller sea lions or other consumers, including fisheries. Atka mackerel may be one of the more easily characterized sea lion prey items, but we can not describe their onshore and offshore movements, their distribution inside and outside of critical habitat or in the vicinity of rookeries and haulouts, the relation between eastern and western stocks (or whether separate stocks exist), the causes for their (apparent) two- to three-fold changes in abundance over the last two decades, and so on. Pollock appear to be considerably more dynamic in their spatial and temporal patterns, and their presence within Steller sea lion critical habitat is even more difficult to describe in a detailed or quantitative fashion.

5 ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR §402.02). The environmental baseline for this biological opinion includes the effects of a wide variety of human activities and natural phenomena that may affect the survival and recovery of threatened and endangered species in the action area. NMFS recognizes that natural phenomena and many human activities have contributed to the current status of populations of threatened and endangered species in the action area. Some of those activities have occurred in the past but no longer affect these species. Other activities may have affected, and continue to affect populations of listed species in the action area.

NMFS has managed fisheries under the FMPs for Alaska groundfish in the BSAI and the GOA since 1978 and 1981, respectively. The actions being considered in this biological opinion necessarily include past activity under the FMPs as well as proposed actions for continuing the future fisheries. Therefore, the status of threatened and endangered species in the action area partly reflects past activities conducted under these FMPs and other environmental and human-induced impacts. Consequently, the Environmental Baseline for this biological opinion will include fisheries and other activities associated with these FMPs that occurred prior to the present.

5.1 Environmental Change in the Action Area

This section summarizes the principal natural phenomena and human-related activities in the action area that are either occurring, or have occurred, and are believed to affect designated critical habitat and also the likelihood that threatened and endangered species will survive and recover in the wild. To prepare this section, NMFS relied on numerous published documents; environmental impact statements prepared by NMFS and the Department of the Interior's Minerals Management Service; annual Stock Assessment for Fisheries Evaluation (SAFE) reports for the groundfish fisheries of the BSAI, and GOA; documents that have been transmitted with annual SAFE reports since 1995; biological opinions prepared on Federal activities in the action area; and detailed information on the ecology of this region provided in reports prepared for the Minerals Management Service's Outer Continental Shelf Environmental Assessment Program; Ackley et al. (1995), Bakkala (1993), Hood and Calder (1981), Hood and Zimmerman (1986), Loughlin and Ohtani (1999), and the National Research Council (1996).

5.1.1 Natural climatic variability and the regime shift hypothesis

The North Pacific Ocean is dominated in the winter by an atmospheric phenomenon called the Aleutian Low. The Aleutian Low is a semi-permanent low pressure area that develops late in the year, dominates the winter, and begins to break down during the spring to be replaced by an extensive high pressure system during the summer (Beamish 1993). It can produce changes in atmospheric temperature, storm tracks, ice cover, and wind direction in the BSAI, and GOA (Wyllie-Echeverria and Wooster 1998). Short-term El Niño Southern Oscillation events intensify the Aleutian Low Pressure cell, which enhances wind forcing and precipitation in the North Pacific. This increases the advection of warm water into the northern region of the North Pacific Ocean, increases sea surface temperatures in the BSAI, and GOA, and can trigger a series of oceanographic events that increase ocean productivity. These events cause the marine ecosystems of the BSAI, and Gulf of Alaska to oscillate between “warm” climatic regimes and “cold” climatic regimes (Ebbesmeyer et al. 1991, Trenberth 1990, Brodeur and Ware 1992, Beamish 1993, Francis and Hare 1994, Miller et al. 1994, Trenberth and Hurrell 1994; Ingraham et al. 1998).

From 1940-1941 an intense Aleutian Low was observed over the BSAI, and GOA, this was followed recently from December 1976 to May 1977 with an even more intense Aleutian Low. During this latter period, most of the North Pacific Ocean was dominated by this low pressure system which signaled a change in the climatic regime of the BSAI, and GOA. The system shifted from a “cold” regime to a “warm” regime that persisted for several years (Niebauer and Hollowed 1993). Since 1983, the GOA and Bering Sea have undergone different temperature changes. Sea surface temperatures in the GOA were generally above normal and those in the Bering Sea were below normal. The temperature differences between the two bodies of water have jumped from about 1.1 degrees C to about 1.9 degrees C. Recent evidence now indicates that another regime shift occurred in the North Pacific in 1989.

5.1.2 Impacts on Biological Productivity and Animal Populations

Most scientists agree that the 1976/77 regime shift dramatically changed environmental conditions in the BSAI and GOA. However, there is considerable disagreement on how and to what degree these environmental factors may have affected both fish and marine mammal populations. Productivity of the Bering Sea was high from 1947 to 1976, reached a peak in 1966, and declined from 1966 to 1997. Some authors suggest that the regime shift changed the composition of the fish community and reduced the overall biomass of fish by about 50 percent (Merrick et al. 1995, Piatt and Anderson 1996). Other authors suggest that the regime shift favored some species over others, in part because of a few years of very large recruitment and overall increased biomass (Beamish 1993, Hollowed and Wooster 1992; 1995; Niebauer and Hollowed 1993, Wespestad et al. 1997a, Wyllie-Echeverria and Wooster 1998).

All of these authors agree that the regime shift produced environmental conditions that increased the abundance of numerous fish populations, particularly populations of walleye pollock, Atka mackerel, Pacific cod and various flatfish species (Beamish 1993, Niebauer and Hollowed 1993). After reconstructing the strength of different pollock year-classes, Beamish (1993) concluded that the 1978 year-class of walleye pollock was the strongest on record and dominated the commercial pollock catch in the 1980s. Beamish reached similar conclusions for several species of salmon, Pacific cod in the GOA, Pacific halibut, Pacific Ocean perch, Atka mackerel, sablefish, and Pacific herring (Beamish 1993). At the same time, small forage fish like capelin, eulachon, and Pacific sandlance declined in bays and the nearshore waters of the BSAI and western and central GOA (Anderson and Piatt 1996). Based on these observations, investigators have generally concluded that the regime shift in the late 1970s dramatically increased the population size of several marine fish species (Beamish 1993, Hollowed and Wooster 1992; 1995; Wespestad et al. 1997a, Wyllie-Echeverria and Wooster 1998). Other investigators suggest the regime shift caused the entire structure and composition of the invertebrate and fish communities of the region to change (Brodeur and Ware 1992, Beamish 1993, Francis and Hare 1994, Miller *et al*. 1994, Hollowed and Wooster 1992; 1995; Wyllie-Echeverria and Wooster 1998). In summary, there is considerable disagreement about the effect of these oscillations on the carrying capacity (K) of the North Pacific. Perhaps the carrying capacity was increased for some species and decreased for others, or that the entire K was either decreased or increased. At this point, the best available scientific and commercial data are equivocal.

5.1.1.1 Impacts on listed species environment

Although there are several listed species in the action area, Steller sea lions are used here as an example because it is the listed species for which there is the most information. We will focus this discussion on the impacts of climate variability and regime shifts on the forage species known to be important to Steller sea lions.

One hypothesis is that during regime shifts, certain species flourish, such as walleye pollock and Pacific cod, at the expense of other more preferable prey species for Steller sea lions. NMFS believes that the situation is much more complicated than this. First, from 1970 to 1980, the annual groundfish catch in the BSAI and GOA ranged from 1.3 to 2.3 million mt, very close to the current catch levels (see Table 5.1). During the same period, the catch of walleye pollock ranged from 1.0 to 1.9 million mt, which comprised about 70 to 83% of the total groundfish catch. The highest groundfish catch during this period was 2.3 million mt in 1972, of which the pollock catch was 1.9 million mt or 83% of the total.

Second, catches of pollock spawned before the regime shift were high. For example, in the GOA, the catch-per-unit-effort of walleye pollock increased by 6 times from 1961 to 1973-1976 (Ronholt et al. 1978). The greatest increases (about 17 times) were observed in Prince William Sound and around Kodiak Island. Ronholt et al. concluded that the biomass of walleye pollock had increased from 15.9 kilograms/hour to 320.5 kilograms/hour between the 1960s and early 1970s. Megrey and Wespestad (1990) estimated the total biomass of walleye pollock in the action area at around 12 million mt in 1971 and 1972, which fell below about 10 million mt after 1975 (except for 1982).

The data presented here suggest that walleye pollock comprised the majority of groundfish catches in the BSAI and GOA for almost a decade before the regime shift. Although catch is not always a reliable proxy for biomass, given the magnitude of the catches in the late 1960s and 1970s, it does indicate that the pollock biomass had been fairly substantial. In the annual SAFE document (NMFS 1999), NMFS has used models to hindcast back into the 1970s to estimate pollock biomass. However, due to inconsistent survey methodology and the lack of reliable commercial data, NMFS considers those estimates to have very large confidence bounds. For example, in the SAFE NMFS has estimated the pollock biomass in the early 1970s to be about 2 million mt, yet the catch from 1972 alone was 1.9 million mt (Table 5.1). These estimates are obviously questionable since it is inconceivable that the fishery caught nearly every fish, and then in 1973 caught another 1.8 million mt of pollock. It is unclear if these catches would have been sustainable in the long term (i.e., it is possible that overfishing was occurring). This supports the argument that pollock biomass was substantial before the regime shift, and that our current estimates of that biomass may not be accurate due to limitations in the available data.

While biomass was high before the regime shift, it is also reasonable to conclude that the 1976-1977 regime shift produced some very large year-classes of gadids (walleye pollock and Pacific cod). At the same time, the regime shift produced large year classes of other groups, including salmonids (Pacific salmon), clupeids (Pacific herring), scorpaenids (sablefish, Pacific ocean perch, and other rockfish), anoplomatidae (sablefish), and pleuronectids (Pacific halibut) among others (see Beamish 1993). The effects of the regime shift on the productivity of marine species was not limited to the BSAI and GOA. Large year classes were produced as far south as California (Beamish 1993).

NMFS believes it is reasonable to conclude that the regime shift created environmental conditions that produced very large year classes of gadids (i.e. pollock and Pacific cod).

However, because of the historically high catches of gadids before the regime shift occurred, NMFS cannot support the hypothesis that the regime shift favored gadids in a way which would allow them to out compete other fish species and dominate the ecosystem, although the absolute level of biomass is not well known.

NMFS agrees that many competing factors have contributed to the ecosystem in which Steller sea lions now depend. However, the important question here is whether the diet of Steller sea lions was adversely affected by the regime shift. Specifically, the question has been raised as to whether the increase in pollock abundance is now contributing to the decline of Steller sea lions. From the information available, it seems reasonable to conclude that gadids (i.e., pollock and Pacific cod) were abundant before the regime shift, and that sea lions relied upon them for food before the decline. Therefore, it is unlikely that a change in the structure of the ecosystem, resulting in a dominance of gadids is the sole cause of the current decline.

Shima et. al.(2000), looked at the GOA and three other ecosystems which contained pinniped populations, similar commercial harvest histories, environmental oscillations, and commercial fishing activity. Of the four ecosystems only the GOA pinniped population (Steller sea lions) were decreasing in abundance. They hypothesized that the larger size and restricted foraging habitat of Steller sea lions, especially for juveniles that forage mostly in the upper water column close to land, may make them more vulnerable than other pinnipeds to changes in prey availability. They further reasoned that because of the behavior of juveniles and nursing females, the entire biomass of fish in the GOA might not be available to them. This would make them much more susceptible to spatial and temporal changes in prey, especially during the critical winter time period (Shima et. al., 2000).

5.1.1.2 Impacts on listed species foraging success

Ashwell-Erickson and Elsner (1981) studied the energetic value of pollock in the diet of both harbor seals and spotted seals. Their study demonstrated that (a) pollock have lower energy content than herring, but more energy content than invertebrates like squid and crustaceans, (b) harbor seals digested significantly more energy from pollock than herring, and (c) that the energetic value of pollock and herring can depend on how well an animal assimilates its food, which will vary by species and by individual. They recognized that pollock had lower caloric value than fatty species like herring and believed that pinnipeds would have to consume more pollock to make up the difference (7 percent of their body weight per day versus 5 percent of body weight for fattier fish like herring). Recently, several authors have resurrected questions about the caloric value of pollock by arguing that Steller sea lions cannot survive on a diet dominated by pollock because pollock contain fewer calories than species like herring, sandlance, capelin, and smelt (Alverson 1992, Rosen and Trites 2000). A recent study conducted by Rosen and Trites (2000) concluded that captive Steller sea lions lost an average of 6.5% of their body mass after eating only pollock for 11 to 23 days. They concluded that the sea lions in their study would have to consume 35 to 80 percent more pollock than herring to maintain similar energy intakes.

From the dietary studies alone, it might be reasonable to conclude that a diet that consisted of only walleye pollock might cause Steller sea lions to lose weight, depending on the physiology of an individual sea lion. Unfortunately, feeding studies of captive animals provide little more than a general index of consumption rates that are likely in wild populations because captive animals are given diets consisting of single species of fish and have activity patterns that do not reflect those of wild populations. In the wild, pinnipeds probably feed on species that are most abundant within their foraging range and are the most easy to capture (in Ashwell-Erickson and Elsner 1981). Therefore, no clear conclusion can be drawn from the dietary studies that have been conducted to date.

Merrick et al. (1997) suggested that Steller sea lions need a diverse diet to survive. This was based on observations that Steller sea lions declined most sharply in areas with the lowest dietary diversity. This observation is supported by the diversity of species found in the diets of Steller sea lions, harbor seals, spotted seals, and fur seals in the action area. Likewise, Steller sea lions are not likely to persist solely on pollock, although pollock is currently the majority of their diet (see Table 5.2).

Comparisons were made of Steller sea lion diets from the GOA, Kodiak Island area, and southeast Alaska. The diets of Steller sea lions from the different time periods and different regions had percent similarities ranging from 63.85 to 83.85% (coefficients of dissimilarity ranged from 15.87 to 32.30%). Based on these coefficients it is reasonable to conclude that the diets of Steller sea lions presented in Table 5.2 are comparable and that species like walleye pollock, capelin, Pacific cod, and flatfish, occurred in similar proportions. It is also reasonable to conclude that the diets of the eastern population of Steller sea lions contained roughly the same proportions of walleye pollock as the western sea lion population (see Table 5.2). The diet of the eastern population of Steller sea lions was less diverse than the diet of the western sea lion population, and contained a lower percentage of fish like capelin, which have been hypothesized to be more important to Steller sea lions. Given this information, it is difficult to reconcile suggestions that a diet dominated by walleye pollock could cause the decline of Steller sea lions, in part because of the increasing trend of Steller sea lion populations in southeast Alaska and the similar dominance of pollock in their diets.

If a non-preferable diet was a major factor in the decline of Steller sea lions in Alaska, then it would be expected that other populations of Steller sea lions eating a similar diet would also suffer nutritional stress and possibly population declines. However, this does not appear to be the case. In Southeast Alaska, despite comparable diets, the population of Steller sea lions increased by several percent per year from 1979-1997 (Sease et al. 1993, Strick et al. 1997, Sease et al. 1999, Sease and Loughlin 1999). In British Columbia, Canada (P. Olesiuk, Department of Fisheries and Oceans, unpubl. data) and in Oregon (R. Brown, Oregon Department of Fish and Wildlife, unpubl. data) the Steller sea lions have remained stable. Similarly, populations of Steller and California sea lions in Washington, Oregon, and California have been stable even though they rely on diets dominated by whiting (*Merluccius bilinearis*), another gadid that likely has a lower caloric value than capelin or herring. After the whiting fishery was closed south of 42º N, the number of adult California sea lions observed foraging off the Farallon Islands increased during the fall and observations of adult sea lions increased during the summer (Baraff 1999).

There are several explanations for this disparity which have been proposed in peer reviewed documents and by the public: (1) the eastern and western populations of Steller sea lions have different physiologies and, as a result, different responses to their diets, (2) the regime shift has altered the diet of the western population differently than the eastern population, which has resulted in the decline in the western stock, and (3) other environmental conditions caused by the regime shift have resulted in the decline of Steller sea lions.

1. The first explanation is unlikely. It is true that the eastern and western populations of Steller sea lions have genetic differences (Bickham et al. 1998), which could result in different enzymatic responses to similar prey species resulting in different abilities to synthesize proteins. However, this explanation is not likely given the overlapping digestive efficiencies of various pinniped species on diets of pollock, herring, and other food items (Ashwell-Erickson and Elsner 1981, Rosen et al. 2000a). It would be extremely unlikely for the two sea lion populations to have such different responses to similar diets. Therefore, this explanation is rejected.

2. The second explanation is possible, but unlikely. The earlier regime shift of 1940-1941 (warm to a cool phase) was very intense. Yet the best available information on the abundance of Steller sea lions prior to the 1970s suggests they did not experience sharp population declines similar to the 1970s and 1980s after the regime shift of 1976/77 (cool to a warm phase). The available information on the size of the Steller sea lion population in the mid-1950s also suggests that Steller sea lions probably had not declined in response to the regime shift of 1940-1941 (Kenyon and Rice 1961, Merrick et al. 1987). Care is required in drawing any conclusions from these data, but it does suggest that Steller sea lions are not always disadvantaged by regime shifts, which suggests other contributing factors to the current decline.

   Some populations of mammals experience declines similar to the magnitude observed with Steller sea lions, but these mammals are usually short-lived, and have very high fecundity. Long-lived mammals such as sea lions rarely experience declines of 80 to 90 percent except when they are struck by disease or some other catastrophic factor. "*K*" selected species like Steller sea lions grow slowly, have low fecundity, and have developed physiological responses to resist dramatic population declines caused by natural environmental change. Since they are long lived, their breeding populations are protected against short term changes in juvenile survival (Lowry et al. 1982). However, long term adverse affects on survival would have devastating effects on the population as it would take many decades to rebuild a population.

   Furthermore, as described above, the current diet of Steller sea lions in both the eastern and western populations is dominated by pollock. Because the eastern population is increasing, it seems unlikely that the same pattern of prey consumption seen in both stocks would cause a decline in the western stock and an increase in the eastern stock. Again, other factors are likely contributing to the difference between these two populations.

3 It seems unlikely that Steller sea lions would respond to a regime shift with population declines of 80% or more, particularly given the fact that we believe regime shifts happen at 30 to 50 year intervals. It is unreasonable to expect this species to recover quickly after each regime shift. It is important to note that NMFS does not suggest that regime shifts would not cause Steller sea lions to decline at all, rather, that declines of 80 to 90% in the face of short-term, environmental change would imply that Steller sea lions are poorly adapted to changes in their environment, after surviving for thousands of years in that environment.

Based on the best scientific and commercial data available, NMFS concludes the following:

- Gadids such as walleye pollock and Pacific cod were dominant in the pelagic groundfish community both before and after the regime shift;

- The regime shift created environmental conditions that produced large year-classes of many species in the BSAI and GOA (including gadids);

- A diet solely of pollock may contribute to nutritional stress of Steller sea lions; and,

- The regime shift of 1976-1977 was not solely responsible for the decline of the western population of Steller sea lions.

Therefore, NMFS believes that the cause of the continued decline of Steller sea lions is not solely a function of the regime shift, and that other factors such as fishing, predation, and harassment are also likely contributors to the decline. These other factors will be discussed further in this biological opinion. The existence of these contributing causes of the decline do not relieve NMFS of the responsibility to insure, under the ESA, that any action authorized by NMFS is not likely to jeopardize the continued existence of listed species or adversely modify critical habitat for any listed species.

5.1.2 Possible changes in the carrying capacity of the Bering Sea and Gulf of Alaska

Populations can experience abrupt and dramatic declines because of dramatic reductions in environmental carrying capacity (Odum 1971). Such a reduction could explain the decline of top predators in the BSAI and GOA. One hypothesis argues that the regime shift favored gadids which decreased the quality of the natural environment for pinnipeds and some seabirds, due to the lower energy content compared to herring and capelin that theoretically dominated the pelagic community during the "cold" regimes. As a result, this theory would indicate that the regime shift lowered the carrying capacity of the BSAI and GOA for species like Steller sea lions, northern fur seals, harbor seals, kittiwakes, and murres.

Conversely, the other side of this debate accepts that the climatic regime shifted in the mid-1970s and that the regime shift produced large year-classes of groundfish in 1976-1977 (NMFS 1998). This would not necessarily reduce the carrying capacity of the system for pinnipeds, such as Steller sea lions, northern fur seals, harbor seals, kittiwakes, or murres. In fact, it could possibly increase the carrying capacity.

All animal populations fluctuate over time; sometimes in response to changes in their physical environment, sometimes in response to changes in their ecological relationships (predator-prey dynamics), and sometimes in response to combinations of the two. Large, natural variability often masks the effects of human activity on natural ecosystems and populations. Because of the complex relationships between wild populations, their physical environment, and their ecological relationships, it is extremely difficult to assign a populations' decline to a single cause.

Further complicating our understanding of these natural phenomena, a major expansion of the groundfish fisheries occurred in the BSAI and GOA during the 1977-1978 regime shift. As these groundfish fisheries expanded, numerous investigators expressed concern about the effects of the expanded fisheries on populations of pinnipeds and seabirds in the North Pacific Ocean (Alverson 1991, Ashwell-Erickson and Elsner 1981). Several populations of seabirds and pinnipeds declined from the early to mid-1980s. As a result, scientists and fishery managers began to debate the relative roles of the regime shift and the groundfish fisheries on trophic relationships in the BSAI and GOA (Lowry et al. 1982, Alaska Sea Grant 1993). When Steller sea lions were listed as threatened in 1990, then reclassified to endangered in 1997, the debate increased in intensity.

It is clear, given an almost 90% reduction in the western population of Steller sea lions, that the environmental carrying capacity has somehow been reduced. The decline has been so severe, and continuous, that Steller sea lions have been listed as an endangered species under the ESA, and is thereby given all the substantive protections associated with that Act. Given the equivocal data surrounding the dietary needs of Steller sea lions, the regime shift hypothesis, and massive population declines, it is highly unlikely that natural environmental change has been the sole underlying cause for the decline of Steller sea lions. Therefore, this consultation looks to other possible causes of the decline recognizing that environmental change is an important component in this equation, and may combine with other factors to contribute to the past and continuing decline of Steller sea lions.

5.2 Impacts of Killer Whale Predation on Natural Mortality of Listed Species

The following discussion summarizes the best available scientific information on the magnitude and likely impacts of Orca predation on listed species in the action area. This information is typically presented in the Status of Species section. However, given the magnitude of the impacts, especially on Steller sea lions, it is appropriate to discuss this source of natural mortality in the Baseline.

5.2.1 Steller sea lions

Killer whale predation on Steller sea lions has likely been a considerable source of natural mortality for the species. During the 1970s, when Steller sea lions were at their highest recorded levels (about 200,000 animals), predation by killer whales, although numerically large, was probably a minor factor in population growth. Today, given the nearly 90% decline in the population size of Steller sea lions, it is likely that the impact of similar levels of killer whale predation is more significant and may be affecting the species ability to recover.

For this analysis, it has been assumed that predation on Steller sea lions is by transient-type killer whales only (Barrett-Lennard et al. 1995, Forney et al. 1999). A status report on the eastern North Pacific transient stock of killer whales is included in Forney et al. (1999). The distribution of this stock ranges from waters off Alaska south to California. The stock is described as a trans-boundary stock, including killer whales from British Columbia (Canada) and the U.S. A minimum population estimate of 336 is reported by Forney et al. (1999). No data are reported concerning trends in abundance.

Regarding predation by killer whales on Steller sea lions, Frost et al.(1992) reported that an unusual number of killer whales appeared inshore in waters of the southeastern Bering Sea in the summers of 1989 and 1990. Multiple sightings of killer whales were reported from Bristol Bay and the Kuskokwim Bay, where killer whales had been seen only rarely in previous years. Of the 27 reported sightings in 1989 and 1990, one sighting of 4 whales near Round Island involved chasing of a Steller sea lion.

The most comprehensive paper on the impact of killer whale predation on Steller sea lion populations is by Barrett-Lennard et al. (1995). In this report, the authors summarize the results of a survey of mariners regarding observations of killer whale predation on Steller sea lions, available data on the diet of killer whales based on stomach content analysis from stranded killer whales in Alaska and British Columbia, an analysis to estimate the population size of transient killer whales in the eastern North Pacific, and the results of a simulation analysis on the impacts of killer whale predation on Steller sea lion populations.

The authors concluded the following:

- There have been surprisingly few observations of killer whale predation on Steller sea lions by mariners and that most of the attacks that have been witnessed have been directed at adult animals;

- Pup mortality of Steller sea lions caused by killer whales is likely underestimated by techniques based on direct observations;

- Two of eight stomachs (25%) from stranded killer whales contained at least some marine mammal tissues, including tissues from Steller sea lions;

- There are at least 250 transient killer whales in the eastern North Pacific, where approximately 50% of these occur south of Prince William Sound and 50% occur in Prince William Sound or to the west;

- Killer whale predation did not cause the observed decline in sea lion abundance between the 1970s and the 1990s, but at current population levels may be a contributing factor to the current decline; and

- At a population size of 125 killer whales and 42,000 Steller sea lions, 18% of the deaths occurring annually could be caused by killer whale predation. However, the authors noted that the results of the simulations "are not better than the assumptions they are built on" (p. 38).

In the concluding paragraph of the report, the authors also noted that "A better understanding of the impact of killer whale predation on Steller sea lion populations requires more precise knowledge of the age-specificity and seasonality of killer whale predation patterns."

As presently drafted, NMFS considers the conclusions of the Barrett-Lennard et al. report adequate to support the conclusion that killer whale predation on the current population of Steller sea lions in western Alaska is potentially significant and should be investigated further. However, prior to final publication, NMFS believes the following concerns need to be addressed by the authors of the report. First, considerable uncertainty (as noted by the authors) exists in the estimates of parameters used to run the simulations. At a minimum, this uncertainty should be incorporated into the estimation process and used to provide some type of confidence interval around specific output parameters. For example, there is no information available that supports the parameters used to conclude that the vulnerability of pups to killer whale predation is five times the vulnerability of 5 to 20 year old animals. Likewise, there are inadequate data to support the value used in the model regarding the proportion of Steller sea lions in the killer whale diet. While it is unreasonable to expect the authors to provide the information needed to reduce uncertainty in the parameters used in their model, it is clear that additional research is needed before reliable conclusions regarding the impact of killer whale predation on Steller sea lions can be finalized.

Second, there are a number of problems in the way the model was constructed. These include, but are not limited to, the following:

  - The authors assumed that density dependent effects in the dynamics of the sea lion population model were unimportant because the range of population sizes of Steller sea lions used in the simulations was well below maximum levels. This would be a reasonable approach if it could be assumed that the carrying capacity (K) for this population was constant. However, as noted by several authors (Alverson 1992, Rosen and Trites 2000a) such an assumption seems unwarranted regarding Steller sea lions. Therefore, the underlying population model for Steller sea lions needs to be revised to account for the possibility of density dependent effects in sea lion dynamics due to a reduction in the carrying capacity of the environment for Steller sea lions.

- The authors assumed that killer whale predation on Steller sea lions was additive rather than assuming that at least some of the mortality was compensatory. This difference is likely to be insignificant in models where the population growth rate is independent of density, but is likely to be very important where the growth rate of the sea lion population is affected by its status relative to K. Therefore, one approach that needs to be incorporated into the analysis is the assumption that the mortality of sea lions caused by killer whale predation is entirely compensatory in a density dependent model.

As noted above, the available data are inadequate to develop a reliable estimate of what fraction of total Steller sea lion mortality is due to predation by killer whales. However, as a first-order approximation, the following simplified approach was developed. The results are similar to those reported by Barrett-Lennard et al. Here NMFS has estimated the number of Steller sea lions eaten by a population of killer whales, the mortality rate associated with that level of predation, and the percentage of total mortality due to killer whale predation. The number of sea lions eaten by a specified number of killer whales was calculated as the product of:

1. The amount of Steller sea lions eaten by an average sized killer whale in kg/day;
2. The number of days killer whales feed on Steller sea lions;
3. The number of killer whales in the population;
4. The average weight of a Steller sea lion; and
5. The percent of Steller sea lions in the diet of killer whales.

In the analysis it was assumed that the Steller sea lion population was declining at 5% per year and that killer whale predation was additive. Using the scaled vital rates reported by York (1994), the crude death rate in the absence of killer whale predation was estimated to equal 0.20. It was also assumed that the average size of a Steller sea lion was 160 kg and that killer whales consume 74 kg/day/animal (Barrett-Lennard et al. 1995). Clearly, the uncertainty included in Table 5.3 is only a subset of the actual uncertainty associated with such a calculation, so the reported results should only be considered as a rough approximation to the real impact of killer whales in the North Pacific on the western stock of Steller sea lions.

The results (Table 5.3) indicate that killer whale predation by 125 killer whales on a population of 42,000 Steller sea lions could cause an annual mortality of between 5% to 8%. Expressed as a fraction of the crude death rate, killer whale predation could be responsible for a minimum of 20% or as much as 27% of total mortality. The uncertainty in these results are likely underestimated, as the fraction of Steller sea lion biomass in the diet of killer whales that are located in the range of the western stock of Steller sea lions is unknown. For example, if the percent of killer whale diet made up of sea lions was only 5% (rather than between 10% and 15% assumed in Barrett-Lennard [1995]), the resulting annual mortality associated with killer whale predation would be only 2.5%, while if there were 250 killer whales the annual mortality associated with a diet of 25% sea lions would be 13%.

5.3 Impact to Water Quality Due to Human Population Growth in the Action Area

As the size of human communities increases, there is an accompanying increase in habitat alterations for housing, roads, commercial facilities, and other infrastructure. The impacts of these activities on landscapes and the biota they support increases as the size of the human population expands. The Alaska population has increased by almost 50 percent in the past 20 years, most of that increase has occurred in the Cities of Anchorage and Fairbanks (Table 5.4). Outside of the City of Anchorage, few of the cities, towns, and villages would be considered urbanized. Despite low levels of industrialization in the action area, some commercial and industrial facilities in the action area have had, or have the potential for significant, adverse effects on the terrestrial, coastal, and marine environments, primarily because of their potential effects on water quality.

Four superfund sites occur in the action area: Adak Naval Air Station (Aleutians West), Elmendorf Air Force Base (Borough of Anchorage), Fort Richardson Army Base (Borough of Anchorage), and the U.S. Department of Transportation's Standard Steel and Metals Salvage Yard ((Borough of Anchorage).

The Naval Air Station at Adak covers about 64,000 acres on the Island of Adak near the western end of the Aleutian Island archipelago. Adak Island became a military base in 1942 and has been controlled by the U.S. Navy since 1950. In 1986, the Navy identified 32 areas that potentially received hazardous substances, including chlorinated solvents, batteries, and transformer oils containing polychlorinated biphenyls (PCBs) over a period of 40 years. Investigations on the island focused on two areas: the Palisades Landfill and Metals Landill. Disposals had stopped at the Palisades landfill in the 1970s and the landfill was covered. The Metals landfill contains a hazardous waste pile under the Resource Conservation and Recovery Act and a closure plan is being developed the site.

The cities of Kodiak and Unalaska both have wastewater treatment plants, along with the City of Anchorage and several cities in the Kenai borough. Most of the industrial facilities in the action area (outside of Anchorage and the Kenai Borough) are involved in seafood processing. Canneries or land-based processors occur at Adak, Anchorage, Chignik, Cordova, Dillingham, Egegik, Emmonak,, False Pass, Homer, Kenai, King Cove, King Salmon, Kodiak, Larsen Bay, Nikiski, Ninilchik, Nome, St. Paul, Sand Point, Savoonga, Seward, Soldotna, Togiak, Toksook Bay, Unalaska, Valdez, and Whittier.

In the 1970s, fish and shellfish waste discharged from mobile and shore-based processors at Kodiak, Dutch Harbor, and Akutan polluted coastal waters around those communities (Jarvela 1986). In 1976, waste was discharged at Dutch Harbor. In 1983, the shore-based Trident Seafoods plant at Akutan released between codfish and crab wastes into Akutan Harbor before the plant was destroyed by fire. Sonar surveys of Akutan Harbor identified a waste pile that was about 7 m thick and 200 m in diameter. In 1998, the list of impaired waters that was prepared by the Alaska Department of Environmental Conservation included water bodies in Cold Bay, Dutch Harbor, and Kodiak that had been impaired by seafood processing, logging operations, military materiel, or fuel storage. Although total maximum daily loads will not be developed for these facilities before this biological opinion is completed, the effects of these facilities appear to be localized and would not be expected to adversely affect threatened or endangered species under NMFS' jurisdiction.

As the human population expands, the risk of disturbance to listed species in the action area, especially Steller sea lions, also increases. Several studies have noted the potential adverse effects of human disturbance on Steller sea lions. Calkins and Pitcher (1982) found that disturbance from aircraft and vessel traffic has extremely variable effects on hauled-out sea lions. Sea lion reaction to occasional disturbances ranges from no reaction at all to complete and immediate departure from the haulout area.

The type of reaction appears to depend on a variety of factors. When sea lions are frightened off rookeries during the breeding and pupping season, pups may be trampled or even abandoned in extreme cases. Sea lions have temporarily abandoned some areas after repeated disturbance (Thorsteinson and Lensink 1962), but in other situations they have continued using areas after repeated and severe harassment. Johnson et al. (1989) evaluated the potential vulnerability of various Steller sea lion haulout sites and rookeries to noise and disturbance and also noted a variable effect on sea lions. Kenyon (1962) noted permanent abandonment of areas in the Pribilof Islands that were subjected to repeated disturbance. A major sea lion rookery at Cape Sarichef was abandoned after the construction of a light house at that site, but then has been used again as a haulout after the light house was no longer inhabited by humans. The consequences of such disturbance to the overall population are difficult to measure. Disturbance may have exacerbated the decline, although it is not likely to have been a major factor.

5.4 Historical Harvest of Currently Listed Species

5.4.1 Subsistence harvests of listed species

The MMPA authorizes the taking of any marine mammal by Alaska Natives for subsistence purposes or for the purpose of creating and selling authentic native articles of handicrafts and clothing, given that it is not done in a wasteful manner (MMPA, Section 101[b]). The ESA also contains provisions that allow for the continued subsistence use of listed species. Both the ESA and the MMPA contain provisions that allow regulation of the subsistence harvest of endangered, threatened, or depleted species, if necessary (NMFS 1995).

5.4.1.1 Steller sea lions

Subsistence harvests of Steller sea lions from 1960 to 1990 have been estimated at 150 animals per year (Alverson 1992), but the estimate was subjective and not based on any referenced data. This estimate is well below the levels observed in the 1990s. More recent estimates (Wolfe and Mishler 1993, 1994, 1995, 1996) indicate a mean annual subsistence take of 448 animals from the western U.S. stock (i.e., the endangered population) from 1992 to 1995, declining to 178 (with 95% confidence limits of 137 to 257) in 1998. It is likely that the earlier estimates of subsistence underestimate of the actual number of animals taken for subsistence. The majority of sea lions have been taken by Aleut hunters in the Aleutian and Pribilof Islands. The great majority (99%) of the statewide subsistence take was from west of 144°W long. (i.e., the range of the western population).

The overall impact of the subsistence harvest on the western population of Steller sea lions is determined by the number of animals taken, their sex and age class, and the location where they are taken. As is the case for other sources of mortality, the significance of subsistence harvesting may increase as the western population decreases in size unless the harvesting rate is reduced accordingly. The current subsistence harvest represents a large proportion of the potential biological removal that was calculated for the western stock of the Steller sea lion pursuant to the MMPA (Hill and DeMaster 1998). However, the subsistence harvest accounts for only a relatively small portion of the animals lost to the population each year. For example, a population of about 40,000 growing at 8% per year would be expected to increase to 43,200 after one year; a gain of 3,200 animals. If, instead, that population is observed to decline by about 5%, then it would drop to 38,000, a loss of 2,000. The difference between expected and observed is, then, 5,200 animals, of which a subsistence harvest of say, 250, would account for 5%. Thus, the numbers of animals currently taken must contribute to the decline of sea lions, particularly at certain locations, but are not sufficient to explain the decline throughout the range of the population. It is not known, however, whether the current harvest levels inhibit recovery at selected sites.

5.4.1.2 Large cetaceans

Native Alaskans harvested whales in the eastern north Pacific for many years prior to the arrival of commercial whalers in the 19th century. The Inuit of the Bering Sea coast of Alaska have been whalers for centuries. Aboriginal whaling took place in three main areas in the eastern north Pacific (1) the west and northwest coasts of Alaska, (2) the Aleutian Islands and the Alaska peninsula, and (3) the coasts of Vancouver Island and Washington.

The Aleuts of the Aleutian Islands and the Alaska peninsula hunted whales with hand-thrown spears. They likely harvested humpback whales, gray whales and possibly right whales. Along the coast of British Columbia and Washington, whales were hunted by Nootka, Makah, Quilleute, and Quinault tribes, who targeted gray and humpback whales, and possibly right whales. The number of whales that were taken in these fisheries is unknown (Scarff 1986).

5.4.2 Commercial harvest of listed species

5.4.2.1 Steller sea lions

In 1959, the Bureau of Commercial Fisheries awarded a contract to a commercial fishing company to develop techniques for harvesting sea lions in Alaskan waters. The two-fold purpose of the contract was to reduce the sea lion herds (because of alleged depredations on salmon and halibut fisheries) and to provide an economical source of protein for fur farms, fish hatcheries, and similar purposes (Thorsteinson and Lensink 1962). In 1959, 630 sea lion bulls were killed in an experimental harvest, but the harvest proved uneconomical. Another study was contracted by the Bureau of Indian Affairs of the Department of Interior to analyze the feasibility of a commercial sea lion harvest in Alaska. A total of 45,178 pups of both sexes were killed in the eastern Aleutian Islands and GOA between 1963 and 1972 (Merrick et al. 1987). Such harvests could have depressed recruitment in the short term and may have explained significant portions of the declines noted at some sites in the eastern Aleutian Islands or the GOA. Bigg (1988) provides a minimal accounting of the thousands of sea lions killed at rookeries and haulouts in British Columbia from 1912 to 1968. The impact of such killing on numbers of sea lions in southeast Alaska undoubtedly had a local, temporal effect at the time of the harvests. However, the eastern population of Steller sea lions has been increasing at 2-3 % per year during the 1990s. Therefore, historical harvests do not seem to be impacting current population growth .

Commercial harvests of adult, male sea lions in 1959 likely had no significant effect on population trends. However, harvest of over 45,000 pups from 1963 to 1972 contributed to local population trends in the 1960s through the early 1980s in the GOA and the eastern Aleutian Islands. Similarly, subsistence harvests prior to the 1990s were not measured but may have contributed to population decline in localized areas where such harvests were concentrated.

5.4.2.2 Northern fur seals

Commercial harvests of marine mammals in the Bering Sea began with the industrial harvest of northern fur seals in the Pribilof Islands in the late 1700s. The size of the fur seal population on the Pribilofs was estimated at 2.5 million animals (Kenyon et al. 1954). From its beginning until about 1835, commercial harvests of these fur seals were “extravagant, wasteful, and largely unrecorded” (Kenyon et al. 1954). By 1803, about 800,000 skins had accumulated in storehouses on the Pribilofs, 700,000 of which “were thrown into the sea as worthless.”

By 1834, the northern fur seal population had declined to less than 1,000,000 animals, which resulted in a seven-year ban on killing fur seals to allow the population to recover. From the 1840s to the 1860s, the harvest of fur seals increased from 10,000 animals per year to about 75,000 animals. In 1868, when the U.S. first occupied the Pribilof Islands, 242,000 fur seals were harvested. From 1870 to 1909, commercial companies from the U.S. conducted the fur seal harvest accompanied by the onset of pelagic sealing.

The practice of pelagic sealing was not selective and resulted in the death of a high percentage of pregnant, female fur seals. From the 1860s to about 1911, more than 950,000 fur seals were taken by pelagic sealers. At the same time, more than 2,900,000 fur seals were taken on the Pribilof Islands. `The combination of pelagic sealing and land-based sealing dramatically reduced the size of the fur seal population: by 1897, the fur seal population had been reduced to about 400,000 animals; by 1911, it had been reduced to about 215,000 animals. Because the takes were greatly reducing the fur seal stock, Great Britain (for Canada), Japan, Russia, and the United States ratified the Treaty for the Preservation and Protection of Fur Seals and Sea Otters in 1911. The treaty prohibited pelagic sealing and required a reduction in the taking of seals on the land.

From 1912 to the mid-1950s, the population slowly increased to about 1,500,000 animals with a harvest of about 60,000 male seals each year. In the early 1950s, biologists realized that the fur seal population had ceased to grow and agreed to experiment with increasing the harvest of male fur seals and begin another harvest of female fur seals in the hope that the fur seal population would increase further. In 1953, the harvest of female fur seals began with the death of about 850 female fur seals. This harvest peaked in 1957, with 47,413 animals. From its discovery until the mid-1950s, more than 7.8 million fur seals were taken in commercial harvests. In 1957, the signatories of the 1911 Treaty ratified a new agreement, the Interim Convention on the Conservation of North Pacific Fur Seals, for the conservation, research, and harvesting of fur seals. About 18,000 female fur seals were killed each year from 1963 to 1968.

When this experiment ended, more than 300,000 female fur seals had been killed in an attempt to increase the productivity of the population and, as a result, the size of the commercial harvest (Kenyon et al. 1954). The harvest did not increase the population’s productivity as expected; instead, pup production on St. Paul Island declined by 7 percent per year from 1975 to 1983 and production on St. George declined by 6 percent per year from 1973 to 1990. From 1950 to 1988, the fur seal population declined by over 50 percent (to about 1 million animals).

The authority of the 1957 Convention was extended in 1963, 1969, 1976 and 1980. Under the terms of the 1980 extension, the Convention expired on October 14, 1984. In consultation with the U.S. Departments of State and Justice, and the Marine Mammal Commission, the United States declined to sign an extension. It was determined that no commercial harvest could be conducted under existing domestic law and, therefore, the commercial harvest on St. Paul Island was terminated. Management of the fur seals then reverted to the MMPA. Accordingly, on July 8, 1985, NMFS issued an emergency interim rule to govern the subsistence taking of fur seals for the 1985 season under the authority of section 105(a) of the Fur Seal Act. A final rule was published on July 9, 1985. In 1988, the Pribilof Island fur seal stock was declared depleted under the provisions of the MMPA of 1972 (NMFS 1993).

5.4.2.4 Large cetaceans

By the late 1800s, commercial whaling had severely reduced the population of bowhead whales in the Bering and Chukchi Sea and had left the Pacific right whale population nearly extinct. The modern era of pelagic whaling in the north Pacific began in 1952, with a single factory ship operating off Asia. From 1954 to 1961, only three factory ships operated, but this type of whaling extended eastward to the American side of the Pacific. In 1963, the arrival of seven factory ships from Japan and USSR to whaling grounds in the north Pacific partially resulted from the protection of blue whales in the Antarctic and strict quotas on other Antarctic species. These pelagic whalers concentrated on humpback whales in the early 1960s, switched to fin whales in the mid-1960s, then switched to sei whales in the late 1960s. In 1970s, whalers in the north Pacific focused on hunting sperm whales and took between 8,000 to 10,000 per year during that period. From the 1950s to the 1970s, an estimated 5,671 blue whales, more than 21,000 fin whales, 40,000 sei whales, 30,143 humpback whales, and 210,000 sperm whales had been killed in the North Pacific ocean.

Blue Whales

From 1889 to 1965, about 5,761 blue whales were killed in the North Pacific Ocean (Braham 1991). The effects of these deaths on the blue whale population can be seen in the catch data from Japan. In 1912, 236 blue whales were killed; in 1913, 58 blue whales were killed; in 1914, 123 blue whales were killed; and from 1915 to 1965, the numbers of blue whales that were killed declined continuously (Mizroch et al. 1984a). In the eastern North Pacific, 239 blue whales were killed off the California coast in 1926. Off the Aleutian Islands, Japanese whalers killed 70 blue whales each year from the late 1950s to the early 1960s (Mizroch et al. 1984a).

Bowhead Whales

Prior to commercial whaling, the bowhead whale population was estimated at 14,000 to 26,000 animals (Breiwick et al. 1981). Commercial whalers killed an estimated 19,000 to 21,000 whales from 1848 to 1915. In 1912, their population declined to about 600 animals.

Fin Whales

Fin whales were not hunted until the 20^{th} century, with the advent of fast-moving boats and explosive harpoons. In the 1940s, whalers extended into the North Pacific Ocean to hunt fin whales. From about 1940 to 1962, 80% of the whales killed in the North Pacific were fin whales, which were hunted in five major areas: off the Kamchatka Peninsula to near Attu Island, the south side of the Aleutians, north of Unalaska Island, west of St. Matthew Island and near Cape Navarin.

From 1954 through 1962, whalers killed about 1,560 fin whales per year (Nishiwaki 1966). Between 1963 and 1974 about 21,474 fin whales were killed in the North Pacific Ocean (Tillman 1977; see Table 5.5). From 1960 to 1967, about 4,000 fin whales of these whales were killed in the Gulf of Alaska. Originally, the global population of fin whales was around 470,000; between 70,000 and 75,000 individuals remain.

Gray Whales

The gray whale fishery began in the early 1800s. In 1957, Scammon discovered the calving lagoons in Mexico: the whales were hunted heavily there and by 1875, Scammon predicted that gray whales would be extinct (Lowry et al. 1982). Over 9,000 gray whales were taken from 1846 to 1900 (Rice and Wolman 1982; Brownell 1977). With the advent of modern whaling techniques in the early 20th century, whaling effort increased again and almost 1,000 additional whales were killed between 1905 and 1948, when the IWC banned further hunting of this species. Between 1959 and 1969, 316 gray whales were taken off California for scientific purposes. Since the 1960s, Russia has conducted a regulated, annual hunt of gray whales to provide food for coastal Siberian eskimos; the average annual take is 165 per year (Wolman and Rice 1979). The average annual take of gray whales by Alaskan eskimos has been less than 3 per year since 1970, reaching a maximum of seven in 1975.

Humpback Whales

In the North Pacific, humpback whale populations were targeted by commercial whaling throughout the 1950s until they were protected in 1965 (Tillman 1975). Before whaling began, about 15,000 humpback whales are estimated to have occupied the North Pacific.

Right Whales

Whaling ships from Britain, France, and the United States began hunting right whales in the East China Sea around 1822. Whaling ships from the U.S., France, Britain, Germany, and Hawaii began hunting right whales in waters off Kodiak Island around 1835, with a peak from 1840-1848. Whaling ships from the United States, Britain, France, Germany, Russia, and Hawaii hunted right whales in the Okhtosk Sea around 1845. Between 1840 and 1969, about 15,000 right whales were killed in the North Pacific.

Sei Whales

Between 1963 and 1974, whalers killed about 40,547 sei whales in the North Pacific Ocean (see Table 5.6). Between 1960 and 1967, whalers killed about 5,000 sei whales in the northern Gulf of Alaska (Tilman 1977).

Sperm Whales

Sperm whales were hunted commercially in the North Pacific Ocean from the early 1900s to the early 1980s. In the early 1970s, whalers killed between 8,000 and 10,000 sperm whales per year in the North Pacific. From 1979 to 1980, the IWC set the quota for sperm whales at 2,700 animals in the North Pacific. Before this modern period whaling ended, about 210,000 sperm whales had been killed in the North Pacific Ocean. About 26,000 of these whales were killed in the Bering Sea (unpublished data from IWC cited in NRC 1996).

5.4.3 Aggregate Known Mortality of Steller Sea Lions in Alaska

The western stock of Steller sea lions declined at an unprecedented rate of over 15% per year during the 1980s. However, between 1991 and 2000, the population declined at an annual rate of approximately 4% per year. The observed rate of decline of this sea lion population in the 1980s has been attributed to several factors, including mortality incidental to commercial fishing, the effects of a major regime shift in the North Pacific, predation, harvests by subsistence hunters, and competition with commercial fisheries. Other factors, such as disease or pollutants, while not entirely excluded as contributing factors, have been considered of lesser importance in explaining the observed pattern of declines. The following is an attempt to bring together all of the estimated mortalities of Steller sea lions and a synthesis of the significance of those takes.

Perez and Loughlin (1991) conclude that "the high catch of northern sea lions during the 1970s by foreign fisheries may partially account for the reported decline of their populations in the Aleutian Islands region and the western GOA at that time, but except for 1982-84 Shelikof Strait fishery, incidental catch in recent years by JV fisheries is low and does not explain the present continuing decline." Further, Merrick et. al. (1987) dismissed the commercial harvest as a reason for the overall decline but suggested that local declines may have been affected by the pup harvests. Trites and Larkin (1992) suggested that shooting could have also had local population effects. Another source of mortality that has not been estimated is the take of Steller sea lions for bait in the crab fisheries in the early 1970s. Combined with other incidental take, this may have had an effect in the population declines in the late 1970s and 1980s (Loughlin, pers. comm.)

By themselves, each of the reported takes would have had much less of an effect on the Steller sea lion population. However, when taken together in time and location, a case can be made for significant effects as a result of the pup harvest, shooting, and incidental take in the early years of the decline in the eastern Aleutians and western GOA. By 1990, most of these takes had been discontinued. Mortality incidental to commercial fisheries since 1990 has been estimated to be less than 50 animals per year. Therefore, the contribution of incidental mortality to the current rate of decline is considered negligible. Regarding the major regime shift which is thought to have begun in the late 1970s, there is current evidence that this condition has remained relatively unchanged at least through most of the 1990s. Data are not currently available to assess the impact of predation (e.g., killer whales) on the western population of Steller sea lions in either 1980s or 1990s, other than to conclude killer whale predation could have been a contributing factor in both time periods (although there is no evidence to suggest that there has been a change in predation patterns in the last two decades). Finally, the most recent subsistence harvest data indicates that annual harvest levels are less than 1% per year and are more likely to be less than 0.5% per year. Therefore, removals due to subsistence harvest is not thought to be a primary factor in the current decline.

5.5 Impacts of Commercial Fisheries Within the Action Area

The BSAI and GOA contain some of the most productive waters on earth. The continental shelf in the eastern Bering Sea is broad and supports large, standing stocks of groundfish. The GOA has a much narrower shelf and supports a smaller standing stock. Since the 1950s, a complex international fishery harvests numerous species; most of the fish harvested in this region are groundfish. The Bering Sea supports about 300 species of fish, most of which live on or near the bottom. About 24 of these species support commercial fisheries in the BSAI.

Commercial fisheries in the action area have gone through many cycles of development and collapse since they began in the 1800s and the focus of the fisheries has shifted many times since its beginning. This section is organized in three primary time intervals: the1800s to 1950s, the 1950s to 1970, and 1970 to the present.

5.5.1 Impacts of early commercial fisheries from the 1800s to the 1950s

The first small-scale fishing enterprise began in 1785 at the Karluk River on Kodiak Island to provide dried salmon to the Russian fur traders. Some export of salted salmon began in the early 1800s when the Russian American Company shipped small quantities of salted salmon to St. Petersburg, Russia. The commercial potential of the abundant Alaska salmon resource was not realized until the 1860s when a technique for large-scale canning of salmon was developed. The first salmon cannery on the Pacific Coast was opened in California in 1864, and salmon canneries were built in Alaska for the first time in 1878. The salmon fishery in the Bering Sea began in the late 1800s with harvests from the western region dominating from 1878 to 1910. Prior to Alaska statehood, management of the salmon fishery was inadequate to protect salmon stock and many stocks were overfished as a result.

Pacific cod supported the first groundfish fishery in the Bering Sea. The first reported commercial groundfish fishery did not begin until 1864. The cod was harvested in 1864 as part of an exploratory fishery involving a single schooner. Starting in 1882, they were taken by a fleet operating from ports in Washington, California, and from shore stations in the Aleutian Islands (Bakkala et al. 1981). During this early fishery, the fleet consisted of schooners and the gear consisted of handlines from one-man dories.

Except for Pacific cod, and to a lesser extent sablefish, groundfish generally were ignored for targeted fisheries in the late 1800s and early 1900s. Market demand, and the ability to transport fish products from remote locations in Alaska to the market at reasonable cost, determined whether a fishery for a species would develop; not the abundance or availability of the species to fishermen. Hence, most groundfish, except for cod and halibut, were discarded or used for bait. For example, pollock was considered an excellent bait fish for cod.

The groundfish fisheries were small in scale and used hook and line gear either as hand lines or setlines (long anchored lines with hooks attached at intervals). Stationary gill net gear was introduced in the New England cod fisheries in 1878 and beam trawls towed by sailing vessels appeared in the 1890s, but the extent of their use in the Alaska cod fisheries is unknown. Steam power was introduced to fishing vessels in the beginning of the 20^{th} century. This power source allowed vessels to pull larger and more efficient otter trawls, which relied on otter boards or doors to open the mouth of a trawl instead of a beam. Beam trawl gear in the Northwest was first used in 1884. A sail-powered fishing vessel, and a trade magazine in 1903 reported that an unnamed vessel was experimenting with an otter trawl in the halibut fishery in British Columbia. Trawl or drag fisheries became well-established in the Northwest, and presumably in Alaska, over the next 40 years.

A setline fishery for Pacific cod developed in 1867. Fisheries for halibut, sablefish, and groundfish developed later. Regular annual landings of Pacific cod caught in the Bering Sea began in 1882. This cod fishery reached its peak during World War I, when estimated annual catches ranged from 12,000 to 14,000 mt (Bakkala et al. 1981). In 1918, the Secretary of Commerce issued an order that suspended the prohibitions on landing of catches by foreign vessels in U.S. ports to encourage the importation of fish to compensate for reduced food supplies caused by World War I. This order was terminated in 1921. During the time the order was in effect, Japanese vessels landed 4.5 million dry-salted cod and 80 mt of dried, unsalted cod. Although most of this cod was from around the Kurile Islands and Sea of Okhost. The size of this fishery declined after 1920, their catch slowly declined, and the fishery ended in 1950

(Bakkala et al. 1981).

The increased catching power of trawl gear, coupled with the advent of powered refrigeration and gear handling equipment, electronic navigation, and other technologies, posed a threat to the traditional Alaska fisheries, especially salmon, Pacific cod, sablefish, and halibut. Eventually, though it opened fisheries for lower valued groundfish species, such as flatfish and pollock, because the trawl gear allowed harvesting of larger volumes of fish. This is reflected in the early regulations. The first mention of trawling in Alaska fisheries regulations was for fishing operations in 1930: “The use of any trawl in commercial fishing operations is prohibited, provided that this prohibition shall not apply to fishing operations conducted solely for the purpose of taking shrimp” (Fredin 1987). This prohibition remained in effect until 1935, when it was relaxed to allow trawl gear to take flounders, if flounder fishing with trawl gear did not result in the capture, injury, or destruction of other food fish. The trawl prohibition was further liberalized in 1939, to allow fishing for king crabs west of 150° west longitude outside of Cook Inlet. Eventually, in 1942, trawls were permitted in commercial fishing for all species except salmon, herring, and Dungeness crabs.

From 1933 to 1937, Japan operated a small mothership fleet in the eastern Bering Sea that harvested groundfish, particularly walleye pollock and flounders off Bristol Bay, which were processed into fish meal (Bakkala et al. 1981). Harvests ranged from 3,300 to 43,000 mt. The fishery ended in 1937 because of declines in the price of fish meal. In 1940-1941, the Japanese returned to the eastern Bering Sea to harvest yellowfin sole. During this two-year period, they harvested about 10,000 mt per year.

The United States and Canada established the International Fisheries Commission, which was later re-named the International Halibut Commission (NPFMC 1978) to regulate the fishery and conduct research in 1923. Overfishing by the United States and Canada, stock depletion, and environmental factors, caused the catch of halibut to decline and, in 1930, a new Convention was signed that broadened the Commission’s regulatory power to help rebuild halibut stocks. As part of its regulatory powers, the Commission closed the halibut fishery from November 16 to February 15 annually to protect spawning halibut. The treaty was renegotiated in 1937 to enhance the Commission’s regulatory power, and treaty revisions in 1953 changed its name to the International Pacific Halibut Commission. These early groundfish fisheries appeared to overfish other species as well (Bracken 1983). Bracken provided evidence of a 55 percent decline in the catch per unit effort of sablefish and a decline in average weight from 8 pounds to 6.5 pounds off Alaska between 1937 and 1944.

In 1909, a domestic commercial fishery for herring developed in Norton Sound. The highest recorded catch was 7,300 mt and was taken in 1978. Development of the herring fishery in the EBS was in part related to the depletion of western stocks, which resulting in closing that fishery through a bi-lateral USSR-Japan agreement in 1968. Peak foreign catches of 129,000 and 145,000 mt occurred in 1969 and 1970. From 1975 - 1982, foreign catches have ranged from 9,000 to 25,000 mt.

Pacific halibut supported another early fishery off Alaska. Commercial fishing for halibut began in 1888. Although cod fishermen reported halibut being present in the Bering Sea and GOA in the 1800s, the fishery did not spread to Alaska waters until after World War I. Market demand for halibut grew as experience and technology developed to ice and preserve halibut sufficiently to serve eastern and mid-western markets. Increased demand for halibut inspired fishermen to explore for larger halibut resources farther north. The fishery began off southeast Alaska, off the south end of Baranof Island in 1911. Although cod fishermen reported Pacific halibut in the Bering Sea as early as the 1800s, halibut there were not harvested commercially until 1928 (in Bakkala et al. 1981). The commercial fishery for halibut began in coastal waters of Washington and British Columbia and expanded into the GOA following

World War I.

5.5.2 Impacts of large scale growth of commercial fisheries from the 1950s to the 1970s

5.5.2.1 Fisheries in the Bering Sea/Aleutian Islands

The groundfish fisheries in the BSAI and GOA were developed by Russian and Japanese fishermen between the 1959 and 1976 (except for halibut). Prior to 1976, there was virtually no domestic involvement in these fisheries.

The Soviets began commercial fishing operations off Alaska in 1959, however, no catch statistics were provided until 1964 when the U.S.S.R. began to provide these data to the Food and Agricultural Organization (FAO) of the United Nations. Obtaining accurate fishing mortality data was a general problem of the foreign distant water fisheries off Alaska. Pruter (1976) estimated that the cumulative catch of bottomfish by all nations during the period 1954-1974 amounted to over 22 million mt, of which Japan accounted for over 15 million mt (67 percent), the USSR accounted for about 6 million mt (25 percent) and the U.S. for about 1.5 million mt (6 percent). The remainder of the catch was taken by other nations like South Korea, Poland, East Germany, West Germany, China (Taiwan), and Canada. Historical catches of groundfish and squid taken in BSAI, and GOA.

The U.S. lifted restrictions on Japanese fleets in U.S. waters in 1952. In 1954, Japanese fishing fleets returned to the BSAI with 2 to 4 mothership fleets and up to three independent trawlers. Until 1957, these vessels fished for yellowfin sole and other flounder off Bristol Bay (Bakkala et al. 1981). From 1958 to 1963, the Japanese fleets expanded throughout the Bering Sea and included sablefish, Pacific ocean perch, and herring in the fishery, although yellowfin sole was still their principal focus (Bakkala et al. 1981). These catch statistics reveal the growth and magnitude of the foreign groundfish harvest off Alaska during the late-1950s through the early-1970s. Of particular note were the high catches of the yellowfin sole fishery in the Bering Sea, which peaked in 1962, and the high catches of slope rockfish (e.g. Pacific ocean perch) in the GOA during the period 1963-1968. Both of these stocks were overfished, and while yellowfin sole is believed to have recovered, slope rockfish are still recovering.

From 1960 to 1962, this fishery landed between 421,000 and 554,000 mt annually. The total catch in the eastern Bering Sea rose sharply in the mid- to late-1960s when large, factory trawlers replaced smaller trawlers. From 1964 to the mid-1970s, the fishing power of these fleets created a pattern of overfishing one species before shifting to another species. This pattern was reflected in a progression of increasing catch, followed by steep declines as abundance fell off, followed by another increase in catch as the fleet targeted another species or new fishing grounds. With the decline of catches in the Bering Sea, the fleet moved to new areas, including the GOA.

In the early 1970s, foreign access to U.S. fishing grounds within the 12-nautical mile limit was controlled through bilateral agreements with Japan, Poland, the USSR, Taiwan, and the Republic of Korea. These agreements established time-area restrictions, limits on the amounts of commercial species that could be harvested, and regulations restricting foreign fleets from targeting certain species. The first closures were imposed to reduce the foreign catch of adult and juvenile Pacific halibut. In 1973, when major groundfish stocks began to seriously decline, catch quotas were negotiated between the U.S. and the principal foreign fishing nations.

Despite these restrictions, foreign catch levels remained high. By 1976, foreign fleets had overfished several groundfish stocks including yellowfin sole (Pruter 1973) and Pacific ocean perch, and had dramatically reduced the catch per unit of effort for sablefish and walleye pollock. For example, between 1968 and 1973, fishing effort for walleye pollock had increased almost four times while annual catch-per-unit-effort had declined by 50% and the fishery was increasingly dependent on small, young fish (INPFC 1977). These high catch levels contributed to the decline of other, commercially-important species like Pacific halibut (Larkins 1980).

Since 1981, the groundfish catch from the BSAI has ranged from a low of 1,294,132 mt in 1999 to a high of 1,996,467 mt in 1992. For the 2000 fisheries, the NPFMC adopted a total allowable biological catch level of 2,260,113 mt for the BSAI. In 2000, the NPFMC set the TAC for BSAI groundfish fishery at 2 million mt.

In the 1980s, foreign fleets fishing in the U.S. EEZ were replaced by joint venture fisheries. By 1988, the U.S. fleet was catching the walleye pollock in the eastern Bering Sea and delivering it to foreign vessels through joint-venture fisheries that were set up after the U.S. declared the 200-mile EEZ (Bakkala 1993). By 1995, the groundfish fleet was comprised of 1,545 vessels including 1,159 vessels fishing with hook and line gear, 263 with pots, and 264 with trawls, with some of the vessels using more than one gear type. Of the total number of vessels, about 120 were catcher processors. The groundfish fleet came mainly from communities in Alaska, Washington, and Oregon. Their total groundfish harvest in 1995 was approximately 2.1 million mt, with 90% coming from the BSAI. The overall catch was 65% pollock, 15% Pacific cod, 12% flatfish, 4% Atka mackerel, 2% rockfish, 1% sablefish, and lesser amounts of other species.

The Pollock Fishery in the Aleutian Basin

The pollock fishery in the Aleutian Basin (the Donut Hole) developed rapidly in the 1980s. The uncontrolled growth of this fishery spurred worries about overfishing and the effects of Aleutian Basin catches on the pollock populations of the eastern Bering Sea. The donut hole fishery was being conducted by trawl vessels from Japan, the Republic of Korea, Poland, the People's Republic of China, and the former Soviet Union. Catch data submitted by these countries indicated that annual harvests in the donut hole rose to about 1.5 million mt from the mid-1980s to 1989. Largely due to drastic declines in catch and catch per unit effort from 1990, leading to a total catch of under 300,000 mt in 1991 and under 11,000 mt in 1992, the governments agreed to suspend fishing in the area for 1993 and 1994. The results of monitoring in the region during this 2-year hiatus produced no evidence that the stock recovered.

As a result, and after three years of negotiations, the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea was signed on December 8, 1995. The major principles of this convention included: no fishing in the donut hole unless the biomass of the Aleutian Basin exceeds a threshold of 1.67 million mt; allocation procedures; 100 percent observer and satellite transmitter coverage; and prior notification of entry into the donut hole and of transshipment activities.

From 1997 to 2000, the Parties to the Convention established the Allowable Harvest Level of pollock in the Central Bering Sea at zero, although the Parties agreed that there were insufficient data to directly estimate the pollock biomass in the Aleutian Basin. Nevertheless, in 1998 the best estimate placed this biomass at 342,000 mt, which was about 50 percent lower than the 1997 estimate and the lowest biomass on record for this area. In 1998, the biomass in the entire Aleutian Basin was estimated at 572,000 mt; estimates for 1999 and 2000 showed no increase in biomass. In addition, all trial fishing results in 1997 showed little or no pollock in the Central Bering Sea.

Fisheries for Crab and Shellfish

In 1930, Japan began commercial harvests of king crab, although final development of the fishery was delayed by World War II. U.S. fleets began to harvest king crab in 1947 followed by a resumption of the Japanese fishery for king crab in 1953. In 1959, Russian fleets entered the king crab fishery. By 1964, the catch of king crab peaked with 9,000,000 crabs, then declined to 3,500,000 in 1970 when Russia ended their harvest. The Japanese terminated their fishery in 1974. By 1975, the entire harvest of 9,000,000 was taken by U.S. fishermen (Lowry et al. 1982).

Prior to 1964, eastern Bering Sea tanner crab were harvested incidental to the king crab fishery. Landings peaked at over 24 million crabs in 1969 and 1970. Russian terminated their involvement in the fishery in 1971. By 1976, the harvest of 18 million tanner crabs was divided between the U.S. and Japanese fishermen.

Fishing for shrimp in the Bering Sea began in 1961 and involved Japanese and Russian trawlers. The fishery reached its highest levels in the early 1960s, then declined to negligible levels by 1972 (Lowry et al. 1982).

5.5.2.2 Fisheries in the GOA

Fisheries for Halibut and Salmon

During the late 1950s and 1960s, halibut and salmon dominated the U.S. domestic fishery in Alaska. The catch of groundfish in the northeast Pacific by domestic fisheries was minor compared with foreign harvests and amounted to less than 100 tonnes (Forrester et al. 1978). The halibut fishery, which began to rebuild under the guidance of the International Halibut Commission, reached an all-time high of 24,000 mt in 1962. High annual catches continued until 1966, when catches began to decline again. By 1974, halibut landings declined to 7,300 mt, most of which came from central GOA. For the 20 year period from 1955 to 1975, between 65 and 80 percent of the total halibut landed came from the GOA.

Fisheries for Pacific Ocean Perch

Japanese and Russian vessels began fishing the GOA in the early 1960s and targeted Pacific ocean perch (Alton 1981). This fishery expanded rapidly, resulting in annual catches that peaked at 380,000 tonnes in 1965-1966. By the end of that period, Pacific ocean perch had been overfished. The stock experienced a sharp decline in abundance and during that period, the density of Pacific ocean perch declined by 93% (Alton 1981). With the decline of the Pacific ocean perch, foreign fleets shifted their target to walleye pollock (Alton 1981). When Japan developed a method for producing surimi from pollock on-board, the Japanese fishery shifted to walleye pollock and production grew from 175,000 tonnes in 1964 to 1.9 million tonnes in 1972.

In 1962, Russian vessels began fishing the GOA and targeted Pacific ocean perch (Alton 1981). The following year, a smaller Japanese fleet entered the GOA and fished for Pacific ocean perch and sablefish. This fishery expanded rapidly, resulting in annual catches that peaked at 380,000 tonnes in 1965-1966. By the end of that period, Pacific ocean perch had been overfished and the stock experienced a sharp decline in abundance; during that period, the density of Pacific ocean perch declined by 93% (Alton 1981). The perch fishery peaked in 1965 and has since declined to about 48,000 mt.

With the decline of the Pacific ocean perch, foreign fleets shifted their target to walleye pollock (Alton 1981). When Japan developed a method for producing surimi from pollock on-board, the Japanese fishery shifted to walleye pollock and production grew from 175,000 tonnes in 1964 to 1.9 million tonnes in 1972. The Republic of Korea entered the groundfish fishery in the GOA in 1972, five years after their entry in the Bering Sea. They began by longlining for sablefish, but also had substantial trawl operations. Poland conducted small fisheries in the GOA in 1974 and 1975, taking 2,000 mt of pollock, Atka mackerel, and rockfish.

As noted in the discussion on the development of groundfish fisheries in the Bering Sea (see the preceding section), in the early 1970s, foreign access to U.S. fishing grounds within the 12-nautical mile limit was controlled through bilateral agreements with Japan, Poland, the USSR, Taiwan, and the Republic of Korea. When major groundfish stocks began to decline in the early 1970s, catch quotas were negotiated between the U.S. and the principal foreign fishing nations, but foreign fleets still overfished several groundfish stocks, including yellowfin sole and Pacific ocean perch and had dramatically reduced the catch per unit of effort for sablefish and walleye pollock (see Table 5.8).

Since 1986, the total groundfish catch in the GOA has ranged from a low of 146,703 mt (in 1987) to a high of 261,694 mt (in 1992). In 1999, total groundfish catch was 227,044 mt. All of these catches have been well below the 800,000 mt optimal yield cap. The catches reflect recent biomass trends and a conservative harvesting strategy.

5.5.3 Impacts of commercial fisheries within the action area from the 1970s to the present

In the early 1960s, the U.S. had fisheries authority only to 3 miles and those waters were closed to all foreign fishing beginning in 1964. The U.S. thus had little leverage to restrict the large offshore Japanese and Soviet operations during their initial build-up. Fisheries research and information exchange were conducted initially with Japan and Canada under the auspices of the International North Pacific Fisheries Commission (INPFC), but it focused mainly on salmon interception issues beginning with its first organizational meeting in 1954. The Japanese provided some catch data, but the Soviets, fishing on five-year plans, provided very little information on their harvests.

The U.S. fisheries extended their jurisdiction from 3 to 12 miles on October 4, 1966 (P.L. 89-658). It provided for continued foreign fishing in the 9-mile contiguous zone, but significantly increased U.S. leverage in controlling those fisheries. For example, INPFC first considered joint studies of groundfish (other than halibut) such as Pacific ocean perch and sablefish in 1967-1971. It produced no joint conservation recommendations for either species even though it was well recognized that both stocks were in jeopardy. The INPFC and the U.S.- Canada International Pacific Halibut Commission began a joint monitoring program for halibut bycatch in Japanese trawlers in the eastern Bering Sea in 1972.

U.S.-foreign bilateral agreements were the main mechanism for managing the foreign fisheries. Bilaterals were negotiated in protracted sessions, beginning in 1967 with Japan and the USSR (there was a king crab bilateral with the Soviets in 1965). The first one was negotiated for groundfish with the Soviets in February 1967. The early bilaterals focused on protecting domestic crab, halibut and shrimp fisheries from gear conflicts and grounds preemption by foreign trawlers, and protecting fur seal populations in the Pribilof Islands.

Groundfish management was addressed beginning in 1972-1973. By then, foreign operations had depressed stocks off Alaska. Catches of yellowfin sole in the eastern Bering Sea, for example, had fallen sharply following very large removals by Japan and the Soviet Union. Pacific ocean perch stocks were decimated. Pollock catches were increasing rapidly, and were thought likely to follow the same pattern as perch and flatfish.

In 1973-1974, catch quotas were placed on eastern Bering Sea pollock and flatfish, and on GOA Pacific ocean perch and sablefish. Additionally, a complex array of closures was established mainly to protect U.S. fisheries for crab and halibut. The catch quotas represented the average catches of the previous 3-4 years and were an attempt to put the fisheries on hold so the stocks could be evaluated. Unfortunately, each country was responsible for monitoring its catch quotas, the only internationally acceptable arrangement at the time. The final round of negotiations on bilaterals before the Act was passed occurred in late 1974 with Japan and in mid-1975 with the USSR. The U.S. had negotiated an agreement with ROK in 1972, effective through 1977, and with Poland in 1975.

5.5.3.1 Preliminary fishery management plans (PFMP)

Following the implementation of the FCMA on March 1, 1977, foreign fishing could be conducted in the new 200 nautical mile Fishery Conservation Zone (later changed to Exclusive Economic Zone or EEZ) only pursuant to an international treaty or a governing international fishery agreement. Governing agreements were completed with Taiwan and the USSR in 1976 and with Japan, ROK and Poland in 1977. While these agreements provided foreign fleets access to the EEZ, these fleets had to fish under the rules of PFMP that applied only to foreign fisheries. Foreign fisheries off Alaska were managed under four PFMP: (1) trawl fisheries and herring gillnet fishery of the eastern Bering Sea and Northeast Pacific; (2) trawl fishery of the GOA; (3) sablefish fishery of the eastern Bering Sea and Northeastern Pacific; and, (4) snail fishery of the eastern Bering Sea. The latter fishery was small fishery conducted by 21 Japanese vessels that longlined with pots along the shelf edge of the Bering Sea northwest of the Pribilof Islands, harvesting about 3,000 mt of edible meats in the mid-1970s. Snails were later incorporated as an “unallocated species” in the BSAI groundfish plan published in 1981.

The PFMP recognized that the fisheries could adversely affect marine mammals through (1) direct impacts from trawl netting, plastic wrapping bands and other debris around their necks or bodies; and (2) indirect impacts of the fisheries competing for some of the same species of fish and shellfish used as food by the northern fur seal and other marine mammals. Nevertheless, the PFMPs did not contain measures to reduce potential impacts of the fisheries on marine mammals and seabirds, except for restrictions on operating near the Pribilof Islands.

In summary, the PFMPs continued and enhanced provisions of the various bilateral agreements. In many respects, the PFMPs established the fundamental philosophy in managing the fisheries over future years as it transitioned to a completely domestic fishery in the late 1980s. The PFMPs set harvest limits for the main target species and fishing ceased when those limits were reached.

The PFMPs required the fishermen to report catch and support observers. The PFMPs protected species other than groundfish using time-area closures and prohibiting retention of species such as salmon, halibut, crab, and shrimp that were important target species for domestic fisheries. The PFMPs implemented time-area closures to protect domestic fishermen from grounds preemption and gear conflicts caused by mobile foreign trawl gear.

5.5.3.2 FMPs

The BSAI Area FMP

In August 1981, the NPFMC finalized an FMP for groundfish fisheries in the BSAI. The FMP was implemented with the 1982 fisheries. The FMP carried forward most of the management measures from the PFMPs. Optimal yields were set for each of the main species and species complexes and fisheries were closed when the optimal yield was reached. The concept of a set-aside or reserve was introduced to provide allocations to individual fisheries in-season. In the BSAI, 5% or 500 mt of each species was set aside, whichever was greater, and optimal yields were distributed by management area.

The 1981 FMP specifically focused on rebuilding depleted groundfish stocks. The FMP managed groundfish as a species complex, because populations of some species of groundfish will increase in response to decreases in populations of other species in the complex. The biomass of pollock in the eastern Bering Sea was estimated at 8.24 million mt (the most abundant). In the Aleutian Islands, the most abundant biomass consisted of Pacific ocean perch, pollock, and Atka mackerel. The FMP also emphasized protecting prohibited species and the associated domestic fisheries. The FMP contained a ban on retaining halibut in trawls and expanded time-area closures. Restrictions on bottom trawls were applied to the foreign fisheries and there were depth restrictions on foreign longline fishing for Pacific cod in the Winter Halibut Savings Area in the eastern Bering Sea. Except for a prohibition against retaining prohibited species, the FMP placed no restrictions on domestic fishermen in the Bering Sea.

Since 1981, the groundfish catch from the BSAI has ranged from a low of 1,294,132 mt (1999) to a high of 1,996,467 mt (1992). In 1988, the MSY had been increased to 3.4 million mt. This revised estimate, combined with increased domestic use of the resource, resulted in pressure to increase the 2 million metric ton cap to allow foreign and joint-venture fisheries to continue. In 1988, and for several years thereafter, fishermen asked the NPFMC to increase the 2 million mt cap on optimal yield in the BSAI. The NPFMC rejected these proposals because of uncertainties in the rate of removal of pollock from waters immediately outside of the fishery (e.g., in international waters); the amount of bycatch that would result; and the reliability of scientific methodologies at that time for determining allowable biological catch. For the 2000 fisheries, the NPFMC adopted an ABC of 2,260,113 mt for the BSAI. In 2000, the NPFMC set the TAC for BSAI groundfish fishery at 2 million mt.

Since 1981, the NPFMC has amended the FMP many times, primarily to protect target species, protect prohibited species, control bycatch, balance the social and economic benefits of the fishery, and increase the involvement of the domestic fleet in the groundfish fisheries. The NPFMC achieved this last objective in 1987, when groundfish fisheries in the BSAI became totally domestic (although joint ventures operated in the

BSAI until 1990).

The NPFMC has taken numerous actions to protect prohibited species – mostly red king crab, tanner crab halibut, and salmon – although other species benefitted from these closures. Between 1986 and 1990, the NPFMC closed areas in the eastern Bering Sea (one area around the Pribilof Islands and two areas in Bristol Bay) to protect king crab from domestic trawlers. The Pribilof Islands Conservation Area, Red King Crab Savings Area in Bristol Bay, and a Nearshore Bristol Bay Closure Area, Bristol Bay Winter Halibut Savings Area, Bristol Bay Pot Savings Area, and three Herring Savings Areas (two summer and one winter) that are closed to trawling and scallop dredging to protect king crab and bottom habitat. The NPFMC later established Chum Salmon Savings Areas that were designed to reduce the amount of chum salmon taken as bycatch in trawl fisheries. Together, these areas close about 80,000 square nautical miles to trawling and scallop dredging.

In 1984 the NPFMC began to produce annual resource assessment documents that contained complete descriptions of each stock and its current condition. These documents set the example and standard for SAFE documents that were later required of all regional fishery management councils in the U.S. In 1990, the NPFMC established a comprehensive observer program (paid by industry) that would verify catch levels and monitor bycatch. The NPFMC required 100% observer coverage on all vessels over 125 ft and 30% coverage on those between 60 and 125 ft.

Since the late 1980s, the NPFMC has taken numerous actions to protect habitat, seabirds, and marine mammals. In 1988, the NPFMC approved a habitat policy and established a habitat committee to review permit requests that might impact fish habitat. In 1999, the NPFMC amended FMPs to include essential fish habitat (Amendment 55 to the FMP for the Groundfish Fishery of the BSAI Area and Amendment 8 to the FMP for the Commercial King and Tanner Crab Fisheries in the BSAI).

GOA FMP

On October 11, 1977, the NPFMC finalized the FMP for GOA groundfish fisheries, which was implemented with the 1979 fisheries. The FMP continued most of the management measures contained in the PMPs to protect target species, bycatch species, and the associated domestic fisheries. The FMP set optimal yields for each of the main species and species complexes, and fisheries were closed when the optimal yield was reached. The concept of a set-aside or reserve was introduced to allow for in-season flexibility in the allocation of the catch. In the GOA, the reserve was 20% of each species. The principal groundfish species considered resident in the GOA included walleye pollock (which the plan called Alaska pollock), Pacific cod, sablefish, Pacific ocean perch, halibut, turbot, flathead sole, rock sole, and Atka mackerel. When the FMP was finalized, the fishery was estimated to yield 325,700 mt. Of this total, pollock were expected to represent 169,000 mt or about 52% of the yield.

This FMP also focused on rebuilding depleted groundfish stocks, managed groundfish as a species complex, and protected prohibited species like Pacific halibut. The FMP contained a ban on retaining halibut in trawls and expanded time-area closures.

Restrictions on bottom trawls were applied to the foreign fisheries. The FMP implemented a Prohibited Species Catch limit for halibut for domestic trawlers for the first time off Alaska. By the end of 1985, only minor foreign fisheries, directed on pollock and Pacific cod, were being allowed in the GOA and pollock stocks in the Gulf of Alaska-Shelikof Straits were beginning to decline rapidly. From 1986 to 1990, pollock stocks in the Western and Central GOA declined significantly. The NPFMC responded by setting lower harvest levels every year to protect this stock.

In 1978, the NPFMC closed the GOA east of 140° W to all foreign longlining. The NPFMC prohibited foreign longlining inside of the 500 meter isobath, except that a longline fishery directed at Pacific cod could be conducted landward of the 500 meter isobath west of 157° W longitude (NPFMC 1978). The NPFMC reduced the optimum yield for sablefish to 13,000 mt for the entire GOA to encourage the sablefish stock to rebuild, increase the size of fish available, and encourage a U.S. longline fishery and protect halibut. In 1978, the NPFMC also proposed to distribute the optimum yield through the five INPFC statistical areas in the GOA proportional to the biomass of the stocks found in those area (NPFMC 1978).

Since 1981, the NPFMC has amended the FMP many times, primarily to protect target species, protect prohibited species, control bycatch, balance the social and economic benefits of the fishery, and increase the involvement of the domestic fleet in the groundfish fisheries. The NPFMC achieved this last objective in 1986, when groundfish fisheries in the GOA became totally domestic (although joint ventures operated in the GOA until 1988).

The NPFMC has taken numerous actions to protect prohibited species – mostly red king crab, tanner crab halibut, and salmon – although other species benefitted from these closures. Between 1986 and 1990, the NPFMC closed areas around Kodiak Island to protect king crab from domestic trawlers. In the 1990s, the NPFMC implemented a rebuilding plan for Pacific ocean perch stocks in the GOA, which had been decimated by Soviet fisheries in the 1960s and have not recovered. The NPFMC later revised this rebuilding plan and approved a new program called improved retention and improved utilization for pollock and Pacific cod in the BSAI and for the GOA. This program was intended to reduce bycatch and discard of juveniles; to achieve this outcome, the program required fishermen to land all pollock and cod harvested, even juveniles and other unmarketable fractions.

The NPFMC dramatically improved the amount and quality of information available to manage groundfish fisheries in the GOA. After the NPFMC began to produce annual resource assessment documents for the BSAI, they implemented them for the GOA. In 1990, the NPFMC established a comprehensive observer program (paid by industry) that would verify catch levels and monitor bycatch. As in the BSAI, the NPFMC required 100% observer coverage on all vessels over 125 ft and 30% coverage on those between 60 and 125 ft.

5.5.3.3 Amendments to the FMPs to mitigate fisheries impacts

Amendments to the BSAI FMP to mitigate fisheries impacts

In 1985, the Council voted to prohibit the discard of nets and debris, which often caused entanglement and mortality with marine mammals and other sea life. Between 1986 and 1990, the NPFMC voted against raising the BSAI 2 million mt cap on groundfish, partially in deference to ecosystem impact concerns. In 1991, NMFS listed Steller sea lions as threatened and banned shooting near their rookeries and haulouts, reduced levels of incidental take, and implemented a 3-mile buffer zones around principle sea lion rookeries.

NMFS closed areas year-round to trawling within 10 miles of 37 Steller sea lion rookeries and to within 20 miles during the pollock A season (January 20-April 15) around five rookeries in the BSAI with comparable closures in the GOA in 1991. To reduce competition for prey and avoid localized depletion, the pollock TAC was spread over three areas, and limits were placed on the amount of excess pollock that could be taken in a quarter.

On July 13, 1993, NMFS issued regulations (BSAI FMP amendment 28) that subdivided the Aleutian Islands subdistrict into three subareas (Areas 541, 542, 543) because of concerns that the concentration of fishery removals, particularly Atka mackerel, in the eastern Aleutian Islands that occurred in recent years could cause localized depletion of groundfish stocks (58 FR 37660). Although this measure was designed to disperse the Atka mackerel TAC and conserve the mackerel stock, it was also considered beneficial to Steller sea lions.

In 1998, NMFS issued regulations for Amendments 36/39 to the BSAI and GOA FMPs (63 FR 13009), which created a forage fish species category in both FMPs and implemented management measures for these species. These amendments prohibited directed fishing for forage fish at all times in Federal waters of the BSAI and GOA to prevent the development of a commercial directed fishery for forage fish, which are a critical food source for many marine mammal, seabird, and fish species. The amendments recognized that many species of marine mammals and seabirds in the BSAI and GOA had declined and that decreases in the forage fish biomass could contribute to further declines of these species.

In 1998, the NPFMC recommended changes to the Atka mackerel fishery. The fishery occurs almost exclusively in the Aleutian Islands region west of 170˚W and south of 55˚N (Figs. 2.4 or 4.7). This region (within the US EEZ) consists of 1,001,780 km^2 of ocean surface, of which 104,820 km^2 is Steller sea lion critical habitat (approximately 10 percent). The purpose of the recommended changes was to reduce the potential for competition between the Atka mackerel fishery and Steller sea lions. The evidence for such competition was based on catch-per-unit-effort data from various locations in the Aleutian Islands. The data suggested that local harvest rates were much larger than the overall target rates for the entire Aleutian Island region. Since most of the mackerel catch came from Steller sea lion critical habitat (about 80% in 1995-97), the evidence for locally high harvest rates raised concerns that the fishery might be depleting local prey availability in areas considered critical for sea lion recovery.

The changes implemented in 1999 split the Atka mackerel fishery into two equal (by TAC) seasons and imposed spatial restrictions on the distribution of the fishery. The spatial measures reduced the allowable catch in critical habitat from about 80% to levels at or below 40% over the period from 1999 to 2002. Prior to 1999, a total of 17,120 km^2 (16%) of Aleutian Island critical habitat was closed to all trawl fisheries year round (10-nm trawl exclusion zones around important rookeries and haulouts). As a result of the Atka mackerel measures implemented in 1999, an additional 4,600 km^2 (an additional 4% of critical habitat) was closed to all trawl fisheries from January-April each year (between 10 and 20 nm around the rookeries on Seguam and Agligadak Islands).

BSAI pollock measures and the 1998 jeopardy Biological Opinion

On December 3, 1998, a biological opinion was issued on three fisheries proposed for 1999 through 2002 by NMFS: (1) the authorization of an Atka mackerel fishery from 1999 to 2002 under the Groundfish FMP of the BSAI; 2) the authorization of the pollock fishery from 1999 to 2002 under the Groundfish FMP of the BSAI; and 3) the authorization of the pollock fishery from 1999 to 2002 under the Groundfish FMP Management Plan of the GOA. The opinion concluded that the Atka mackerel fishery was not likely to jeopardize the western population of Steller sea lions or adversely modify its critical habitat. However, the opinion also concluded that the pollock fisheries, as proposed for 1999 to 2002, were likely to jeopardize the endangered western population of Steller sea lions and destroy or adversely modify their critical habitat. The opinion did not prescribe an entire set of reasonable and prudent alternatives (RPAs) for the two pollock fisheries, but rather established a framework to avoid the likelihood of jeopardizing the continued existence of Steller sea lions or adversely modifying their critical habitat. This framework included guidelines (ranging from specific to general) for management measures to achieve three principles: 1) protection of waters adjacent to rookeries and haulouts, 2) temporal dispersion of the pollock fisheries, and 3) spatial dispersion of the fisheries. These three principles, in combination, were intended to modify the fisheries to avoid jeopardy and adverse modification.

On December 13, 1998, the NPFMC recommended a set of revised management measures for the pollock fisheries based on these RPA principles to avoid jeopardy and adverse modification. On December 16, those measures were incorporated (with some modification) into the December 3rd opinion and, on January 22, 1999, the measures were published in an emergency rule for the 1999 pollock fisheries. The emergency rule was extended until July 19, 1999. Therefore, at its June 1999 meeting, the NPFMC made further recommendations for the later half of 1999 (extension of the emergency rule) and for 2000 and beyond (permanent rule).

The NPFMC measures were developed to 1) avoid competition during the early winter season and around rookeries and major haulouts by closing that period and those areas to pollock trawling, 2) disperse the fisheries spatially, and 3) disperse the fisheries temporally. In addition, the Aleutian Islands region was closed to pollock fishing (22,000 mt were caught in the Aleutian Island region in 1998; slightly more than 2% of the BSAI pollock catch). After the measures were implemented, a total of 210,350 km^2 (54%) of critical habitat was closed to the pollock fishery (BSAI and GOA combined). The portion of critical habitat that remained open to the pollock fishery consisted primarily of the area between 10 and 20 nm from rookeries and haulouts in the GOA and parts of the eastern Bering Sea special foraging area.

In the eastern Bering Sea shelf, both the catches of pollock and the proportion of the total catch caught in critical habitat have been reduced significantly since 1998 as a result of the NPFMC actions:

Estimated pollock catches (mt) and percent caught in the Sea Lion Conservation Area in the eastern Bering Sea			
Months	**1998**	**1999**	**2000**
January-March	441,000 (88%)	222,300 (57%)	156,800 (39%)
January-December	642,100 (60%)	372,800 (39%)	

The NPFMC measures taken to implement the RPAs also accomplished some spatial and temporal spreading of the pollock fishery in the eastern Bering Sea (Figs. 5.1 and 5.2). Prior to the measures (1998), the fishery was concentrated into 2 seasons, each approximately 6 weeks in length in January-February and September-October (Fig. 5.2). Ninety-four percent of the pollock catch was taken in these four months (45% in January-February and 49% in September-October). In 1998, the pollock fisheries occurred in the Aleutian Islands (1,001,780 km^2 inside the EEZ), the eastern Bering Sea (968,600 km^2), and the GOA (1,156,100 km^2). The marine portion of Steller sea lion critical habitat in Alaska west of 150˚W encompasses 386,770 km^2 of ocean surface, or 12% of the fishery management regions.

In 1999, the fishery was dispersed into March (reducing the percent taken in February) and into August. Little pollock was taken in April-July. Thus, the 1999 fishery was dispersed only slightly better than the 1998 fishery (Figs. 5.1 and 5.2). In 1998, daily catch rates averaged over 8,100 mt/day, and peaked at over 21,300 mt/day (Fig. 5.3). In 1999 and 2000, average daily catch rates for January-March declined about 22% to 6,200 mt/day and 6,400 mt/day, respectively; daily maximums were 15,400 mt/day and 12,500 mt/day, respectively. These changes resulted from a combination of the RPAs and the implementation of cooperatives under the AFA (see below).

For both the pollock and Atka mackerel fisheries, ABC and TAC levels were unchanged. The underlying assumption of the 1998 Biological Opinion was that the total amount of the catch was not an issue; rather, certain periods (early winter) and areas (around rookeries and major haulouts) were protected from competition, and the catch was otherwise dispersed temporally and spatially.

On October 15, 1999, NMFS issued a revised set of RPAs which NMFS implemented by regulations for the 2000 fishing year. These revised RPAs and their effects on listed species and designated critical habitat, will be evaluated in section 6.

Amendments to the GOA FMP to mitigate fisheries impacts

Since the late 1980s, the NPFMC has taken numerous actions to protect habitat, seabirds, and marine mammals. In 1988, the NPFMC approved a habitat policy and established a habitat committee to review permit requests that might impact fish habitat. In 1985, the Council voted to prohibit the discard of nets and debris, which often caused entanglement and mortality with marine mammals and other sea life. In 1991, NMFS listed Steller sea lions as threatened and banned shooting near their rookeries and haulouts, reduced levels of incidental take, and implemented a 3-mile buffer zones around principle sea lion rookeries.

In the mid-1990s, the NPFMC chartered an Ecosystem Committee to evaluate methods for formally addressing ecosystem concerns in Council deliberations. The NPFMC also expanded membership of its GOA and BSAI Groundfish Management Plan Teams to include marine mammal and seabird experts to provide scientific advice on annual TACs and management actions that decrease the probability and magnitude of adverse effects on marine mammals, seabirds, and habitat.

NMFS has closed areas year-round to trawling within 10 miles of Steller sea lion rookeries in the GOA that were comparable to closures established in the BSAI during the pollock A season (January 20-April 15) in 1991. To reduce competition for prey and avoid localized depletion, the pollock TAC was spread over three areas, and limits were placed on the amount of excess pollock that could be taken in a quarter.

In 1998, NMFS changed the seasonal apportionment of the pollock TAC in the western and central GOA by moving 10% of the TAC from the 3rd fishing season (which starts on September 1) to the 2nd fishing season (which starts on June 1) to reduce the potential effect of pollock fishing during the fall and winter months, a period that is critical to Steller sea lions (63 FR 31939). The NPFMC took this action because of concerns about the importance of the fall and winter to Steller sea lions, particularly lactating females and newly-weaned juveniles. In 1999, the NPFMC amended FMPs to include essential fish habitat (Amendment 55 to the FMP for the Groundfish Fishery of the GOA Area).

GOA pollock measures and the 1998 jeopardy Biological Opinion

The potential effects of the GOA pollock fisheries were addressed in the December 3, 1998 Biological Opinion. The opinion concluded that the GOA groundfish fisheries, as proposed in 1998, were likely to jeopardize the continued survival of the western population of Steller sea lions and adversely modify its critical habitat.

For the GOA, the RPAs were intended to disperse the pollock fishery temporally into four discrete seasons dispersed through the period from January 20 to November 1. For 1999, little temporal dispersion was accomplished (Figs. 5.4 and 5.5). For 2000, these four seasons were to begin January 20, March 15, August 20, and October 1. The catch was dispersed accordingly. However, the fleet capacity in the GOA exceeds that required to take the catch in this area, and as a consequence, the catch was effectively dispersed into four discrete pulses.

For the GOA pollock fishery, the RPAs were intended to achieve two objectives with respect to spatial dispersion. The first was to reduce pollock catches from around significant rookeries and haulouts by requiring that fishing occur 10 nm away from these areas, and the second was to distribute the seasonal catches according to the seasonal pollock biomass distributions by area. In the GOA, survey and fishery data suggested that winter pollock fishing effort could be higher in Shelikof Strait (part of critical habitat) than had previously been observed. Surveys indicated that as much as 50% of the exploitable biomass of pollock in the GOA was inside Shelikof Strait in March, yet the recent pre-RPA winter GOA fishery did not catch 50% of its pollock from that area. Instead, the fishery worked principally in other parts of critical habitat, presumably with less available biomass, but with other advantages (e.g., closer to ports). Therefore, fishing effort may have been disproportionately large in some portions of critical habitat and considerably lower in others (e.g., Shelikof Strait). To distribute the pollock catch according to the pollock distribution, the NPFMC established a separate Shelikof Strait management area (combined areas 621 and 631) and allocated approximately 50% of the A and B season quotas to it. This essentially shifted effort from one part of critical habitat to another to more closely match the winter biomass distribution. Because of this, pollock catches from critical habitat in the A and B seasons would not be expected to decline as a result of the RPAs. During the C and D seasons, the RPAs allocated TAC by fishery management area.

Pollock catches and the percent of catch removed from critical habitat in the GOA increased in 1999 and 2000 relative to 1998 (see below). Pollock catches during January-March from critical habitat have increased from almost 20,000 to over 34,000 mt, and the proportion caught in critical habitat increased from 70% to 97%. As stated above, this is not a surprising result since the Shelikof Strait area (critical habitat) was allocated over half of the GOA pollock TAC during the A and B seasons.

	Estimated Pollock Catches (mt) and Percent Caught in the Steller Sea Lion Critical Habitat in the GOA		
Months	**1998**	**1999**	**2000**
January-March	19,900 (70%)	31,700 (88%)	34,100 (97%)
January-December	99,700 (79%)	75,600 (82%)	

Contrary to the EBS, the GOA pollock fishery has generally become increasingly concentrated in smaller areas within Steller sea lion critical habitat (Fig. 5.4). Some of this may be attributable to decreases in total catch between 1998 (125,400 mt) and 1999-2000 (100,000 mt in both years).

On October 15, 1999, NMFS issued a revised set of RPAs which NMFS implemented by regulations for the 2000 fishing year. These revised RPAs and their effects on listed species and designated critical habitat, are evaluated in section 6.

5.5.3.4 Amendments to the FMPs to conserve salmon

Bycatch of salmon by groundfish fisheries in the Bering Sea and the GOA has been an important issue in fisheries management for decades. Chinook salmon are caught incidentally in trawl fisheries in the BSAI and GOA, particularly in the BSAI midwater pollock fishery. Salmon are a prohibited species in the BSAI groundfish fisheries. They cannot be retained, and must be returned to the sea as soon as possible with a minimum of injury after they have been counted by a NMFS observer. However, the mortality rate for salmon caught in trawl fisheries is 100 percent as salmon do not survive interception by trawl gear.

Chinook salmon bycatch in trawl fisheries reached a high in 1980, when foreign trawl vessels intercepted approximately 115,000 chinook salmon. Following Federal action to reduce bycatch in the trawl fisheries, the foreign fleet was constrained by a bycatch reduction schedule that reduced the allowable level each year from 65,000 chinook salmon in 1981, to 16,500 chinook salmon by 1986. Domestic vessels began fishing in the mid-1980s and bycatch numbers remained below 40,000 fish until 1993. From 1994-1998, most of the chinook salmon bycatch in the BSAI was within the area designated as the Chinook Salmon Savings Area (CSSA) (Table 5.9a). During this same period, the bycatch limit of 48,000 chinook salmon was exceeded four times, with a high of about 63,000 chinook salmon intercepted in 1998. Since 1996, a PSC limit of 48,000 chinook salmon has been in place during the period from January 1 until April 15 for vessels using trawl gear, with no restrictions on the amount of chinook salmon bycatch in the subsequent months. Historically, most of the chinook salmon taken as bycatch has been by pelagic trawl gear for pollock.

Although the groundfish fisheries are prohibited from retaining any salmon they catch, about 60,000 chinook salmon were taken incidentally in the BSAI each year between 1996 and 1998 in trawl fisheries. In that same period, about 60,000 to 80,000 other salmon (mostly chum salmon) were estimated as trawl bycatch annually. Most of the salmon bycatch has been taken by vessels using pelagic trawl gear targeting pollock. In the Bering Sea, a limit of 48,000 chinook salmon between January 1 and April 15 was established for trawl gear in the CSSA (November 29, 1995; 60 FR 61215).

In the BSAI, bycatch of other salmon has ranged from about 22,000 in 1995 to 78,000 in 1996. Again, the vast majority of the salmon were caught in trawl fisheries. In Table 5.10, the “other” salmon category is broken out by percentages of the salmon that were identified within this category. No “other” salmon were caught in either the jig or pot gear fisheries. Chum salmon comprise the majority of the catch, 98 percent in trawl fisheries and about 92 percent in hook-and-line fisheries. Coho salmon are the next largest component, about 1.5 percent in trawl fisheries and 6.5 percent in hook-and-line. About 1.4 percent are pink salmon caught in hook-and-line fisheries, and very few sockeye are intercepted and no steelhead were reported.

On July 5, 1995 (60 FR 34904) NMFS established the Chum Salmon Savings Area (CSSA) in the BSAI. A limit of 42,000 non-chinook salmon is established for vessels using trawl gear during August 15 through October 14 in the CVOA. If the limit is reached, trawling would be prohibited within the CSSA during the remainder of the period from September 1 through October 14. These existing regulations prohibit trawling in the CHSSA through April 15 of each year once the bycatch limit of 48,000 chinook salmon is reached. Historically, the majority of the chinook salmon bycatch was accounted for before April 15 (in the winter/spring pollock trawl fisheries). Recently, chinook salmon bycatch has also been high in the fall/winter period.

In 1997, the NPFMC, started analyses that would help lower the chinook salmon bycatch limit in the BSAI. This proposal, submitted by the Yukon River Drainage Fisheries Association, identified the current bycatch trigger of 48,000 chinook salmon as too high to effectively reduce chinook salmon bycatch. At its meeting in February 1999, the NPFMC considered this information and the analysis prepared by staffs from the ADF&G and the NPFMC in support of this action, and adopted Amendment 58 to the BSAI FMP to reduce chinook salmon bycatch in the BSAI. Five alternatives were presented to the NPFMC for consideration. The alternative adopted by the NPFMC would: (1) reduce the chinook salmon bycatch limit from 48,000 to 29,000 chinook salmon over a 4-year period, (2) implement year-round accounting of chinook salmon bycatch for the pollock fishery, beginning on January 1 of each year, (3) revise the boundaries defined by the CHSSA, and (4) set new CHSSA closure dates.

In the GOA, while PSC limits have not been established for salmon, the timing of seasonal openings for pollock in the Central and Western GOA have been adjusted to avoid periods of high chinook bycatch. The number of salmon taken as bycatch has been much lower in the GOA than in the BSAI. The number of chinook salmon taken has ranged from about 14,000 in 1995 to just over 18,000 in 1999. Nearly all of the salmon taken have been by trawl gear in the GOA.

About 3,000 and 13,000 “other” salmon have been taken in the GOA as bycatch (“other” salmon is primarily chum salmon) since 1996. In 1995, a high of about 65,000 “other” salmon were taken, mostly in the trawl fisheries. Again, chum salmon represent the majority of the bycatch, with coho salmon second. Nearly all of the bycatch of salmon in the GOA (see Table 5.9b) is intercepted in trawl fisheries, with very few salmon caught in the hook-and-line fisheries. From 1995 through 1999, about 88% of the trawl “other” salmon bycatch were chum, 10 percent coho, 1 percent sockeye, and 1.5 percent pink salmon (Table 5.10). Again, no steelhead salmon were reported in the fishery.

5.5.3.5 The American Fisheries Act of 1998

On October 21, 1998, the President signed into law the AFA. The AFA:

1. Established a new allocation scheme for BSAI pollock that allocates 10 percent of the BSAI pollock TAC to the CDQ Program, and after allowance for incidental catch of pollock in other fisheries, allocates the remaining TAC as follows: 50 percent to vessels harvesting pollock for processing by inshore processors, 40 percent to vessels harvesting pollock for processing by catcher/processors, and 10 percent to vessels harvesting pollock for processing by motherships.

2. Provided for the buyout and scrapping of nine pollock catcher/processors through a combination of $20 million in Federal appropriations and $75 million in direct loan obligations. The AFA also established a fee of six-tenths (0.6) of one cent for each pound round weight of pollock harvested by catcher vessels delivering to inshore processors for the purpose of repaying the $75 million direct loan obligation.

3. Listed by name and/or provided qualifying criteria for those vessels and processors eligible to participate in the non-CDQ portion of the BSAI pollock fishery. The AFA increases the U.S. ownership requirement to 75% for vessels with US fisheries endorsements and prohibited new fisheries endorsements for vessels greater than 165 ft, LOA, greater than 750 gross registered tons, or with engines capable of producing greater than 3,000 shaft horsepower.

4. Increased observer coverage and scale requirements for AFA catcher/processors.

5. Established limitations for the creation of fishery cooperatives in the catcher/processor, mothership, and inshore industry sectors.

6. Required that NMFS grant individual allocations of the inshore BSAI pollock TAC to inshore catcher vessel cooperatives which form around a specific inshore processor and

agree to deliver the bulk of their catch to that processor.

7. Required harvesting and processing restrictions (commonly known as "sideboards") on fishermen and processors who have received exclusive harvesting or processing privileges under the AFA to protect the interests of fishermen and processors who have not directly benefitted from the AFA.

8. Established excessive share harvesting caps for BSAI pollock and directed the Council to develop excessive share caps for BSAI pollock processing and for the harvesting and processing of other groundfish.

Since the passage of the AFA in October 1998, the Council and NMFS have developed extensive management measures to implement the requirements of the AFA. While some of the resulting regulations were in place for the 1999 fisheries, the majority of the regulations were implemented in 2000 through emergency regulations. NMFS is currently in the process of preparing proposed rules including those regulations, although it is likely that these regulations will be implemented by emergency regulations again in 2000. For example, the AFA emergency regulations require the allocation of pollock TAC among fishery sectors (and within sectors where necessary), among fishery areas, and among fishing seasons. The rule also establishes harvest restrictions or "sideboards" on the participation of unrestricted AFA catcher/processors in other BSAI groundfish fisheries and completely prohibits AFA catcher/processors fishing in the GOA.

The effects of the AFA on the BSAI groundfish fisheries are largely related to ownership restrictions and restrictions on the number of vessels in the fishing fleet, allocation of pollock among the four sectors in Bering Sea, improving observer coverage and assessment of tons caught, restrictions in other fisheries (including fisheries in the GOA) of vessels benefitting from the AFA, and requirements for formation of cooperatives within sectors. These allocations have altered the nature of the pollock fishery by eliminating the race for fish, and allowing for better temporal dispersion of catch. The formation of cooperatives may also facilitate spatial dispersion of the catch to the extent that vessels can be more deliberative about where and when they fish to maximize profit. At present, no evidence suggests that the implementation of the AFA will increase the likelihood of operational or biological interactions between the BSAI groundfish fisheries.

As described previously, the AFA, established a new allocation scheme for BSAI pollock, provided for buyout and scrapping of nine BSAI pollock catcher/processors, listed by name or provide qualifying criteria for non-CDQ BSAI pollock participants, increased observer coverage and scale requirements for BSAI catcher/processors, established limits on BSAI pollock fishery cooperatives in the non-CDQ sectors, required individual allocations of BSAI pollock TAC to inshore catcher-vessel cooperatives, required restrictions on vessels benefitting from the AFA to protect vessels not participating in the AFA, and established excessive share caps.

In total, the AFA deals with rules and limits for participation in the BSAI pollock fishery, and allocation of the pollock among the participants. In general, issues related to allocation of TAC are resolved or managed in the NPFMC arena, where the industry and the public at large have an opportunity to participate. The AFA should indirectly benefit Steller sea lions by reducing the fishing power of the catcher/processor sector of the BSAI pollock fleet, reducing the rate at which pollock can be taken, increasing the temporal dispersion of the fishery, and thereby reducing the probability of localized depletion of pollock. The AFA also should increase the amount and accuracy of fisheries data from the catcher/processor sector. Such data is essential to assess the pollock stock, fishing practices, and potential effects on Steller sea lions. The effects of the AFA on fisheries authorized by the groundfish FMPs will be evaluated in section 6.

5.5.4 Impacts of Alaska State managed fisheries

ADF&G manages fishing activity within state territorial waters (from zero to three miles, hereby referred to as state waters). Additionally, the state oversees BSAI crab, salmon, and some rockfish fisheries in Federal waters (EEZ) under FMPs adopted by the Council. With the exception of Alaska state fisheries that have specified guideline harvest limits (GHLs) for species such as sablefish, Pacific cod, and the Prince William Sound pollock fishery, ADF&G coordinates their fishery openings and in-season adjustments with Federal fisheries. For example, when groundfish fishing is open in Federal waters, current state regulations allow fishing to occur in state waters in what is referred to as the “parallel” fishery. However, the State retains regulatory jurisdiction over fisheries within State waters.

Where and when do state fisheries occur? As described above, state fisheries occur inside the state territorial waters from zero to three miles, which happen to lie almost entirely within Steller sea lion critical habitat. Not only do these fisheries occur inside critical habitat, they are concentrated in space (usually bays or river outlets) and in time (usually spawning aggregations and salmon congregating near rivers for their return to spawning grounds in spring and summer). The exception to this are the crab fisheries, some rockfish fisheries, and salmon catch that occur outside of state waters.

State fisheries are managed by a highly localized system of regional offices scattered throughout the state. Generally, each region has separate state FMPs and is responsible for producing management reports, issuing GHLs, and providing in-season management of fisheries. This is in stark contrast to the Federal fishery which is composed of very large management units with relatively large harvest limits. The state’s system allows for micro-management down to the bay or stream level. Closures are often issued over VHF radio, and fishery openings can be as short as 20 minutes. Whereas the Federal fishery uses summer and winter surveys combined with stock assessment models to assess biomass and catch limits, the state employs a variety of methods of determining catch and biomass including stock recruitment models, aerial surveys, escapement goals, historical fishery harvest performance, and others. This next provides an overview of the fisheries, including historical catch, gear used, stock assessment methods, and health of the fishery, then we discuss possible direct and indirect effects of these fisheries on listed species and critical habitat.

5.5.4.1 State groundfish fisheries

There is a relatively long history of state management of groundfish fisheries (e.g., lingcod, sablefish, rockfish, Pacific cod, flatfish) in Southeast Alaska. In addition to management of fisheries in inside waters, the Federal groundfish FMP for the GOA established a joint state-Federal management plan for demersal shelf rockfish (DSR) in the Eastern Regulatory Area. The Council annually specifies the TAC for DSR. Under Federal oversight, ADF&G manages the DSR fishery throughout the EEZ in the Eastern Regulatory Area under a state FMP adopted by the Alaska Board of Fisheries (BOF).

In the western GOA, the state has established separate GHLs and seasons for the following fisheries: sablefish, lingcod, Pacific cod, black rockfish *(Sebastes melanops)*, and blue rockfish *(S. mystinus)*. The state-managed fisheries for sablefish and Pacific cod occur within state waters, whereas the state has full management authority for lingcod and black and blue rockfish fisheries throughout the EEZ. In the Central GOA, state-managed fisheries in state waters consist of Pacific cod, sablefish, pollock in Prince William Sound (PWS), and all rockfish species in state waters of PWS and lower Cook Inlet (LCI). In the western GOA, the state has full management authority for lingcod and black and blue rockfish fisheries throughout the EEZ and territorial waters. The cumulative impact of these state fisheries will be evaluated in section 7.

Pacific cod

In 1996, the BOF adopted Pacific cod FMPs for fisheries in PWS, LCI, Chignik, Kodiak, and the South Alaska Peninsula. All five FMPs have some common elements that include: only pot or jig gear is permitted, pot vessels are limited to no more than 60 pots, jig vessels are limited to no more than five jigging machines, and exclusive area registration requirements. Vessels participating in the South Alaska Peninsula and Chignik areas are limited to no more than 58 feet in length. Catches are allocated to users as: 85% pot and 15% jig in South Alaska Peninsula and Chignik areas, 60% pot and 40% jig in PWS, and 50:50 in Kodiak and Cook Inlet areas. If target gear allocation percentages are not met by late in the season, then the unattained GHL becomes available to all gear types. State GHLs are set as a percentage of the Federal TAC. State GHLs for PWS are set at 25% of the Federal TAC for the eastern GOA. Similarly, up to 25% of the central GOA TAC is allocated among Chignik (up to 8.75%), Kodiak (up to 12.5%) and Cook Inlet (up to 3.75%). Finally, the state GHL for the South Alaska Peninsula fishery is set at 25% of the western GOA TAC. The fishery generally occurs in the spring following the Federal fishery, the state Pacific cod fishery opens by regulation between 7 and 14 days after the Federal fishery closes.

In 2000, ADF&G implemented a small boat fishery around Adak Island (see ADF&G news release dated July 5, 2000). In state waters around Adak, vessels larger than 60' were prohibited, and gear types were limited to nontrawl. Effectively, this created a state fishery operating off the Federal Pacific cod TAC, which further complicates the link between state and Federal fisheries. This was brought up during the 2000 September Council meeting in Anchorage, when a proposal was made for a Pacific cod management action to separate the BSAI Pacific cod TAC into BS and AI components. Because the small boat portion of the TAC is only about 1.4%, given that Adak would now only receive 1.4% of a much lesser amount (an 89% reduction from the previous allocation) there was significant resistance to the proposal for the Federal fishery.

Walleye pollock

The PWS pollock fishery is based on a constant harvest rate strategy. Because reliable estimates of biomass and natural mortality are available, the PWS pollock stock falls into Tier 5 of the Federal stock assessment strategy (see section 2.4.2.3). The GHL is calculated as the product of the biomass estimate, instantaneous natural mortality rate (0.3) and a “safety factor” of 0.75. Biomass is estimated by bottom trawl surveys in summer and hydroacoustic surveys of spawning aggregations in winter. In 1999 the BOF directed the ADF&G to file an emergency regulation establishing a PWS pollock trawl fishery management plan to reduce potential impacts on the endangered population of Steller sea lions. The plan divides the Inside District of (PWS) into three management sections. The management plan also specifies that no more than 40% of the GHL may be taken from any one section. To implement this plan, ADF&G managed the fishery to target 30% of the GHL from any one area. The remaining 10% of the GHL was intended to insure against overharvest that could occur from an unforeseen increase in harvest rate or as result of incorrect inseason haul weights. This measure was in lieu of closing two Steller sea lion haulouts that were specified to be closed under the 1998 biolocial opinion (NMFS 1998). Although pollock in the GOA are considered to be one stock, the state surveys pollock in PWS separately from NMFS surveys in the GOA. However, NMFS takes the PWS fishery into consideration when setting the GOA TAC. In 2000, the fishery began on January 20, and was estimated to be about 1,420 mt of pollock. Typically, the fishery closes by mid-February.

Sablefish

ADFG manages sablefish fisheries in three management areas west of 144º W longitude. The PWS sablefish fishery is managed for a GHL set as the midpoint of a guideline harvest range derived from the estimated size of sablefish habitat and a yield-per-unit-area model. The state sets a fishing season length based on the GHL, estimated number of participants, and past catch rates. Rockfish bycatch is limited to 20%. In LCI, the first GHL was set in 1997 based on a five-year average harvest for the area adjusted up or down annually in proportion to the Federal TAC set for the GOA. The Aleutian Islands sablefish management area includes all state waters west of Scotch Cap Light (164˚ 44" W. longitude) and south of Cape Sarichef (54˚ 36" N. latitude). The fishery opens and closes concurrent with the Federal fishery unless closed earlier by emergency order when the state GHL is attained. In the Aleutian Islands the GHL is based on a combination of harvest history, fishery performance, and the Federal TAC based on NMFS surveys. In 1999, the GHL was set at 113 mt (250,000 lbs).

Lingcod

The minimum legal size of lingcod is 35” total length or 28” measured from the front of the dorsal fin to the tip of the tail. The minimum legal size restriction is intended to allow lingcod to spawn at least two years prior to becoming vulnerable to the fishery. In the PWS Management Area, the lingcod fishery is split among two districts: the Inside District and the Outside District. For each district, a GHL is established based on 75% of the recent 10-year average harvest. For 1999, the GHL for the Inside District was 1.8 mt (4,000 lb), and 10.2 mt (22,500 lb) was set for the Outside District. In PWS lingcod are primarily caught as bycatch mainly by hook-and-line vessels. In LCI, a GHL was set at 15.8 mt (35,000 lb) as 50% of recent five-year harvest, and only mechanical jig and hand jig (hand troll) gear may be used to target lingcod. During the open fishing season in PWS and LCI, lingcod may be retained as bycatch in other directed fisheries in an amount that does not exceed 20% by weight of the directed groundfish species aboard the vessel.

In the western GOA, lingcod are taken largely incidental to other fisheries. Therefore, no GHLs are set and harvests are reported to be small. In Kodiak and Chignik areas, there are no gear restrictions and lingcod over the size limit may be retained during July 1 – December 31. The South Alaska Peninsula represents the western range limit of the species, ADFG has no specific lingcod catch regulations for that area.

Rockfish

The PWS rockfish management plan, adopted by the BOF in 1992, includes three main components: (1) vessel trip limits, (2) bycatch allowance for low-level retention once the directed fishery is closed, and (3) a GHL for all species. There is trip limit of 1.4 mt (3,000 lb) per 5-day period to provide for a slower paced fishery. Unlike sablefish and lingcod, most rockfish die when discarded at sea. Therefore, ADFG has set a 20% bycatch allowance which they feel provides for retention of unavoidable bycatch of rockfish while avoiding an incentive to target rockfish after the closure of the directed fishery. A GHL of 68 mt (150,000 lbs) for all rockfish species is set relative to average harvests sustained over time. This GHL-setting method is similar to the tier 6 approach used by NMFS.

The Cook Inlet Area Rockfish Management Plan imposes a 68-mt annual pound harvest cap and vessel trip limits such that a fishing vessel may not land or have onboard more than a total of 0.45 mt (1,000 pounds) of all rockfish species within five consecutive days. When the directed fishery is closed, bycatch limits for rockfish are set at 10% (more conservative than the PWS plan above).

In the western GOA, only black and blue rockfishes are managed by the state. As in the central GOA, GHLs are set from historical catch data. In the Kodiak area, separate GHLs are set for seven fishing districts to disperse harvest and reduce the likelihood of localized depletion. Likewise, separate GHLs were established for four fishing subdistricts in the Akutan District and the Unalaska District was split into three subdistricts, one of which was split further into five sections. Once the directed fishery is closed in the western GOA, fishers are allowed to retain up to 5% by weight of black rockfish caught incidentally in other directed fisheries.

5.5.4.2 State herring fisheries

Alaska's commercial herring industry began in 1878 when 30,000 pounds were prepared for human consumption. By 1882, a reduction plant at Killisnoo in Chatham Strait was producing 30,000 gallons of herring oil annually. The herring reduction industry expanded slowly through the early 20th century reaching a peak harvest of 142,000 mt in 1934 (Fig 5.6). However, as Peruvian anchovetta reduction fisheries developed, Alaska herring reduction fisheries declined so that by 1967 herring were no longer harvested for reduction products.

Substantial catches of herring for sac roe began in the 1970s as market demand increased in Japan, where herring harvests had declined dramatically. Presently, herring are harvested primarily for sac roe, still destined for Japanese markets. Statewide herring harvests have averaged approximately 45,000 mt in recent years, with a value of approximately $30 million. In addition, commercial fisheries for herring eggs on kelp harvest about 400 mt of product annually with a value of approximately $3 million.

At present, the state fishery is located in the following areas: Prince William Sound, Cook Inlet, Kodiak, Alaska Peninsula, Bristol Bay, Kuskokwim, Norton Sound, Southeast, and Port Clarence. Fisheries in the Southeast and Port Clarence regions are not likely to affect the western population of Steller sea lions and are not considered further. Approximately 25 distinct fisheries for Pacific herring occur in these regions. Harvest methods are by gillnet, purse seine, and handpicking of roe from kelp. Herring are primarily caught for their roe during the sac roe harvest in the spring. On occasion the entire allowable harvest has been taken in less than one hour, although most sac roe fisheries occur during a series of short openings of a few hours each, spanning approximately one week. Fishing is not allowed between these short openings to allow processors time to process the catch, and for managers to locate additional herring of marketable quality.

Spawn-on-kelp fisheries harvest intertidal and subtidal macroalgae containing freshly deposited herring eggs. Both of these fisheries produce products for consumption primarily in Japanese domestic markets. Smaller amounts of herring are harvested from late July through February in herring food/bait fisheries. Most of the herring harvested in these fisheries are used for bait in hook-and-line and pot fisheries for groundfish and shellfish. Smaller amounts are used for bait in salmon troll fisheries. When herring harvested during spring sac roe fisheries produce low quality roe, they are then sold as food/bait herring, although for regulatory purposes the catch is included as part of the sac roe quota. Herring spawn timing is temperature dependent, so that herring spawning and roe harvest timing occurs progressively later from southeast Alaska, where spawning begins in March, through the northern Bering Sea, where spawning ends in June.

GOA herring have some genetic distinction from Bering Sea herring and are smaller and non-migratory, generally moving less than 100 miles among spawning, feeding, and wintering grounds. Bering Sea herring are much larger and longer lived. Most travel to offshore central Bering Sea wintering grounds, with some herring migrating over 1,000 miles annually. Herring are planktivores and provide a key link in pelagic and nearshore food chains between primary production and upper-level piscivores.

Harvest policies used for herring in Alaska set the maximum exploitation rate at 20% of the exploitable or mature biomass. The 20% exploitation rate is considered to be lower than commonly used biological reference points for species with similar life history characteristics. In some areas, such as Southeast Alaska, a formal policy exists for reducing the exploitation rate as the biomass drops to low levels. In other areas, the exploitation rate is similarly reduced, without a formal policy. In addition to exploitation rate constraints, minimum threshold biomass levels are set for most Alaskan herring fisheries. If the spawning biomass is estimated to be below the threshold level, no commercial fishing is allowed. Threshold levels are generally set at 25% of the long-term average of unfished biomass (Funk and Rowell 1995).

Most herring fisheries in Alaska are regulated by management units or regulatory stocks (i.e., geographically distinct spawning aggregations defined by regulation). Those aggregations may occupy areas as small as several miles of beach or as large as all of Prince William Sound. Herring sac roe and spawn-on-kelp fisheries are always prosecuted on individual regulatory stocks. Management of food and bait herring fisheries can be more complicated because they are conducted in the late summer, fall, and winter when herring from several regulatory stocks may be mixed together on feeding grounds distant from the spawning areas. Where possible, the BOF avoids establishing bait fisheries that harvest herring from more than one spawning population.

The 1999 harvest of herring for sac roe of approximately 38,000 tons is less than the recent average harvest of approximately 48,000 tons, because of lower abundance in some areas. Allowable harvest quotas in some areas were not entirely taken in 1999 because of marketing and processing considerations. The major populations of herring in Alaska are at moderate levels and in relatively stable condition, with the exception of Prince William Sound and Cook Inlet.

5.5.4.3 State salmon fisheries

Commercial salmon fishing in Alaska began in the 1880s (Fig 5.7). Initial commercial harvests were primarily salted, and canning became predominant at the turn of the century. After the United States purchased Alaska in 1867, the U.S. Federal government had jurisdiction over these fisheries until statehood. The White Act, passed in 1924, required a closure of the fishery after the halfway point of the runs. At that time, much of the catch was taken in large fish traps. Federal management was weak, poorly funded, and ineffectively enforced.

After World War II, W. F. Thompson of the University of Washington began investigations of salmon and their management in Alaska. After statehood in 1959, the state of Alaska took over salmon management. Fish traps were banned. Based on the work of W. F. Thompson and his students, ADFG implemented a management system based on maintaining a constant stock size, and a program to find stock sizes that maximize the yield. A network of regional and area offices was created to closely monitor local salmon runs and to open and close fisheries to meet conservation mandates. A state fish and wildlife enforcement program was instituted to assure compliance. Largely as a result of this management system, adequate enforcement, and commitment to salmon resource conservation, the fishing industry in Alaska has enjoyed the full benefit of the salmon resource when the environment has been favorable for large fish runs. The industry has accepted and encouraged restrictions during years of low runs. In general these salmon runs are considered rebuilt, and are at or near record abundances (Fig 5.7).

The state salmon fishery includes five species: chinook, sockeye, coho, pink, and chum. These fisheries are divided into southeast, Prince William Sound, Cook Inlet, Bristol Bay, Kodiak, Chignik, Alaska Peninsula, Kuskokwim, Yukon, Norton Sound, and Kotzebue management areas. Salmon are taken by purse seines, gill nets, trolling, and beach seining via an extensive small boat fleet. The catch in 2000 was about 135 million fish. Economically, the salmon fishery is worth more than all other state fisheries combined. The fisheries are managed for minimum escapement goals, where regional ADFG biologists have determined what level of escapement seems to produce the maximum yield per year. These methods have not been standardized, and range from aerial flights to determine if the streams are “full” to fish weirs and remote sonar counters. The timing of the fisheries correspond with the various spawning time for each run, which is highly variable and which is managed on a stream by stream basis.

5.5.4.4 State managed crab fisheries

The state manages all crab fisheries in the BSAI and GOA, although State management in the BSAI is subject to a federal FMP for the crab fishery. King (brown, red, blue), Dungeness, and Tanner crabs are taken by hand-picking, shovel, trawl, pot, and dredge gear. Crab fisheries began in the early 1960s when the stocks were abundant, then declined in the mid-1980s into the 1990s (Fig. 5.8). State crab fisheries occur in Bristol Bay, Dutch Harbor, Alaska Peninsula, Kodiak, Cook Inlet, Adak and W. Aleutian Islands, and Prince William Sound. Crab fisheries primarily occur during the winter season. Over the past ten years, the industry has focused on Alaska snow crab (*C. opilio*), and the catch has exceeded historical levels of king crab harvests from the late 1970s.

Most westward crab stocks were not healthy in 1999. All major red king crab stocks, except those in Norton Sound, BB, and the Pribilof Islands, were very low in abundance and continue to decline. Consequently, these fisheries have been closed for sometime. Bering Sea Tanner crab has been declared overfished and closed since 1997. St. Matthew and Pribilof Islands blue king crab fisheries have been closed since 1999 due to low stock abundance. The Bering Sea snow crab GHL was drastically reduced in 1999 because of stock decline.

Crab species harvested in 1999 included red king, blue king, golden king, scarlet king, snow, Dungeness, and Korean hair crab. Approximately 96,302 t of crab was landed with BS snow crab dominating the total harvest. The 1999 harvest consisted of snow crab 91.5%, red king crab 5.6%, golden king crab 2.5%, Dungeness crab 0.3%, Korean hair crab 0.1%, and scarlet king crab <0.0001%. Exvessel prices were high for Bristol Bay and AI king crabs due to stable Asian economies, increased domestic demand for crab, decreased Russian production, and closures of Pribilof Islands and St. Matthew Island king crab fisheries.

5.5.4.5 State shrimp fisheries

Five species are targeted in Alaska shrimp fisheries: northern (formerly, pink) shrimp, *Pandalus borealis*; sidestriped shrimp, *Pandalopsis dispar*; coonstriped shrimp, Pandalus hypsinotus; spot shrimp, *Pandalus platyceros*; and humpy shrimp, *Pandalus goniurus*. In 1999, northern and sidestriped shrimp contributed to almost all the landings from the areas west of 144º W long. (PWS, Cook Inlet, Kodiak, AI coasts, and BS [Pribilof Islands and St. Matthew Island]). Shrimp resources in Alaskan waters have been exploited since 1915, but catch records are only available since the mid-1960s. Effort was highest during the late 1970s and 1980s, but has undergone severe declines in most areas (Fig 5.8). Currently, the shrimp fishery occurs in the southeast and Yakutat areas, and to a lesser extent in Prince William Sound, Kodiak, Dutch Harbor, Cook Inlet, and the Alaska Peninsula. Shrimp are harvested by pot gear and often sold to floating processors. In 1995, over 45,000 mt of shrimp were harvested by 351 vessels. In the last ten years, effort has increased in the southeast due, in part, to the availability of floating processors, which allow fishing vessels to devote more of their time to fishing. Harvest strategy for shrimp is based on a minimum biomass estimate by region, the plan is to maintain the biomass above that level, where a fishery could occur at a harvest rate up to 20%. However, biomass estimates and recruitment are largely unknown for shrimp.

5.5.4.6 State shellfish (invertebrate) fisheries

Clam, abalone, octopus, squid, snail, scallop, geoduck clams, sea urchins, and sea cucumbers have been harvested throughout the state. Most of the catch of shellfish is taken from April to September, and they are taken by hand-picking, shovel, trawl, pot, and dredge gear. Harvest levels were relatively consistent through the 1980s, but have increased dramatically in amount and annual variation in the 1990s. The variability has been due, in large part, to recent but sporadic catches in Bristol Bay and the Bering Sea, areas not usually fished for shellfish. With the exception of the recent large catches in these areas, most of the shellfish fisheries have traditionally taken place in the Kodiak and Cook Inlet areas. Limited stock assessment surveys are available for these species, and almost all of the above invertebrates are managed with GHLs based on past fishery performance data.

Of all the above invertebrates, the giant Pacific octopus (*Octopus dofleini*) and squid (*Berryteuthis magister*) are the most likely prey of sea lions. Octopus, is harvested in all Alaskan waters primarily as bycatch in groundfish pot (mostly Pacific cod), trawl, and hook-and-line fisheries. Squid is also taken as bycatch in shrimp and groundfish trawl fisheries.

5.5.4.7 Interactions between State fisheries and listed species

Direct interactions between the fisheries and listed species would include direct take (mortality), disturbance (e.g., disturbance of a sea lion haulout), vessel noise, entanglement in nets, and among others, preclusion from foraging areas due to active fishing vessels. NMFS has already issued a comprehensive biological opinion for the southeast Alaska salmon troll fishery (NMFS 1999) that evaluates the fishery's impacts on listed salmon.

Direct take of listed species (cetaceans, Steller sea lions, and leatherback sea turtles) are expected to be very low relative to other mortality. Accurate estimates of take in the state fishery are not available due to lack of observer coverage. Estimates in the Federal fishery place the annual mortality at around 30 Steller sea lions. In the 1970s, the crab fleet purportedly killed sea lions for bait; however, the numbers killed are not known.

Perhaps the most important interaction between state fisheries and listed species arises from the intense pattern of localized removals of spawners. Although the patterns are generally similar from one fishery to the next, the sheer number of distinct fisheries make it difficulty to describe them individually. Likewise, each fishery is distinctly different in either the number of boats, gear used, time of year, length of season, and fish species. Therefore, a few examples are presented to demonstrate some of the competitive interactions which may occur.

Direct interactions between Steller sea lions and herring fisheries could occur if vessel activity interferes with sea lions foraging in the area, or if mortality results from fishery-sea lion interactions. Steller sea lions are attracted to areas where herring spawn; they are likely feeding on the dense aggregations of herring present during the short spawning period. Because herring spawn timing is somewhat variable, fishery managers have learned to depend on the presence of Steller sea lions to determine when herring spawning is imminent. Managers generally begin flying aerial surveys over potential herring spawning grounds well in advance of the expected spawning event. For several weeks prior to spawning, herring are usually present adjacent to the spawning grounds, but they occur in depths too deep to be detected from aircraft. However, the presence of Steller sea lions and cetaceans on the spawning grounds alerts the fishery manager to the presence of herring and impending spawning. Fishery managers usually note the presence of Steller sea lions in their field notebooks, occasionally recording actual counts.

Several days before spawning, herring move into shallower water and become directly detectable by aerial surveyors. About this time the fishing fleet begins arriving in the general area where the fishery will take place. Several hours before the opening, the fishing fleet moves into position, directed to the herring schools by spotter aircraft. Fishery openings, particularly purse seine openings, can be very short, on the order of 30 minutes, with a number of openings over a few days or a week. Steller sea lions have been observed in the middle of these fishing areas. There is not sufficient information to know whether these animals are there because they are not being disturbed and have no fear of the fishing vessels, or if they are the brave few venturing out into the disturbed area. Additionally, there is no way of knowing how many animals were excluded that were not observed foraging in the spawning area. Steller sea lions are observed leaving the grounds within a few days after the herring have spawned. Fishery biologists make note of their departure, as spawn deposition SCUBA biomass survey assessments do not begin, for safety reasons, until the sea lions leave the area.

One example of a herring spawning event where Steller sea lion counts were quantified during aerial surveys is shown in Figure 5.9. There was no fishery at Hobart Bay in the spring of 2000 because the quota had been taken in the earlier food/bait herring fishery. However, if a fishery had occurred, managers would typically have allowed 6-12 hours of gillnet fishing about April 29. Steller sea lions were already in the area at the time of the first ADF&G aerial survey on April 19, diving on the deeply submerged herring schools, as were a number of humpback whales. Following the spawning event, large numbers of birds appeared on the beaches to feed on the herring eggs, noted in numbers of 11,000 to 20,000. Approximately 150 Steller sea lions were counted in the area. Similar descriptions of humpback whale and Steller sea lion presence on herring spawning grounds are available in field notes from other herring fishing areas.

Steller sea lions and humpback whales are seen foraging extensively on herring schools, ADFG uses that behavior to signal the fishery, then the fishery moves in and eliminates entire schools of herring at peak condition. The entire fishery may last only about a week or two, but given the short spawning period when these stocks are concentrated and are easy prey for fisherman, marine mammals, and seabirds, that time may be essential to the survival of animals such as Steller sea lions. They may depend on these short intervals of high prey availability to get them through other bottle neck periods of low prey availability. However, in many instances they are instead faced with dozens of boats removing whole schools of prey. Some animals may be able to adapt, by learning to forage among the fishing boats, but others may choose to avoid the area. These are the animals that we do not see and have no reliable way to estimate. For animals that remain, we have no way to gauge their foraging success among the fishing vessels, nor do we have a way to gauge the impact on the animals that were excluded.

Additional interactions may occur in the salmon fisheries. Many of these fisheries take place at stream or river outlets where salmon congregate before heading up to spawn. Vessels converge on these areas and fish in tight groups, setting driftnets or purse seines. Again, sea lions may be excluded from this rich foraging area by direct vessel and fishing gear interactions.

5.5.5 Direct effects of commercial fisheries on listed species

5.5.5.1 Direct effects on Steller sea lions

Commercial fisheries can directly affect Steller sea lions in the BSAI, and GOA by capturing , injuring, or killing them in fishing gear or in collisions with fishing vessels, and if fishermen kill them intentionally. Observations of Steller sea lions entangled in marine debris have been made throughout the GOA and in southeast Alaska (Calkins 1985), typically incidental to other sea lion studies. Two categories of debris, closed plastic packing bands and net material, accounted for the majority of entanglements. Loughlin *et al*. (1986) surveyed numerous rookeries and haulout sites to evaluate the nature and magnitude of entanglement in debris on Steller sea lions in the Aleutian Islands. Of 30,117 animals counted (15,957 adults; 14,160 pups) only 11 adults showed evidence of entanglement with debris, specifically, net or twine, not packing bands or other materials. Entanglement rates of pups and juveniles appear to be even lower than those observed for adults (Loughlin *et al*. 1986). It is possible that pups were too young during the survey to have encountered debris in the water or that pups and juveniles were unable to swim to shore once entangled and died at sea. Trites and Larkin (1992) assumed that mortalities from entanglement in marine debris were not a major factor in the observed declines of Steller sea lions and estimated that perhaps fewer than 100 animals are killed each year.

Steller sea lions have been caught incidental to foreign, commercial trawl fisheries in the BSAI and GOA since those fisheries developed in the 1950s (Loughlin and Nelson 1986, Perez and Loughlin 1991). Alverson (1992) suggested that from 1960 to 1990, over 50,000 sea lions were incidentally taken in these fisheries, or almost 40% of his estimated total mortality due to various fishery and subsistence activities. Perez and Loughlin (1991) reviewed fisheries and observer data and reported that from 1973 to 1988, sea lions comprised 87% (over 3000) of the marine mammal incidental take reported by observers. They extrapolated the take rate to unobserved fishing activities and suggested that the incidental take during 1978 to 1988 was over 6,500 animals. Using the average observed incidental rates during 1973 to 1977, they also estimated that an additional 14,830 animals were incidentally taken in the trawl fisheries in Alaska during 1966 to 1977. Finally, they concluded that incidental take was a contributing cause of the population decline of Steller sea lions in Alaska, accounting for a decline of 16% in the BSAI and 6% in the GOA. However, because the actual decline has exceeded 80% since 1960, sea lions deaths incidental to fishing operations do not appear to be the principal factor in their decline.

More recent estimates suggests that the number of sea lions killed incidental to commercial fisheries in the action area has declined substantially from historic levels. The average number of Steller sea lions that were estimated to have been killed each year incidental to BSAI and GOA groundfish trawl and longline fisheries for 1990 to 1996 was 11 animals and the estimate from the Prince William Sound salmon drift gillnet fishery was 15 animals; resulting in a total estimated mean mortality rate in observed fisheries of 26 sea lions per year from the endangered western stock (Hill and DeMaster 1998). Another 30 Steller sea lions were believed to be killed each year in interactions with state fisheries, although these estimates are not reliable. Hill and DeMaster (1998) estimated that 10 Steller sea lions from the eastern population were taken by fisheries in southeast Alaska.

Satellite tracking studies suggest that Steller sea lions rarely go beyond the U.S. EEZ into international waters. Given that the high-seas gillnet fisheries have ended and other net fisheries in international waters are minimal, the probability that significant numbers of Steller sea lions are taken incidentally in commercial fisheries in international waters may be low. NMFS has concluded that the number of Steller sea lions taken incidental to commercial fisheries in international waters is too small to have measurable effects on the population dynamics of Steller sea lions (Hill and DeMaster 1998).

Intentional take of Steller sea lions

Historically, Steller sea lions and other pinnipeds were seen as nuisances or competitors by the fishing industry and fishery management agencies. Steller sea lions damaged fishing gear, damaged fishermen's catch, and were believed to compete for fish (Mathisen *et al*. 1962). As a result, the Federal and state government sanctioned efforts to reduce the size of the sea lion population through bounty programs, controlled hunts, and indiscriminate shooting. As noted previously, Steller sea lions were also killed for bait in crab fisheries managed by the State of Alaska.

The total number of sea lions killed between 1900 and 2000 is unknown. Alverson (1992) suggested that intentional take may have reached or exceeded 34,000 animals from 1960 to 1990. Fishermen were seen killing adult animals at rookeries, haulout sites, and in the water near boats. The loss of that many animals would have an appreciable effect on the population dynamics of sea lions, but the effect would not account for the total decline of the western population. The effect was likely concentrated in areas closer to fishing communities and less important in more isolated areas (e.g., central and western Aleutian Islands).

Government-sanctioned efforts to control the population of Steller sea lions stopped in 1972 with the passage of the MMPA. Sea lion populations appear to be growing slowly in southeast Alaska, where considerable commercial fishing occurs. Expanded observer coverage in the domestic groundfish fishery after 1989 and increased public awareness of the potential economic and conservation impacts of continued sea lion declines have probably reduced the amount of shooting. Nevertheless, anecdotal reports of shootings continue and a small number of prosecutions still occur. The full extent of incidental killing is undetermined and therefore should be considered a potential factor in the decline of sea lions at some locations.

5.5.5.2 Direct effects on critical habitat for Steller sea lions

Commercial fisheries in the action area would have affected critical habitat that has been designated for Steller sea lions primarily through the effects on the value of critical habitat to Steller sea lions (discussed under indirect effects below). Critical habitat has not been designated for any other listed species covered by this biological opinion.

5.5.5.3 Direct effects on cetaceans

Commercial fisheries can directly affect endangered cetaceans in the BSAI, and GOA by capturing , injuring, or killing them in fishing gear or in collisions with fishing vessels, and if fishermen kill them intentionally. In the biological opinions NMFS has prepared on commercial fisheries in the action area over the past 20 years, NMFS has identified very few direct effects on endangered cetaceans. However, information on the direct effects of commercial fisheries on whales in the action area has been limited until recently. In 1997, for example, a humpback whale was entangled in longline gear (pots for brown king crab). This whale was freed when the line was cut, but reports on the incident are unclear about whether the whale was injured during the incident. NMFS has generally considered commercial fisheries in the action area to have negligible effects on endangered cetaceans (Hill and DeMaster 1999).

5.5.5.4 Direct effects on salmon

The available information does not allow us to characterize the stock composition of the chinook bycatch in the groundfish fisheries. Consequently, we cannot estimate how the various fisheries in the action area have affected mortality rates of threatened and endangered salmonids over time. However, at least small numbers of some listed salmonids have been caught as bycatch in Alaska groundfish fisheries.

Chinook salmon rear in freshwater followed by 2-4 years of ocean feeding before they begin their spawning migration. Chinook from individual brood years can return over a 2-6 year period, although most adult chinook return to spawn as 4 and 5 year old fish. Chinook salmon migrate and feed over great distances during their marine life stage; some stocks range from the Columbia River and coastal Oregon rivers to as far north as the ocean waters off British Columbia and Alaska. As a result, cohorts of chinook salmon can be vulnerable to fisheries for several years. Most chinook stocks are vulnerable to harvest by numerous commercial troll, sport and commercial net fisheries in marine areas. Many are also taken in rivers and streams during their spawning migration by sport, commercial net and subsistence fishermen.

Their extended migrations and the extreme mixed stock nature of most chinook fisheries greatly complicates the management of chinook salmon. Prior to the mid-1970s, the extent of chinook migration and the impacts of ocean fisheries on particular chinook stocks was poorly understood. This changed with the advent of the Coded-wire tags and extensive tagging programs; large scale tagging of chinook made it possible for fishery managers to determine chinook migration routes, the timing of their migrations, and stock-specific impacts in distant fisheries. This kind of information, though sparse by today's standards, was used to establish the original harvest ceilings for ocean fisheries.

Snake River fall chinook

There is little direct information regarding the impact of NPFMC groundfish fisheries on Snake River fall chinook. There have been no recoveries of tagged fall chinook from the Snake River in either the BSAI or GOA groundfish fisheries. Coded-wire tags recoveries of the Snake River hatchery indicator stock in the ocean salmon fisheries indicate that the greatest concentration of recoveries occurs off the southern British Columbia and Washington coasts. Tags have been recovered from southern California to southeast Alaska, but the concentration of Snake River fall chinook expressed in terms of listed fish caught per thousand chinook is much lower in these more distant areas suggesting that they are being sampled from the margins of their distribution.

Although no Snake River fall chinook have been recovered in the NPFMC groundfish fisheries, there have been several observed recoveries of upper Columbia River fall chinook (known as upriver brights) in the GOA groundfish fisheries. Upriver Brights are known to have a more northerly distribution than Snake River fall chinook based on a longer and much more extensive tagging history. The presence of Upriver Brights in the GOA fishery suggests that the occasional occurrence of Snake River fall chinook in NPFMC groundfish fisheries is at least plausible.

As discussed in the *Status of the Species* section of this opinion, virtually all chinook caught in the Bering Sea are considered stream-type fish. Myers et al. (1996) used scale samples to determine general life history characteristics and major region of origin for chinook taken as bycatch in the eastern Bering Sea. They estimated that only about four percent of the bycatch were ocean-type fish comparable to Snake River fall chinook or other fall chinook stocks. If one assumes an annual chinook bycatch in the BSAI of 55,000 (from the most recent biological opinion, NMFS 1995b), then only a small portion, about 2,200, (55,000 * 0.04) are ocean-type fish that could be Snake River fall chinook. However, existing information continues to suggest that it is unlikely that Snake River fall chinook will be caught in the BSAI fisheries.

The southeast Alaska salmon fisheries represent the closest geographic region where estimates of the relative abundance of Snake River fall chinook are available. The concentration of Snake River fall chinook in the fishery has been estimated at about 0.3 per thousand for the 1987 - 1991 time period. A similar analysis for the 1985 - 1991 time period resulted in an estimate of 0.2 per thousand (PSC 1992). (These estimates were derived using the PSC chinook model.) Other estimates developed using the PFMC chinook model have ranged from 0.5 to 1.1 Snake River fall chinook per thousand depending on the time period and assumptions used in the analysis (NMFS 1993). Higher concentrations were generally observed when analyzing 1993 than when averaging estimated concentrations over a longer time period.

Snake River fall chinook are observed in the southeast Alaska fisheries, but in concentrations that are substantially lower than in southern fisheries. It is reasonable to assume that the concentration of listed fish will continue to decrease to the north. Given the great additional distance to the BSAI area, the low abundance of ocean-type fish in the BSAI area, and the relatively few Snake River fall chinook compared to the more populous ocean-type stocks from the British Columbia and Washington and Oregon production areas, NMFS concludes that it is highly unlikely that any Snake River fall chinook are taken in BSAI groundfish fisheries.

It is more difficult to assess the potential impacts of the GOA groundfish fisheries on Snake River fall chinook because there is no information on the origin of chinook taken in the groundfish fisheries. It is reasonable to assume that the Snake River fall chinook in the GOA groundfish fisheries will be lower than that observed in the southeast Alaska salmon fisheries because of the greater distance from the apparent center of their distribution. Similarly, it is reasonable to assume that there will be more stream-type fish in the GOA groundfish fishing areas than in the southeast Alaska fishery based on their observed dominance in the BSAI area. In 1999, NMFS produced a very conservative estimates of the possible occurrence of chinook salmon in GOA groundfish fisheries by multiplying concentration factors for the southeast Alaska salmon fishery by the assumed maximum chinook bycatch of 40,000 (NMFS 1999a). This analysis suggests that the catch of Snake River fall chinook could be as high as 8 to 44 fish per year (i.e., 40,000 * 1.1 Snake River fall chinook per thousand (from previous discussion) = 44). However, this analysis does not account for expected decreases in the concentration of listed fish in the more northerly GOA groundfish fisheries. Based on that analysis, NMFS concluded that the catch of Snake River fall chinook in the GOA groundfish fishery is unlikely to average not more than five per year.

Upper Willamette River chinook

About 33 chinook salmon coded-wire tages from the upper Willamette River have been recovered from GOA groundfish fisheries and one in BSAI groundfish fisheries since 1986. However, the number of upper Willamette River chinook salmon that were intercepted in relation to the amount caught in directed salmon fisheries in southeast Alaska and British Columbia is very low. Although it is impossible to extrapolate these observed recoveries into exploitation rates, NMFS believes that the take of these chinook is a relatively rare event. Two to three of these coded-wire tags have been recovered per year, with none recorded in the last 3 years. In 1993, 11 upper Willamette River chinook salmon were recovered in GOA fisheries, which is the highest number of any year since 1986.

Lower Columbia River chinook

These spring stocks have a wider ocean distribution than most stocks originating in the lower Columbia River, and are impacted by ocean fisheries off Alaska, Canada, and the southern U.S. They were also subject, in past years, to significant sport and commercial fisheries inside the Columbia. Since 1984, there have only been 9 LCR Coded-wire tags recoveries in GOA groundfish fisheries, indicating that it is a relatively rare event.

The three tule stocks in the ESU include those on the Coweeman, East Fork Lewis, and Clackamas rivers. These are apparently self-sustaining natural populations without substantial influence from hatchery-origin fish. These stocks are all relatively small. Since 1984, there have no reported Coded-wire tags recoveries in BSAI or GOA groundfish fisheries for this ESU component. The interim escapement goals on the Coweeman and East Fork Lewis are 1,000 and 300, respectively. Escapements have been below these goals 8 of the past 10 years for the Coweeman, and 5 of the past 10 years for the East Fork Lewis. The 10 year average escapement for the Coweeman is 700 , compared to a recent 5 year average of 995 (range 146-2,100). In the East Fork Lewis, the 10 year average escapement is 300, compared to a recent 5 year average of 279. There is currently no escapement goal for the Clackamas where escapements have averaged about 350 per year.

Three natural-origin bright stocks have also been identified. There is a relatively large and healthy stock on the North Fork Lewis River. Since 1984, there have no reported Coded-wire tags recoveries in BSAI or GOA groundfish fisheries for this ESU component. The escapement goal for this system is 5,700. That goal has been met, and often exceeded by a substantial margin every year since 1980 with the exception of 1999. This year the return is expected to be substantially below goal because of severe flooding during the 1995 and 1996 brood years. Nonetheless, the stock is considered healthy. The Sandy and East Fork Lewis stocks are smaller. Escapements to the Sandy have been stable and on the order of 1,000 fish per year for the last 10-12 years. Less is known about the East Fork stock, but it too appears to be stable in abundance.

Puget Sound Chinook salmon

There have been no reported Coded-wire tags recoveries from the PS ESU in BSAI or GOA groundfish fisheries.

Snake River Spring/Summer and Upper Columbia River spring chinook

The available information suggests that UCRS chinook are rarely caught in the proposed BSAI and GOA groundfish fisheries. The PFMC Salmon Technical Team previously reviewed the record of coded-wire tag recoveries of spring and summer chinook from the Snake River and other relevant information regarding distribution and harvest related mortality. There were no Coded-wire tags recoveries or other information to suggest that Snake River spring/summer chinook are caught in Alaskan fisheries (PFMC 1992, Clark et. al. 1995). There were also no recoveries from summer chinook releases were reported from Alaskan fisheries.

Sockeye salmon

Although the ocean distribution and migration patterns of Snake River sockeye and Ozette Lake sockeye are not well understood, catch information suggest that they are unlikely to be caught in proposed groundfish fisheries of the BSAI and GOA. NMFS found no information to suggest that there is any significant harvest of Snake River sockeye salmon in ocean fisheries (November 20, 1991, 56 FR 58619). NMFS previously concluded that Snake River sockeye are not likely to be caught in BSAI and GOA groundfish fisheries because few sockeye salmon are caught in trawl or hook-and-line fisheries that rarely intercept sockeye salmon. Given the low total abundance of Snake River and Ozette Lake sockeye salmon, they are not likely to be taken in BSAI or GOA groundfish fisheries.

Columbia River steelhead

Lower Columbia River and Upper Willamette River steelhead ESUs are coastal steelhead stocks. The Upper Willamette River stocks are winter run stocks; the Lower Columbia River steelhead stocks are primarily winter run although there are a few summer run stocks in the upriver portion of the ESU. Upper Columbia River, Snake River, and Middle Columbia River steelhead ESUs include inland stocks generally comprised of summer-run fish (Busby et al 1996).

The summer-run steelhead generally enter freshwater from May through October (Busby et al 1996) with peak entry occurring in July based on timing at Bonneville dam. Mark recoveries indicate that immature Columbia River steelhead are out in the mid North Pacific Ocean at this time. Data from high seas tagging studies found maturing summer-run Columbia River steelhead distributed off the coast of Northern British Columbia and west into the North Pacific Ocean (Myers et al 1996). Coded-wire tag data indicates summer-run steelhead are also present off the West Coast of Vancouver Island, with occasional recoveries in near shore Canadian fisheries.

The Lower Columbia River and Upper Willamette steelhead winter-run stocks enter freshwater from November through April (Busby et al. 1996). As mentioned above, the ocean distribution of winter-run steelhead is far offshore as compared with their summer counterparts, although coded-wire tag data indicates they are found as far east as the west coast of Vancouver Island. Adults move rapidly back to the Columbia River once the migration begins, averaging 50 km/day mean straight-line-distance (range = 15-85 km/day).

The ocean distributions for listed steelhead are not known in detail, but steelhead are caught only rarely in ocean salmon fisheries and are, therefore, not likely to be caught in BSAI and GOA groundfish fisheries (ODFW/WDFW 1998). For the salmon fishery in Alaska, during 1982-1993, when the southeast Alaska seine landings were sampled for tagged steelhead, only one tag was recovered, although tag releases of southern U.S. steelhead were quite high. Since then, only one other steelhead coded-wire tags has been recovered while sampling for other species. From 1995 through 1999, no steelhead were reported as bycatch in the "other" salmon bycatch category in the BSAI or GOA.

5.5.5.5 Direct effects on leatherback turtles

NMFS has no evidence that there are any direct effects of commercial fisheries in the BSAI, and GOA on the continued existence of leatherback turtles.

5.5.6 Indirect effects of commercial fisheries on listed species

Commercial fisheries have numerous indirect effects the include social effects, economic effects, physical effects, chemical effects, and biotic effects. Other indirect effects of commercial fisheries include the industrial infrastructure to process the catch and deliver the catch to markets. Fisheries can also have indirect biological effects that occur when fisheries remove large numbers of target species and non-target species (bycatch) from a marine ecosystem. These removals can change the composition of the fish community with associated effects on the distribution and abundance of prey organisms. Fishery removals of biomass can also compete with other consumers that depend on target organisms for food. These biological effects are generally termed cascade effects and competition.

5.5.6.1 Indirect effects on water quality

After fish are harvested in the ocean, they are usually processed before they are delivered to markets. Seafood processing covers a range of activities that can be as simple as removing viscera and storing whole fish on ice, it can require cutting fish into fillets or steaks, or it can involve more processing to form products like surimi or fish meal. Seafood processing generates waste that consist of highly biodegradable constituents such as tissue solids, oil and grease, along with fluids from viscera, heads, bones, and other discarded materials. The major constituents that are not highly degradable are crab and shrimp shells. These materials are usually ground up before being discharged from seafood processing facilities.

The adverse effects of discarding this material tend to be highly local and usually depend on flushing rates and dispersal regimes of the receiving waters. When discharges exceed the dispersion and biodegradation rates of the receiving waters, they can build up, increase the biological oxygen demand of the receiving waters, and can produce noxious smells. Waste generated by seafood processing can cause receiving waters to become anoxic, can elevate ammonia levels, can smother benthic organisms, and attract scavengers such as gulls or rodents, which may cause public health problems (Patten and Patten 1979).

In the 1970s, fish and shellfish waste discharged from mobile and shore-based processors at Kodiak, Dutch Harbor, and Akutan polluted coastal waters around those communities. In 1971, about 3.3×10^4 mt of waste was discharged at Kodiak (Jarvela 1986). In 1976, about 2.1×10^4 mt of waste was discharged at Dutch Harbor. In 1983, the shore-based Trident Seafoods plant at Akutan released between 9 and 11×10^4 mt of codfish and crab wastes into Akutan Harbor before the plant was destroyed by fire. Sonar surveys of Akutan Harbor identified a waste pile that was about 7 m thick and 200 m in diameter.

Section 303(d)(1)(C) of the Clean Water Act and the EPA's implementing regulations (40 CFR 130) require the establishment of a Total Maximum Daily Load (TMDL) to achieve state water quality standards when a body is limited by water quality. A TMDL identifies the degree of pollution control needed to maintain compliance with standards using an appropriate margin of safety. The focus of the TMDL is reduction of pollutant inputs to a level (or load) that fully supports the designated uses of a given waterbody. In 1997, the Alaska Department of Environmental Conservation (AKDEC) identified Udagak Bay (Beaver Inlet on Unalaska Island in the Aleutian Islands) and King Cove lagoon in King Cove (on the Alaska Peninsula in the Aleutians East Borough) as being water quality-limited for seafood wastes. TMDLs were established for both facilities in 1998.

For Udagak Bay, AKDEC concluded that the Northern Victor Partnership facility *P/V Northern Victor* produced seafood processing wastes (from Pacific cod, Pacific halibut, herring, walleye pollock, salmon, and a variety of other fish) that created a waste pile deposit of settleable solid residues measuring at least 2.4 acres in area and 7 feet thick on the seafloor. AKDEC concluded that the waste pile exceeded Alaska's water quality standards for residues. For King Cove, the AKDEC concluded that the Peter Pan Seafoods facility created a waste pile covering 11 acres of seafloor to an average depth of 3 feet.

In 1998, the list of impaired waters that was prepared by the AKDEC included six additional water bodies in Cold Bay, Dutch Harbor, and Kodiak that had been impaired by seafood processing, logging operations, military materiel, or fuel storage. Although total maximum daily loads for these facilities were not available for this biological opinion, the effects of these facilities appear to be localized and would not be expected the adversely affect threatened or endangered species under NMFS' jurisdiction.

5.5.6.2 Indirect effects on Steller sea lions

The discussion over the indirect, biological effects of the groundfish fisheries in Alaska S specifically cascade effects and competitive interactions S and their potential impacts on non-target species, has centered on the effects of the fisheries on the endangered western population of Steller sea lions. There is general scientific agreement that the decline of the western population of Steller sea lions results primarily from declines in the survival of juvenile Steller sea lions, although the available evidence also indicates that reproduction in these sea lions has been compromised. There is also general scientific agreement that the problems probably have a dietary or nutritional cause. There is much less agreement on whether fishery-induced changes in the forage base of Steller sea lions have contributed to and continues to contribute to the decline of the Steller sea lion. However, as explained below, based on the best scientific and commercial information available, the BSAI and GOA groundfish fisheries have likely adversely affected Steller sea lions by (a) competing for sea lion prey and (b) affecting the structure of the fish community in ways that reduce the availability of alternative prey.

In 1982, Lowry et al. provided a series of questions to assess competitive interactions between fisheries and Steller sea lion: (a) does the subject fishery affect the diet of Steller sea lions? (b) do any changes in diet compromise the condition of individual animals? (c) are any changes in condition sufficient to reduce growth, reproduction or survival? and (d) are any changes in reproduction and/or survival sufficient to have significant population effects? Unfortunately, the data required to answer these questions are either unavailable or equivocal.

In the absence of unequivocal data, the debate about competition between groundfish fisheries and Steller sea lions has continued since the Stellers' listing in 1991. The scientific community in Alaska has conducted workshops (Alaska Sea Grant 1993, National Research Council 1996) and published scientific papers (Loughlin and Merrick 1989, Alverson 1992, Trites and Larkin 1992, Ferrero and Fritz 1994) without resolving the debate. Since 1991, the question of whether the Alaska groundfish fisheries compete with Steller sea lions has been considered in annual biological opinions NMFS has prepared on the fisheries. For example, on April 5, 1991, NMFS issued biological opinions on the effects of the Alaska groundfish fisheries on endangered and threatened species, including the Steller sea lion. The opinion recognized that the groundfish fisheries could adversely affect Steller sea lions by (1) reducing food availability (quantity and/or quality) due to harvest; (2) entangling them in fishing gear; (3) intentional harassment (including killing and wounding) from fishermen; and 4) disturbance by vessels and fishing operations. Nevertheless, the 1991 opinion concluded that the fishery was not likely to jeopardize the continued existence and recovery of the Steller sea lion.

In 1998, NMFS prepared biological opinions on the walleye pollock fisheries in the BSAI and GOA that concluded the fisheries were likely to jeopardize the continued existence of the endangered western population of Steller sea lions and adversely modify critical habitat that had been designated for the sea lions (NMFS 1998). In the absence of definitive data or conclusive evidence, NMFS made the following assumptions to address the question of competition in the 1998 Biological Opinion on the walleye pollock fisheries:

1. The abundance of any species in a particular space at a particular time is finite. Therefore, an activity that can remove hundreds of pounds in a single tow and thousands of tons of fish per day must, on at least a very local scale and for short periods of time, reduce the biomass of the targeted fish remaining in the ocean. By extension, it is reasonable to assume that, as fishing effort increases or is concentrated in a particular area in a specific period of time, the extent and duration of those reductions would increase.

2. The likelihood of locally depleting a fish resource increases when that resource is patchily distributed. That is, fish species are not homogeneously distributed throughout the water column. Instead, there are specific areas that have larger numbers of fish and other areas that have limited numbers of fish (Bakun 1996). Walleye pollock and Atka mackerel are schooling fish that are patchily distributed: within a school their biomass is very high while outside of a school their densities are low. Fishing effort that targets schools of pollock or mackerel and removes a significant percentage of a school is likely to reduce the biomass remaining in the ocean for at least a short period of time in a particular space.

3. If these reductions in schools of pollock or mackerel occur within the foraging areas of the endangered western population of Steller sea lions, the reduced availability of prey is likely to reduce the foraging effectiveness of sea lions. The effects of these reductions become more significant the longer they last and the reductions are likely to be most significant to adult female and juvenile Steller sea lions during the winter months when these animals have their highest energetic demands.

NMFS (1998) argued that these assumptions were reasonable and consistent with assumptions made by others who had tried to resolve the issue of fishery effects on Steller sea lions (National Research Council 1996). This would imply that pollock are effectively removed from some areas at some time, and the local populations would probably take at least days or week to be rebuilt by in-migration from elsewhere. It is thus possible that food shortage for some mammals and birds - perhaps at crucial times and places for juveniles - have been exacerbated by this intense pulse fishing.

NMFS has cited, as examples of localized depletions of walleye pollock possibly associated with fishing effort, the Bogoslof Island area of the Aleutian Islands, the “donut hole” region of the Bering Sea, and the Shelikof Strait in the GOA. Pollock were once abundant in these areas, were heavily exploited by fisheries, and now consist of reduced stocks. While these stocks appeared to have declined, in part, for natural reasons, exploitation appeared to have contributed to those declines. NMFS (1998) cited Shelikof Strait as a more dramatic example of possible localized depletion of walleye pollock (Fritz et al. 1995). A fishery developed after a large spawning aggregation was discovered in the Strait in the late 1970s. Because of this fishery, pollock catches in the GOA increased from less than 100,000 mt to more than 300,000 mt. By 1993, the exploitable biomass of pollock in the GOA declined from 3 million tons in 1981 to less than 1 million (NPFMC 1993). The National Research Council (1997) concluded that "During this same interval, sea lion counts on nearby rookeries showed a dramatic decline, and animals began to show signs of reduced growth rate (Calkins and Goodwin 1988, Lowry et al. 1989)."

Based on these assumptions, NMFS' 1998 Biological Opinion concluded that the pollock fisheries in the BSAI and GOA were likely to jeopardize the continued existence of the endangered western population of Steller sea lions and adversely modify critical habitat designated for the sea lions. As a result of that opinion the debate about whether the Alaska groundfish fisheries compete with Steller sea lions intensified.

NMFS' 1999 Biological Opinion on the Alaska groundfish fisheries (for species other than pollock and Atka mackerel), outlined some of the remaining uncertainties in the available data. It argued that the amount of prey available is rarely known in the areas where sea lions forage, and measures of harvest or total biomass for a larger area (i.e., total biomass in the BSAI region) may or may not be good indicators of prey availability. For example, a large catch in a small area may indicate that the prey available was severely reduced (creating poor conditions for sea lions), or it may indicate that large amounts of prey were available (good conditions). If total biomass estimates for a large region (i.e., the entire stock or some large subset of the entire stock) are used as an index of availability, then spatial and temporal patterns of distribution must be predictable or assumed constant over space. But observations of fishing distribution (Fritz 1993) and survey results indicate that the patterns of the fishery and the distribution of fish may vary considerably and, therefore, total biomass estimates may or may not be related to localized biomass estimates.

NMFS' 1999 Biological Opinion discussed potential competition between the fisheries and Steller sea lions based on selection of prey by size, depth of prey, season of the fishery, and nature of the interaction. These discussions are relevant to the issues evaluated in this biological opinion and will be repeated below.

Competition and selection of prey by size

Size selection of prey by fisheries and by sea lions may have significant bearing on the question of whether or not competitive interactions occur. Fisheries may compete with sea lions if they remove the same size of prey from the same areas. Fisheries may also reduce the spawning biomass of prey to the extent that the reproductive capacity of the fish stock is reduced and, over time, fewer fish become available for sea lions.

The degree of overlap in the sizes of groundfish taken by Steller sea lions and by the various groundfish fisheries is not known for most species, but it is reasonable to assume at least some overlap occurs. The December 3, 1998 Biological Opinion provided evidence that the size of pollock taken by the fishery and by sea lions overlaps. Evaluation of the overlap is confounded by a number of factors. First, the sizes consumed by sea lions are determined by the available prey and any preferential selection of prey by size. In the majority of cases, scientists do not have sufficient information to characterize the available prey and therefore can measure only what was consumed, not necessarily what was preferred. Second, much of the information presented in the scientific literature on sizes of prey taken by sea lions or fisheries has been based on numbers taken by length. Inferences on relative importance of prey by numbers taken by length are, however, misleading, as dietary value is determined by biomass consumed by length, rather than number. That is, sea lions may gain a great deal more nutrition from consumption of a single large prey item than from the consumption of multiple small prey items and, therefore, number, is not the best indicator of dietary value.

Competition and depth of prey

The possibility of competition between groundfish fisheries and the Steller sea lion has been argued on the basis of depth of fishing, and depth of diving by sea lions. Overlap by depth may occur for any of the species that occur and are taken by fisheries on the shelf or shelf break. Competition may be less likely for species that tend to be found deeper in the water column.

The extent to which competition between fisheries and sea lions may be avoided through partitioning of resources by depth can be difficult to judge using the available information. Scientific studies of sea lion foraging patterns are just beginning to characterize the diving depths and patterns of sea lions, and they are likely capable of foraging patterns not yet understood or anticipated. In addition, prey for sea lions and fisheries move vertically in the water column as a function of life history traits, geography, light levels, temperature gradients, and perhaps a range of other factors.

Competition and the winter season

Changes in behavior, foraging patterns, distribution, and metabolic or physiologic requirements during the annual cycle are all pertinent to consideration of the potential impact of prey removal by commercial fisheries. Steller sea lions, at least adult females and immature animals, are not like some marine mammals that store large amounts of fat to allow periods of fasting. They need more or less continuous access to food resources throughout the year. Nevertheless, the sensitivity of sea lions to competition from fisheries may be exaggerated during certain times of the year. Reproduction likely places a considerable physiological or metabolic burden on adult females throughout their annual cycle. Following birth of a pup, the female must acquire sufficient nutrients and energy to support both herself and her pup. The added demand may persist until the next reproductive season, or longer, and is exaggerated by the rigors and requirements of winter conditions. The metabolic requirements of a female that has given birth and then become pregnant again are increased further to the extent that lactation and pregnancy overlap and the female must support her young-of-the-year, the developing fetus, and herself. And again, she must do so through the winter season when metabolic requirements are likely to be exaggerated by harsh environmental conditions.

Nursing pups are still dependent, at least to some extent, on their mother. If the mother is able to satisfy all the pup’s nutritional needs through the winter, then at least from a nutritional point of view, winter may not be a time of added nutritional risk to the pup. If, on the other hand, the pup begins a gradual transition to independence before or during the winter season, then the challenge of survival may be greater for the pup through the winter.

Weaned pups are independent of their mothers, but may not have developed adequate foraging skills. They must learn those skills, and their ability to do so determines, at least in part, whether they will survive to reproductive maturity. This transition to nutritional independence is likely confounded by a number of seasonal factors. Seasonal changes may severely confound foraging conditions and requirements; winter months bring harsher environmental conditions (lower temperatures, rougher sea surface states) and may be accompanied by changing prey concentrations and distributions (Merrick and Loughlin 1997). Weaned pups' lack of experience may result in greater energetic costs associated with searching for prey. Their smaller size and undeveloped foraging skills may limit the prey available to them, while at the same time, their small size results in relatively greater metabolic and growth requirements.

Diet studies of captive sea lions indicated that they adjust their intake levels seasonally, with increases in fall and early winter months (Kastelein et al. 1990). These adjustments varied with age and sex of the studied animals, and the extent to which the patterns observed are reflective of foraging patterns in sea lions in the BSAI or GOA regions is not known. Nonetheless, such studies support the contention that the winter period is a time of greater metabolic demands and prey requirements.

Changes in condition, availability, and behavior of prey may also be essential to successful foraging by all sea lions in winter. For example, pollock in reproductive condition (i.e., bearing roe—toward the end of the winter) are presumably of greater nutritional value to sea lions (for the same reasons that the fisheries would rather take roe-bearing pollock than pollock spent after the spawning season). Also, the relative value of any prey type must also depend on the energetic costs of capturing, consuming, and digesting the prey. Prey spawning aggregations may lead to a reduction in sea lion energetic costs associated with foraging. The characteristics of such aggregations may determine their significance to foraging sea lions. Such characteristics likely include their size, depth, location, composition, density, persistence, and predictability.

Nonetheless, the information that suggests that winter may be a crucial season for Steller sea lions does not lessen the importance of available prey year-round. The observed increases in consumption by captive animals in the fall months indicates that preparation for winter months may also be essential. Spring may also be important as pregnant females will be attempting to maximize their physical condition to increase the likelihood of a large, healthy pup (which may be an important determinant of the subsequent growth and survival of that pup). Similarly, those females that have been nursing a pup for the previous year and are about to give birth may wean the first pup completely, leaving that pup to survive solely on the basis of its own foraging skills. Thus, food availability is surely crucial year-round, although it may be particularly important for young animals and pregnant-lactating females in the winter.

Interactive competition versus exploitative competition

Much of the preceding discussion on the potential for competition between the Steller sea lion and BSAI and GOA groundfish fisheries has focused on exploitative competition; that is, competition that occurs when fisheries remove prey and thereby reduce prey availability to sea lions. In addition to exploitative competition, fisheries may affect sea lions through interactive competition. Examples of interactive competition include disruption of normal sea lion foraging patterns by the presence and movements of vessels and gear in the water, abandonment of prime foraging areas by sea lions because of fishing activities, and disruption of prey schools in a manner that reduces the effectiveness of sea lion foraging.

The hypothesis that these types of interactive competition occur can not be evaluated with the information currently available. The only data are from the POP database, and are not sufficient to describe the response of sea lions to fishing or other vessels. For example, few observations of sea lions from fishing vessels could mean that a) sea lions are present and tolerant of fishing but rarely sighted, or b) that sea lions are disturbed by fishing vessels and therefore abandon areas that are being fished. Incidental catch of sea lions in the 1970s and 1980s indicates that at least some sea lions were relatively tolerant of vessels and fishing activities. On the other hand, such interactions are relatively rare today, and it is possible there has been some selection for sea lions that avoid vessels and fishing activities.

The effects of fishing on groundfish schools are not understood. Vessels fishing for Atka mackerel trawl the same locations repeatedly, as they are unable to search for schools (Atka mackerel don’t have a swim bladder and therefore are not evident on fish-finders). Analyses (Fritz, unpubl. manusc.) have shown that this repeated trawling can lead to severe localized depletion. The number of schools affected and the effects on schooling dynamics are not known, but these factors will be important in understanding the overall impact of trawling for Atka mackerel on Steller sea lions.

Vessels trawling for other targets can use fish finders and are therefore able to search for prey until they have found schools or aggregations of suitable density. The strategy used is to continue to trawl that school (or set of schools) until such time as their size or density is no longer sufficient to justify further trawling, and then to resume searching until another aggregation of suitable density is located.

The strategies used by fishing vessels likely alter schooling dynamics and important features of target schools: their number, density, size, and persistence. If sea lion foraging strategies are adapted to take advantage of prey aggregations or schools, then trawling may result not only in exploitative competition through removal of prey, but also in interactive competition through disruption of schools or aggregations and their normal dynamics. For example, the removal of a portion of a fish school by a trawl net must create at least a temporary localized depletion (i.e., a gap in the prey school). How long that gap persists and the responses of the remainder of the schooling prey to trawling are unknown. The school may aggregate again, either quickly or over time, or it may disperse. The short-term effects may be prolonged when trawling is repeated. Hypothetically, it is possible that sea lions in the immediate vicinity of the trawled school are able to take advantage of the disruption to isolate and capture prey. On the other hand, sea lions have probably adapted their foraging patterns to normal schooling behavior of their prey; trawling may disadvantage sea lions not only by removing their potential prey within their foraging areas (exploitative competition), but also disrupting the normal schooling behavior of the prey species. Other investigators have observed this effect of fisheries on schooling species.

It is also important to note the potential cumulative effects of the Federal and state fisheries on Steller sea lions. As discussed previously (in *Natural Change in the Action Area*), walleye pollock clearly dominate the diets of Steller sea lions, although the sea lions will prey on a variety of other species (see Table 5.2 and Fig. 4.5). Since the 1970s, commercial fisheries for pollock has been focused within the foraging areas of Steller sea lions, and has sufficient fishing power to locally deplete pollock schools or disaggregate the schools (see the following section for more detail).

A predator faced with this kind of competitive pressure would normally shift its diet. Steller sea lions, however, would then have to compete with fisheries for Pacific cod, yellowfin sole, flatfish, Pacific salmon, herring, rockfish, etc. With each of these potential prey, Steller sea lions would find competitive pressure caused by a reduction of the biomass of a species and a change in its size structure and a local reduction caused by fishing vessels in critical habitat for the sea lions.

All these phenomena singularly in or combination may have reduced the reproductive success and population size of the western population of Steller sea lions in a way that have reduced their likelihood of surviving and recovering in the wild. The available evidence suggests that a significant part of the problem is the availability of prey. Studies of animals collected in the GOA in 1975-1978 and 1985-1986 indicate that animals in the latter collection were smaller, took longer to reach reproductive maturity, produced fewer offspring, tended to be older, and exhibited signs of anemia — all observations consistent with the hypothesis of nutritional stress (Calkins and Goodwin 1988, York 1994). In addition, the survival of juvenile animals has dropped in both the eastern Aleutian Islands (Ugamak Island; Merrick et al. 1987) and the GOA (Marmot Island; Chumbley et al. 1997). These results, the evidence of substantial changes in the physical and biological features of the BSAI and GOA ecosystems, and the expansion of fisheries in these regions all support the contention that lack of available prey has contributed significantly to the past decline of the western population, and may still be so contributing.

5.5.6.2 Indirect effects on critical habitat for Steller sea lions

Prey resources are not only the primary feature of Steller sea lion critical habitat, but they also appear to control the maximum size of the Steller sea lion population. Therefore, the concepts of critical habitat and environmental carrying capacity are closely linked: critical habitat reflects the geographical extent of the environment needed to recover and conserve the species. The term “environmental carrying capacity” is generally defined as the number of individuals that can be supported by the resources available. The term has two main uses: first as a descriptive measure of the environment under any given set of circumstances, and the second as a reference point for the environment under “natural” conditions (i.e., unaltered by human activities). Thus, the definition can have different implications depending on whether it is used to describe the carrying capacity of an environment that is unaltered by humans or the carrying capacity of an environment that has been altered by human-related activities.

The changes observed in the 1970s and 1980s in Steller sea lion growth, reproduction, and survival are all consistent with limited availability of prey. One cannot distinguish the relative effects of natural (i.e., oceanographic) phenomena from human-related activities (i.e., fisheries) on the availability of prey for sea lions based on the scientific and commercial data available. However, previous biological opinions have concluded that groundfish harvests in designated critical habitat have reduced the availability of fish species that are important prey for Steller sea lions. After considering all of the commercial fisheries that occur in the action area, especially in areas designated as critical habitat for sea lions, and comparing those fisheries against the various fish species consumed by Steller sea lions, we would conclude that commercial fisheries would reduce the availability of Steller sea lion prey in designated critical habitat. Given the magnitude of these harvests and their spatial and temporal extent, these removals could reduce the availability of prey in critical habitat for Steller sea lions sufficient to reduce the habitat's value to the sea lion population.

5.5.6.3 Indirect effects on cetaceans

The groundfish fisheries in the BSAI and GOA could indirectly affect endangered whales by altering the trophic structure of the pelagic ecosystem, through cascade effects, and by competing with them for food. However, the limited information on the biology, ecology, and demography of endangered cetaceans in the BSAI, and GOA has made it very difficult to assess these potential effects. In 1979, NMFS issued a biological opinion on the effects of the BSAI groundfish fishery and the BSAI FMP on endangered cetaceans, that concluded that the BSAI groundfish fishery was not likely to jeopardize the continued existence and recovery of these cetaceans. Based upon the best scientific information available, the opinion concluded that none of the 8 species of endangered whales in the BSAI would be adversely affected by direct disturbance from or physical contact with groundfish fishing operations. Of the 8 species, the opinion concluded that the fisheries were likely to compete with the fin, humpback, and sperm whales. Because fin and humpback whale populations do not compete with the groundfish fishery for their preferred food items, and because humpback whales are increasing, NMFS concluded that no adverse impact has, or will, result from this small amount of competition. Given the relative health of the sperm whale population in the North Pacific, and the relatively small catch of squid species allowed by the FMP, NMFS comcluded that sperm whales would not be jeopardized by competition with the groundfish fishery.

NMFS has considered the effects of groundfish fisheries on endangered cetaceans in several section 7 consultations since 1979, none of the biological opinions resulting from these consultations concluded that the groundfish fisheries were likely to jeopardize the continued existence of cetaceans in the BSAI, and GOA. At the same time, the absence of current information on the biology, ecology, demography, status, and trends of endangered cetaceans in the action area prevents these conclusions from being definitive.

5.5.6.4 Indirect effects on salmon

NMFS has no evidence to conclude that the commercial fisheries in the BSAI, and GOA indirectly affect listed salmon.

5.5.6.5 Indirect effects on leatherback turtles

NMFS has no evidence to conclude that the commercial fisheries in the BSAI, and GOA indirectly affect leatherback sea turtles.

5.6 Impacts of Oil and Gas Development

For almost three decades, oil and gas exploration, development, and production activities have been associated with the State of Alaska. Since the 1970s, the Minerals Management Service has made blocks of the Outer Continental Shelf off Alaska available for oil and gas leases; nine of those leases have occurred in the action area for this consultation (see Table 5.11). Except for two active leases in lower Cook Inlet, all of the leases have either expired or been relinquished.

On October 15, 1993, NMFS completed a biological opinion on the Cook Inlet lease sale (lease sale Number 149), which concluded that the lease and associated exploration activities were not likely to jeopardize the continued existence of any listed or proposed species, nor were they likely to destroy or adversely modify critical habitats. That biological opinion recognized the proximity of the lease area to important sea lion rookeries and haulouts in Shelikof Strait, the use of the Strait by foraging sea lions, and its value as an area of high forage fish production, but recognized the low probability of oil spills during exploration activities. In 1995, NMFS conducted another section 7 consultation with the Minerals Management Service and concluded that the lease sale and exploration activities for the proposed oil and gas Lease Sale Number 158, Yakutat were not likely to jeopardize the continued existence of any listed or proposed species, nor were the activities likely to destroy or adversely modify critical habitats (NMFS 1995).

The State of Alaska also manages oil and gas leasing in the action area. In 1896, oil claims were staked at Katalla approximately 50 miles south of Cordova. Oil was discovered there in 1902. An on-site refinery near Controller Bay produced oil for over thirty years. The refinery burned down in 1933 and was not replaced.

Exploration in Cook Inlet began in 1955 on the Kenai Peninsula in the Swanson River area, and oil was discovered in 1957. Today, a number of active fields produce oil in Cook Inlet, all of which is processed at the refinery at Nikiski on the Kenai Peninsula. Estimated oil reserves in Cook Inlet are 72 million barrels of oil. Currently there are additional lease sales planned through 2005 for the Cook Inlet area, but none for areas outside of Cook Inlet which would fall within the action area.

5.7 Impacts of Research and Other Activities

Steller sea lions have been killed for scientific research since the end of World War II (Thorsteinson and Lensink 1962, Calkins and Pitcher 1982, Calkins and Goodwin 1988, and Calkins et al. 1994). In 1959, 630 sea lions bulls were killed in an experimental, commercial and provided life history information (age, size, reproductive condition, food habits). Between 1975 and 1978, 250 sea lions were killed in nearshore waters and on rookeries and haulouts of the GOA; their stomachs were removed and examined for food content, reproductive organs were preserved for examination, blood samples were taken for disease and parasite studies, body measurements were recorded for growth studies, skulls were retained for age determination, tissue samples were preserved for elemental analysis and pelage samples were taken for molt studies. In 1985 and 1986, 178 sea lions were killed in the GOA and southeast Alaska to compare food habits, reproductive parameters, growth and condition, and diseases, with the same parameters from animals which were collected in the 1970s. The study was designed to address the problem of declining numbers of sea lions in the North Pacific and particularly in the GOA. More recently, sixteen Steller sea lions were killed for a Natural Resources Damage Assessment study following the Exxon Valdez oil spill.

For more than a decade, researchers have been conducting surveys and behavioral research on Steller sea lions. The results of their annual studies suggest that Steller sea lion populations are not adversely affected by this research, although individual animals may be adversely affected or killed. In 1998, 48,000 Steller sea lions were disturbed by these investigations, 384 pups were captured, tagged, and branded, but there were no mortalities. In 1997, 31,150 Steller sea lions were approached by these researchers, 14,550 were disturbed, 137 were captured, and 121 were tagged, but there were no known mortalities. The studies conducted in 1996 had similar effects, although one Steller sea lions died during the study (which equates to 0.002% of the animals approached or 0.007% of the animals disturbed). In 1995, 7,500 Steller sea lions were disturbed and none of them died.

Calkins and Pitcher (1982) found that disturbance from aircraft and vessel traffic has extremely variable effects on hauled-out sea lions ranging from no reaction at all to complete and immediate departure from the haulout. When sea lions are frightened off rookeries during the breeding and pupping season, pups may be trampled or, in extreme cases, abandoned. Sea lions have temporarily abandoned haulouts after repeated disturbance (Thorsteinson and Lensink 1962), but in other situations they have continued using areas after repeated and severe harassment. Johnson et al. (1989) evaluated the potential vulnerability of various Steller sea lion haulout sites and rookeries to noise and disturbance and also noted a variable effect on sea lions. Kenyon (1962) noted permanent abandonment of areas in the Pribilof Islands that were subjected to repeated disturbance. A major sea lion rookery at Cape Sarichef was abandoned after the construction of a light house at that site, but then has been used again as a haulout after the light house was no longer inhabited by humans. The consequences of such disturbance to the overall population are difficult to measure. Disturbance may have contributed to or exacerbated the decline, although Federal, State, and private researchers familiar with the data do not believe disturbance has been a major factor in the decline of Steller sea lions.

5.8 Summary of Conservation Measures Taken Under the MMPA and the ESA for Listed Species

The following is a compilation of the conservation measures implemented by NMFS since the development of the BSAI and GOA FMPs.

5.8.1 Steller sea lions

1. In 1989, the Environmental Defense Fund and 17 other environmental organizations petitioned NMFS for an emergency rule listing all populations of Steller sea lions in Alaska as endangered and to initiate a rulemaking to make that emergency listing permanent.

2. On April 5, 1990, NMFS issued an emergency interim rule (55 FR 12645) to list the Steller sea lion as a threatened species under the ESA and established protective regulations as emergency interim measures to begin the recovery process. The rule established the following:

    - Monitoring of incidental take and monthly estimates of the level of incidental kill of Steller sea lions in observed fisheries.

    - Aggressive enforcement of protective regulations, especially as they relate to intentional, lethal takes of Steller sea lions.

    - Establishment of a Recovery Team to provide recommendations on further conservation measures.

- Prohibition of shooting at or within 100 yds of Steller sea lions (this did not apply to Alaska native subsistence hunting).

- Establishment of 3 nm "no-approach" buffer zones around the principle Steller sea lion rookeries in the GOA and Aleutian Islands.

- Reduction of incidental kill quota from 1,350 to no more than 675 Steller sea lions.

3. On November 26, 1990, NMFS issued the final rule to list the Steller sea lion as threatened under the ESA (55 FR 49204).

4. On January 7, 1991, NMFS issued a final rule to implement regulations to amend the BSAI and GOA FMPs that limited pollock roe-stripping and seasonally allocated the pollock TAC in the BSAI and GOA (56 FR 492). For BSAI fisheries, the pollock TAC was divided between an A (roe) season and a B season (summer-fall). In the GOA fisheries, the pollock TAC for the Central and Western (C/W) Regulatory areas was divided into 4 equal seasons. NMFS noted in the proposed rule (55 FR 37907, September 14, 1990) that "shifting fishing effort to later in the year may reduce competition for pollock between the fishery and Steller sea lions whose populations have been declining in recent years".

5. On June 19, 1991, NMFS issued an emergency interim rule to ensure that pollock fishing did not jeopardize the continued existence or recovery of the threatened Steller sea lion (56 FR 28112). The rule contained the following measures to protect Steller sea lions:

   - Allocated the pollock TAC for the combined W/C Regulatory areas equally between two subareas located east and west of 154°W,

   - Limited the amount of unharvested pollock TAC that may be rolled over to subsequent quarters in a fishing year, and

   - Prohibited fishing with trawl gear in the EEZ within 10 nm of 14 Steller sea lion rookeries.

6. On January 23, 1992, NMFS issued a final rule to implement amendments 20/25 to the BSAI and GOA FMPs (57 FR 2683). This replaced prior emergency rules, and extended some of the protections. The amendments contained the following protections:

   - Prohibited trawling year-round within 10 nm of 37 Steller sea lion rookeries in the GOA and BSAI,

   - Expanded the no-trawl zone to 20 nm for 5 of these rookeries from January 1 through April 15 each year,

   - Established 3 GOA pollock management districts, and

   - Imposed a limit on the amount of an excess pollock seasonal harvest that may be taken in a quarter in each district.

7. On January 7, 1993 NMFS released the final Steller sea lion Recovery Plan. Section 4(f) of the ESA requires that NMFS develop and implement plans for the conservation and survival of endangered and threatened species. NMFS appointed a Steller Sea Lion Recovery Team to draft the Recovery Plan in 1990. The draft Recovery Plan was released for public review and comment on March 15, 1991. NMFS responded to comments received and provided notice on January 7, 1993 that the final Recovery Plan was available (58 FR 3008).

8. On March 12, 1993, NMFS issued a final rule to implement a seasonally expanded no-trawl zone around the Ugamak Island Steller sea lion rookery in the eastern Aleutian Islands during the pollock roe fishery season in the BSAI (58 FR 13561). The expanded buffer zone around Ugamak Island was expected to better encompass Steller sea lion winter habitats and juvenile foraging areas in this portion of the southeastern Bering Sea shelf during the BSAI winter pollock fishery.

9. On July 13, 1993, NMFS issued a final rule to implement regulations (BSAI FMP amendment 28) that subdivided the Aleutian Islands subdistrict into three subareas (Areas 541, 542, 543) (58 FR 37660). This action was taken because of concerns that concentrated fishery removals, particularly Atka mackerel, in the eastern Aleutian Islands could cause localized depletions. While dispersal of the Atka mackerel TAC was initiated to conserve fishery resources, it was also consistent with the conservation objectives for Steller sea lions.

10. On August 27, 1993, pursuant to the ESA (§1533(a)(3)(A)), NMFS designated critical habitat for Steller sea lions (58 FR 45269).

11. On November 1, 1993, NMFS initiated a status review of Steller sea lions to determine whether a change in classification to endangered was warranted (58 FR 58318). NMFS solicited comments and biological information concerning the status of Steller sea lions to be used in its review.

12. On November 29-30, 1994, NMFS convened the Steller Sea Lion Recovery Team specifically to consider the appropriate ESA listing status for Steller sea lions and to evaluate the adequacy of ongoing research and management programs. The Recovery Team recommended that NMFS list the Steller sea lion as two separate population segments, split to the east and west of 144°W. The Recovery Team recommended that the western population segment be listed as endangered and the eastern population segment be listed as threatened.

13. On February 22, 1995, NMFS forward its recommendation to NMFS Headquarters to split the Steller sea lion population east and west of 144°W, and to list the western population as endangered. In October 1995, NMFS issued a proposed rule to list the western population of the Steller sea lion as endangered.

14. On May 5, 1997, NMFS reclassified Steller sea lions as two distinct population segments under the ESA (62 FR 24345). The population segment west of 144°W (near Cape Suckling, AK) was reclassified as endangered, while the population east of 144°W was maintained as threatened.

15. On March 17, 1998, NMFS issued regulations to create a separate forage fish category (Amendments 36/39 to the BSAI and GOA FMPs; 63 FR 13009). Directed fishing for forage fish was prohibited at all times in Federal waters of the BSAI and GOA. The intended effect of this action was to prevent the development of a commercial directed fishery for forage fish, a critical food source for many marine mammal, seabird, and fish species.

16. On June 11, 1998, NMFS issued a final rule to reallocate pollock TAC in the W/C Regulatory areas of the GOA by moving 10% of the TAC from the 3rd fishing season, which started on September 1, to the 2nd fishing season, which started on June 1 (63 FR 31939). This seasonal TAC shift was a precautionary measure intended to reduce the potential impacts on Steller sea lions.

17. On January 22, 1999, NMFS issued a final rule to spatially and temporally distribute the Atka mackerel TAC in the Aleutian Islands subarea. This was a precautionary approach to reduce the probability of localized depletions of Atka mackerel inside Steller sea lion critical habitat. The amendment implemented both spatial and temporal redistribution of the Atka mackerel TAC.

18. On January 22, 1999, NMFS published an emergency interim rule (64 FR 3437) implementing the reasonable and prudent alternatives (RPAs) from the December 3, 1998 Biological Opinion which concluded that the pollock fisheries as proposed were likely to jeopardize the continued existence of the endangered western population of Steller sea lions and adversely modify its critical habitat. The rule created (1) Temporal dispersion of fishing effort, (2) spatial dispersion of fishing effort, and (3) pollock trawl exclusion zones around Steller sea lion rookeries and haulouts.

    On July 21, 1999, NMFS extended the emergency rule through December 31, 1999 (64 FR 39087), with revisions to include specifications for the B and C pollock seasons in the Bering Sea.

19. In October 1999, NMFS conducted additional analyses of the RPAs and developed revised final RPAs (RFRPAs) to be incorporated into the December 3, 1998 Opinion as compelled by a Court Order. The RFRPAs provided a detailed set of alternative management measures that would avoid the likelihood that the pollock fisheries would jeopardize the continued existence of the western population of Steller sea lions or adversely modify its critical habitat. Season dates, pollock catch percentages within critical habitat, and no pollock trawling areas were modified from the original RPAs.

20. On January 25, 2000, NMFS published an emergency interim rule (65 FR 3892) implementing the RFRPAs from the December 3, 1998, Biological Opinion as modified in October 1999. On June 12, 2000, NMFS extended the emergency interim rule through December 31, 2000 (65 FR 36795).

5.8.2 Salmon

1. On November 29, 1995, NMFS published a final rule (60 FR 61215) which implemented Amendment 58 to the BSAI FMP. This established annual prohibited species catch (PSC) limits for chinook salmon and specific seasonal no-trawling zones that were triggered when bycatch limits were reached.

2. On October 12, 2000, NMFS published a final rule to amend the BSAI FMP (58) to implement modifications to the chinook salmon savings areas in order to reduce the overall bycatch amount of chinook salmon (65 FR 60587).

6 EFFECTS OF THE FEDERAL ACTION

The federal action assessed in this opinion is the continued authorization of the BSAI and GOA groundfish fisheries under the existing FMPs, as amended. The FMPs provide the overarching guiding documents for the fisheries. As such, they determine the manner in which the fisheries are implemented, and thereby also determine the nature and magnitude of fishery effects on the BSAI and GOA ecosystems, and the listed species and critical habitat therein.

The purpose of this section is to analyze the effects of the action as described in Section 2. The scope of this analysis is intended to be comprehensive. The effects analysis will be broad and will examine the FMPs for federally managed fisheries in the GOA and BSAI, and the manner in which the total allowable catch levels are set as well as the process that leads to setting these levels. The analysis considers the direct and indirect effects of the FMPs and the effects of the fisheries prosecuted under the FMPs, on threatened and endangered species and critical habitat including the amount of prey biomass taken from sea lion critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR 402.02). Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

6.1 Analytical Approach

The analysis begins with some brief background, including information on the population dynamics of the target stocks and definitions of relevant terms. This information is essential for understanding the remainder of the section. The effects analysis is then divided into four main parts (6.3, 6.4, 6.5, and 6.6). Responses of listed species or the ecosystem to these effects are discussed in section 6.6. It is important to note that while much of this section describes the impact of fish management on fish stocks, ultimately the health and availability of the stocks are relevant to the condition of listed species.

The first part of the effects analysis (6.3) is a characterization of the fundamental elements of fishery management as practiced under the FMPs. A subset of these characteristics are particularly important sources of potential ecosystem effects and are highlighted in subsequent sections.

In the second part of this analysis (6.4), focus is on one of those characteristics in particular, exploitation strategies, because of their potential relevance, both past and present, in shaping changes in the abundance and population structure of groundfish stocks. The analysis presents as an example one of the present fishery management regime’s maximum target fishing reference points of $B_{40\%}$ to illustrate the potential direction and intensity of direct effects. This regime employed for certain groundfish species, utilizes a target fishing mortality rate ($F_{40\%}$) which reduces the equilibrium spawning biomass per recruit of the target stock to 40% of its equilibrium unfished level (i.e. a 60% reduction). Differences exist in available data for determining these levels for the different fish species under the FMP (a tiered system is used), but the reference point strategy is the same.

The third part of this analysis (section 6.5) evaluates all the elements of the cycle that underlay management decisions (other than B_{40} above). This section steps through the annual fishery cycle, from surveys through the establishment of TACs, to the prosecution of fisheries as a means of presenting analyses of several more important elements in chronological order. The effects are evaluated specific to the major stages of the cycle and whether the effects can be compounded through subsequent steps in the cycle.

Finally, the fourth part of this analysis (6.6) examines specific management elements, the FMPs as guiding documents for management of the fisheries and protection of the associated ecosystems. Whereas sections 6.2 & 6.3 focus primarily on the scientific foundations which underlay the management decision, here we deal with management elements that incorporate the scientific foundations. Examples of management elements that would be used in implementing the fisheries include access, fleet capacity, gear types, and time/area closures. This analysis will include the fisheries that are prosecuted under the FMPs, specifically, whether the FMPs, contain the conservation and management measures necessary to reasonably ensure that the action directly or indirectly does not adversely affect threatened and endangered species in a manner that appreciably reduces their likelihood of both survival and recovery in the wild (jeopardy), or appreciably diminishes the value of designated critical habitat for both the survival and recovery of threatened and endangered species in the wild (adverse modification).

6.2 Background Information

6.2.1 Definitions

In this section, the intent is to provide a brief review of several concepts in population dynamics that are necessary to understand our terminology and subsequent analyses in this section. The following is a list of working definitions:

Stocks — The term "stock" refers to a group of individuals that form a population unit with some unifying characteristic. That characteristic may be based on biological information (i.e., a genetic stock, or a group of individuals with similar genetic characteristics that separate them from other individuals), or managerial (i.e., a GOA Pacific cod stock that may be genetically inseparable from the BSAI cod stock but is managed separately because of geography, and for the purpose of setting TACs). In this section, we use the term "stock" to mean a group of individuals that form a management unit.

Metapopulation — The term "metapopulation" is used to indicate a "population of populations." That is, a metapopulation consists of multiple population units that are linked by some level of individual exchange between subpopulations.

Closed populations or stocks — The term "closed" is used with respect to populations or stocks to indicate that the population is effectively isolated from exchange with other populations. That is, the dynamics of a closed population are determined by reproduction and mortality without influence from immigration or emigration. Unless stated otherwise, we will assume that the stocks or populations under consideration are closed.

Replenishment — In the absence of immigration, populations or stocks are "replenished" by reproduction (addition to the number of individuals) and somatic growth (addition of mass to existing individuals).

Mortality — In the absence of emigration, populations or stocks are reduced by mortality. Natural mortality occurs from predation, disease, injury, etc. Fishing mortality occurs as a consequence of fishing.

Recruitment — Recruitment can be defined as the number or biomass of fish added to some portion of a population (i.e., the mature portion, the fished portion). Throughout this opinion, recruitment has been used to indicate the number or biomass of fish added to the fished portion of a stock through the processes of aging and somatic growth. Recruitment is generally described in terms of cohorts or age classes, and the age of recruitment is defined as a set age. The actual recruitment process may vary from these conventions, as fish grow at different rates, and not all of the fish in an cohort are necessarily recruited at the same age. In general, the process of recruitment is more easily assessed and used as a starting point for an age-structured analysis of a population. The factors or processes that actually determine recruitment (reproduction, larval and juvenile life histories and survival) are less well understood, and the accounting processes involved in quantitative fisheries biology often start with the age of recruitment.

Age structure — The fact that individuals of the target stocks live and reproduce over multiple years means that the stocks are age-structured. That is, they have individuals of age 0 that were just produced, age 1 that were produced one year previous, age 2, age 3, and so on. As these individuals also are capable of living multiple years past the age of recruitment to the fished portion of the population, this portion is also age-structured. Age-structure is an important characteristic of these stocks, because it means that from the age of recruitment, cohorts are subjected to fishing mortality (on top of natural and non-fishing anthropogenic mortality) year after year until the cohort no longer persists. That is, the fact that these populations are age-structured is a fundamentally important determinant of the impact of fisheries.

Population dynamics of an unfished population — When taken together, the above information indicates some basic elements of a stock's population dynamics. Consider a groundfish stock *without fishing* (Fig. 6.1a).

- Each year, a cohort or age class is produced through the process of reproduction.

- From the annual point in time in which reproduction is complete, the cohort can only *decrease in number* through natural mortality (other non-fishing mortality is not included). Natural mortality is depicted by the points in Figure 6.1a. Natural mortality can be very high for young fish, but is generally treated as a constant from a certain age (e.g., age 3 in Fig. 6.1a).

- Individuals in the cohort *increase in body size (biomass)* as a result of somatic growth. Total biomass (histogram bars in Figure 6.1a) for each cohort increases until the growth rate no longer keeps pace with losses due to natural mortality (about age 5 in Figure 6.1a).

- The age structure of an unfished stock, then, is a consequence of numbers of fish produced annually, their somatic growth, and losses due to natural mortality. The age structure can be depicted in terms of numbers per age class, or biomass per age class. Biomass is the preferred presentation because value to fisheries and other predators is best measured in units of biomass.

Now consider the stock structure *with fishing*

- Recruitment is an annual process whereby a new cohort is added to the fished part of the stock. Recruitment to the fished part of the stock occurs when the fish have reached a sufficient size (or age) to be taken in the fishery (depicted as age 3 in Figure 6.1a).

- Fishing mortality can only reduce the number and biomass of fish in a recruited age class or cohort (Fig. 6.1b, c).

- Recruitment does not replenish older age classes that are diminished by natural mortality or by fishing mortality (non-fishing anthropogenic mortality is not considered).

- Once an age class has recruited to the fishery, it is fished year after year without replenishment other than that occurring through somatic growth.

Localized depletion — A reduction in prey availability that adversely affects the foraging efficiency of a predator dependent on that particular prey field. We can also describe this factor in terms of niche overlap. In the wild, it is rare that two predators rely on exactly the same prey, often, there is substantial separation in time of capture, size taken, location, or many other factors which allow the resource to be compartmentalized. For example, northern fur seals eat substantially smaller pollock than do Steller sea lions. But, if for discussion they did rely upon the same size of pollock, they would deplete prey for each other. If we think of the fishery as a top level predator such as fur seals, sea lions, or whales then we can examine the extent to which a fishery results in *competitive niche overlap* via localized depletions.

Prey field — Finally, we use the term “prey field” to refer to the environment that a particular predator experiences during foraging. The prey field consists of individuals from multiple age/size-structured prey populations (i.e., individuals of multiple groundfish stocks). The availability of each prey type is a function of a range of factors including their standing biomass in the foraging area, their behavior, their age/size-structure, and their life history.

6.2.2 The fundamental characteristics of groundfish fisheries

Section 2 outlines the MSA, the fishery management process, and the specific measures of the FMPs, that shape the fundamental characteristics of the federally managed Alaska groundfish fishery. Assessing the effects of this action requires looking at the functioning of these factors within the ecosystem. The MSA and associated National Standards recognize the importance of an ecosystem view. Specifically, the MSA and National Standard 1 establish optimum yield as the goal of fishery management and, by definition, “optimum” must take into account the protection of marine ecosystems and ecological factors (16 U.S.C. 1802(28)). The MSA uses the term “conservation and management” to refer to all the rules, regulations, conditions, methods, and other measures which are required to maintain the environment and which assure that irreversible or long-term adverse effects on fishery resources and the marine environment are avoided (16 U.S.C. 1802(5)). MSA FMPs must contain necessary and appropriate conservation and management measures that are consistent with any other applicable law (16 U.S.C. 1853(a)), including the ESA. One of the main purposes of section 7 of the ESA is to assess the impacts of federal actions within the context of environmental baseline and cumulative effects–an ecosystem concept. ESA also provides for protection of the critical habitats upon which endangered species and threatened species depend (16 U.S.C. 1531). Though both the ESA and MSA address the ecosystem concept, some of the specific methods used to comply with the MSA mandate are not identical to what may be appropriate in the ESA context. For example, the fish mortality figured into fish stock assessments considers successful predation on fish by animals like sea lions in determining removal rates, but does not consider sea lion predation that was unsuccessful. This section will assess the FMPs and the FMP process from the latter perspective.

6.2.3 Other applicable law which effect the FMPs and their consequences

Before NMFS can promulgate regulations to implement an FMP or allow a fishery operate according to a recommendation from the NPFMC, NMFS conducts several reviews as required by Federal statutes. Several federal laws – the National Environmental Policy Act of 1969, the Endangered Species Act of 1973, and the Essential Fish Habitat provisions of the MSA – require NMFS to evaluate the environmental effects of fisheries before NMFS acts on a recommendation from the NPFMC. Together these provisions require review that should identify the impact of the proposed actions on marine and coastal ecosystems, threatened and endangered species, designated critical habitat, species that are proposed for listing as threatened or endangered, and candidate species.

6.2.3.1 NEPA review

The National Environmental Policy Act (NEPA) has two principal purposes: it requires federal agencies to evaluate the potential environmental effects of any major federal action they are involved in planning or permitting and alternatives to that action and it informs the public of the potential impacts of major federal actions and alternatives during the earliest planning stages of those actions (42 U.S.C. 4321 *et seq*.). NEPA's first purpose is intended to ensure that decision-making officials in federal agencies make well-informed decisions about actions they are considering by having documents that disclose the potential impacts of an action and alternatives to that action. NEPA's second purpose provides the public an opportunity to become involved in and influence final decisions on federal actions.

6.2.3.2 EFH consultation

Pursuant to Section 305(b)(2) of the Magnuson-Stevens Act, Federal agencies must consult with NMFS regarding any of their actions authorized, funded, or undertaken or proposed to be authorized, funded, or undertaken that may adversely affect EFH. The EFH regulations at 50 CFR Section 600.920(g)(2) require that an EFH assessment must contain:

1. A description of the proposed action;

2. An analysis of the effects, including cumulative effects, of the proposed action on EFH, the managed species, and associated species, such as major prey species, including affected life history stages;

3. The Federal agency's views regarding the effects of the action on EFH; and

4. Proposed mitigation, if applicable.

Protection of essential fish habitat is important in maintaining healthy fish stocks, and so indirectly may benefit ESA listed species. If fish and protected species essential habitats overlap, more direct benefits may be realized.

6.2.3.3 ESA review

The ESA provides a comprehensive program for conserving the critical habitat that supports threatened and endangered species and for conserving the species themselves. Section 7 consultations, such as the consultation that resulted in this biological opinion, form part of the core of ESA's program. Section 7 of the ESA contains several important provisions, but two of those provisions are relevant to this consultation: the conservation provisions of section 7(a)(1) of the ESA and the prohibitions against jeopardy and adverse modification of critical habitat contained in section 7(a)(2).

Section 7(a)(1) of the ESA directs the Secretaries of Commerce and Interior to use their authorities to further the conservation purposes of the Act (16 U.S.C. 1536). Section 7(a)(2) of the ESA was described at the beginning of this biological opinion. NMFS has conducted multiple internal section 7(a)(2) consultations on the BSAI and GOA groundfish fisheries (see Table 1.1).

6.3 Description of the FMP Process for Determining the Annual Groundfish Catch

This section considers the effects of the annual fisheries cycle on listed species. We will use the pollock fisheries as an example and relate them to the individual components of the cycle as they were described in the Description of the Action (section 2).

6.3.1 Biological information – groundfish surveys

The purpose of the surveys is to estimate the abundance and age structure of groundfish species. This information is essential to the determination of the annual harvest amount (TAC). Current surveys are designed to provide information to manage groundfish harvests on a single species basis. To manage groundfish harvests on a multi-species level much more information would be necessary beyond what is currently collected.

Three types of surveys are currently conducted, including bottom trawl for shellfish and bottom fishes, hydroacoustic or echo integration-trawl (EIT) for pollock , and longline for bottom fishes (e.g., sablefish) of the deeper waters of the continental shelf and slope. Summer bottom trawl surveys of the eastern Bering Sea have been conducted annually since 1972, with the current standardized time series beginning in 1979. These surveys follow a systematic grid of sampling stations. Triennial summer bottom trawl surveys for the Aleutian Islands and the Gulf of Alaska began in 1980 and 1984, respectively. In 1999 the GOA was changed from a triennial to a biennial bottom trawl survey. These surveys are based on area and depth-stratified random sampling among a set of predetermined stations. Annual winter EIT surveys were initiated in 1981 to study abundance of spawning pollock in Shelikof Strait, and in 1988 to study pollock abundance in the vicinity of Bogoslof Island. Summer longline surveys were initiated by Japanese scientists in 1979 to assess sablefish abundance over the upper continental slope in the Gulf of Alaska. These surveys are now conducted by U.S. scientists, and have been extended to the Aleutian Islands and the eastern Bering Sea slope, where they are conducted in alternate years. Current surveys are as follows:

1. Summer bottom trawl surveys in the eastern Bering Sea,

2. Triennial and biennial summer bottom trawl surveys in the Aleutian Islands and GOA respectively,

3. Summer longline surveys for estimation of sablefish abundance, and

4. Winter EIT surveys in the Bogoslof and Shelikof areas on an annual basis.

The following surveys may be initiated in the future:

1. Winter EIT surveys may be instituted to determine abundance of pollock in sea lion critical habitat,

2. Summer EIT surveys may be initiated on an alternate year basis in the GOA and eastern Bering Sea, and

3. Based on results of a bottom trawl slope survey this summer (2000), biennial slope surveys may be initiated in the eastern Bering Sea.

Surveys are conducted to assess the abundance or biomass of stocks. In addition, they also provide important information on age and sex composition, recruitment of young fish to the fished stock, length and weight at age, reproductive status or condition, food habits, and other pertinent biological characteristics. Assessment of each of these parameters may be affected by sampling variability, measurement error, or systematic bias. Considerable effort is directed at minimizing measurement error and bias, but sampling variability may still occur and must be evaluated and reported to provide an indication of the confidence with which final parameter estimates may be. If this estimation procedure is unbiased, then 68% of the time this interval also would be expected to enclose the true value for pollock in the area assessed.

A principal concern of the survey design with respect to listed species is whether the timing and frequency of the surveys, and the scale of the surveys, allow for biomass estimates that can be used to assess potential competition at scales relevant to foraging listed species, especially Steller sea lions. Survey information is used to spatially allocate TACs to management areas. Surveys in the GOA and AI are used to allocate TACs in proportion to biomass. However, more frequent surveys would be necessary in order to confidently allocate TACs in proportion to biomass in areas smaller than entire regions (e.g. in areas smaller than GOA). Bottom trawl surveys in the GOA, for example, have historically been conducted every three years. Results from the 1993, 1996, and 1999 surveys demonstrate the difficulty of understanding the spatial/temporal dynamics of the pollock stocks in this region based on those results.

Year	GOA-wide biomass estimate (mt)	95% confidence interval (mt)	Percent in area 610	Percent in area 620	Percent in area 630
1993	793,926	543,841 – 1,044,013	49%	25%	26%
1996	707,434	509,934 – 904,934	25%	42%	33%
1999	632,763	158,246 – 1,107,279	72%	18%	9%

The estimated portion of the stock in area 610 changed by almost 50% over a three-year period and the change was in the opposite direction of that observed in the previous three years. These data may represent actual changes in pollock distribution of the population, or they may reflect the magnitude of the observation error in measurement of pollock biomass (e.g., large confidence intervals on the GOA-wide estimates). The distribution of the stock in intervening years also can not be described. Thus, use of the existing data to spatially allocate TAC in order to distribute catch in proportion to biomass is problematic even for the seasons in which the surveys are conducted (summer). Spatial allocation of TAC in winter has been more challenging since GOA-wide surveys have not been conducted in winter.

6.3.1.1 Spatial limitations

Tilman et al. (1997, p.3) wrote

> "All organisms are discrete entities that mainly interact with neighboring individuals of their own or other species. This discrete nature and spatial confinement is most evident for sessile organisms. . . However, even motile organisms have their greatest impacts in a rather confined region – the region through which they move. These simple observations have profound implications for the dynamics and outcome of both intraspecific and interspecific interactions. In particular, local interactions and local movement/dispersal mean that population densities do not change in response to average conditions across a large habitat, as is assumed in classical nonspatial models, but rather in response to the local conditions experienced by each individual."

Surveys cannot be conducted to provide relevant ecological information on all scales, but the need for stock information on finer scales has recently become apparent. The prey removal and the subsequent prey availability within critical habitat have been identified as an important issue to be addressed. The lack of fine-scale survey information on the spatial distribution of the stocks has made it difficult to distribute catch in proportion to biomass, even though distributing catch in this manner has been identified as an important principle for management of these fisheries. Recently, progress has been made toward estimating the biomass of key groundfish species inside critical habitat on a monthly basis (NMFS 2000). This information will be used to compare the monthly average per capita prey availability for Steller sea lions within critical habitat with the monthly consumption estimates (see NMFS 2000). This comparison is necessary to determine potential effects of competition between commercial fisheries and Steller sea lions on the scale that is important to a foraging Steller sea lion. The results of this analysis represent the best available scientific and commercial data. However, surveys conducted on finer scales such as critical habitat or even smaller would be needed to better assess whether there is sufficient prey inside critical habitat for Steller sea lions to forage without competitive niche overlap with commercial groundfish fisheries.

6.3.1.2 Temporal limitations

Spatial limitations in the survey data are compounded by the lack of information on the seasonal distribution of fish stocks. Even though the vast majority of the groundfish fisheries occur during the winter/spring period, most of the groundfish stock surveys are conducted during the summer. From limited surveys and tagging studies, we know that pollock and Pacific cod move between spawning areas in winter (largely in critical habitat) and feeding areas in summer. Efforts to estimate the magnitude of these migrations have used information from surveys conducted at different times of the year (e.g., bottom trawl surveys in the summer, EIT surveys of the GOA in the spring, and a few winter bottom trawl surveys in the EBS), fishery CPUE data collected throughout the year, and tagging studies.

Information on groundfish stock distributions during the seasons when concentrated fishing occurs is important in assessing the ecological effects of these removals. Without this information, the potential interactions between the fisheries and listed species is difficult to assess. The analytical approach described in section 6.4.3 and Appendix 3 (see also NMFS 2000) addresses the prey field of Steller sea lions on a monthly time scale and a spatial scale that discriminates between biomass inside and outside of critical habitat for sea lions. Surveys conducted on a temporal scale consistent with the needs of listed species such as Steller sea lions (i.e, seasonal vs annual) would significantly reduce the uncertainty around seasonal or monthly estimates of available biomass inside critical habitat.

6.3.2 Stock assessment

The purpose of stock assessment is to describe those stocks that are targeted by the fisheries and the nature and magnitude of fishery effects on those stocks (i.e., the stocks' tolerance for fishing). Consistent with the fundamental approach to fishery management, the primary objective of stock assessments is to estimate biomass and the size-age structure of target stocks. The following paragraphs we will describe the basic information necessary to understand the stock assessment process, and the potential stock assessment process effects on a target stock and its associated marine community.

6.3.2.1 Stock structure

Research on stock structure for groundfish species is continuing (e.g., Bailey et al. 1999). Currently, the best available information is based on limited tagging data for sablefish and Pacific cod, morphometrics or genetic studies for pollock, Pacific ocean perch, Atka mackerel, and a few other rockfish.

Pollock will be used in this section as an example to describe some of the patterns in stock structure that have been observed in the past. Pollock in the BSAI are managed as three units: eastern Bering Sea, Aleutian Islands, and the Aleutian Basin/Bogoslof Island (Basin). Recruitment to the Basin stock is thought to occur primarily as density-dependent migration of pollock from the eastern Bering sea shelf stock. Large cohorts of shelf pollock appear to be the source of most of the pollock in the Basin, which suggests that the Basin stock itself is not self-sustaining. Fishing on the Basin stock was terminated in 1992 by international agreement, but it has since failed to recover. Given the reduced recruitment in the 1990s compared to the large year classes in the late 1970s and 1980s, the Basin stock would have been expected to decline in size even in the absence of fishing. The extent to which spawning in the Bogoslof region contributes to recruitment of the shelf stock is unknown. For example, overfishing in the Basin may have exacerbated the decline of the Basin stock, and it may have adversely affected recruitment in the shelf stock.

Pollock stocks in the Aleutian Islands region have also declined since the mid-1980s, from a high of 496,000 mt in 1983 to 105,000 mt in 1997 (Ianelli et al. 1999). Since the decline of pollock in the Aleutians parallels that of the Basin, the two stocks may be closely related. Several explanations for the lack of population recovery in the Aleutians might be explained primarily as a series of years with poor recruitment. Ianelli et al. (1999) describe the pattern of pollock fishing in the Aleutians in the 1990s, where the fishery moved increasingly westward apparently because spawning aggregations in the eastern portion had disappeared (i.e. around Kanaga Island and in Amukta Pass). It is not known whether spawning from these basin aggregations contributed to the Aleutian stock (though it would seem likely that they did). The role that fishing played in the lack of recovery in the area has not been evaluated.

6.3.2.2 Stock complexes

Under the FMPs, many stocks have been placed in complexes (e.g., groupings). Uncertainty is an even greater concern for species managed in complexes because they often are placed into complexes if the available information is insufficient to manage a species as a single target stock. The risk of fishery effects on a single species may be greater when the species is fished as part of a complex. Fishing mortality rates for complexes may be tolerable for more common or prolific species, but may not be tolerable for the more rare, slow-growing, long-lived species with relatively limited capacity for reproduction, recruitment, or recovery. For example, if a complex consists of three species, one with *natural mortality (M)* = 0.10, the second with *M* = 0.15, and the third with *M* = 0.20, and *Fishing Mortality (F)* is set for the whole complex based on either *M* = 0.15 or 0.20, then overfishing is likely for the species with *M* = 0.10. The only way to ensure that none of the species in the complex are subject to overfishing would be to set *F* on the basis of the lowest *M*. But *M* is unknown for many of the species in these complexes.

More than 144 stocks are incorporated into management complexes: GOA deepwater flatfish (3 spp.), GOA shallow-water flatfish (8+ species), GOA other slope rockfish (12+ spp.), GOA shortraker/rougheye rockfish, GOA pelagic shelf rockfish (4+ spp.), GOA demersal shelf rockfish (7 spp.), AI northern / sharpschin rockfish (2 spp), BSAI other flatfish (16 spp.), other rockfish (33+spp.), other slope rockfish (17 spp.), BSAI squid (multiple species), and AI shortraker /rougheye rockfish (2 spp.).

Some of the large complexes listed above (e.g., BSAI and GOA other species) are composed of a very diverse assemblage of species, some of which are prey for listed species (e.g., squid, octopus, and sculpins). While the magnitude of fishing effects on any single species in the other species assemblage is not thought to be large given the group catch amounts, the limited or non-existent information on the status or catch of any single species makes this determination uncertain. One example of precautionary management that addresses this is the establishment of retention thresholds for forage fish (e.g., osmerids and myctophids) to prohibit the establishment of new commercial fisheries. In general, the ecological consequences of fishing on groundfish complexes can not be evaluated due to the lack of data on the stock structure of individual species.

6.3.2.3 Stock distribution

As noted in the above description of stock surveys, information on the distribution of affected (fished and unfished) stocks is vital to assessment of fishery effects. The distribution of a species is an important determinant of the ecological role it plays in local marine communities, including availability to predators. This information is required to assess fishery effects on prey availability in Steller sea lion critical habitat. Recent opinions have identified a clear need for such information on the distribution of target stocks.

Better information on the spatial and temporal distribution of prey are needed to improve the assessment of whether the prey base under the current fishing regime is optimal in promoting the recovery of Steller sea lions. As noted in section 6.4.3 and Appendix 3 estimates of the spatial and temporal distribution of prey have recently been improved. However, the confidence intervals around these estimates remain fairly large.

6.3.2.4 Stock biomass

Biomass is used to describe or estimate stock status and trend, tolerance for fishing, and reproductive capacity. Under the current harvest guidelines, a fishing mortality rate for a species is set on the basis of its effect on target stock biomass and its reproductive capacity. That is, the fishing mortality rate is intended to maintain the species at B_{MSY} or a proxy for it ($B_{40\%}$). Further, the stock-recruitment relation fundamental to the MSY concept is based on recruitment as a function of spawning biomass. Thus, stock biomass is clearly an important measure of the stock and a basis for evaluating potential fishery yields.

Accurate estimates of stock biomass depend both on information from surveys and from the fishery (total removals and catch age composition). Biomass estimates for the early years of the pollock fishery are uncertain. Estimates of stock biomass for the early years of the pollock fishery are uncertain because of limited and potentially biased information from both sources. In the Bering Sea, the trawl survey began in the late 1960s, but the survey was initially designed to survey crab populations and did not encompass the range of the pollock stock (Bakkala et al. 1985, Megrey and Wespestad 1990). In 1975, the survey was expanded to cover most of the eastern Bering Sea shelf, and has been conducted annually since 1979. Catch information from the foreign fishery during the 1970s was submitted by the fishing nations at bilateral meetings or under provisions of the International Pacific Fisheries Commission. Since this was prior to the development of fisheries observer programs, there was no way to verify the accuracy of the catch information, and there were often questions about the credibility of some the reported fisheries data (Megrey and Wespestad 1990).

Based on a most recent pollock assessment (Ianelli et al. 1999), pollock biomass in the 1970s ranged from 2.0 mmt (million metric tons) in 1974 to 5.2 mmt in 1971 (Fig. 6.2, see also Table 1.14 in Ianelli et al. 1999). By contrast, Megrey and Wespestad (1990) reported that pollock in the EBS ranged from about 8 mmt (million metric tons) to 12 mmt for the same time period. The precision of the Ianelli et al (1999) estimates is depicted by the 95% confidence intervals in Figure 6.2, which suggest that biomass in 1970s may have been as high 7.1 mmt (in 1971) or as low as 1.1 mmt (in 1974). These estimates of uncertainty are only approximate and also rely on assumptions of known natural mortality, relatively precise and unbiased total catch estimates and correct model specification. Therefore, the actual variance is likely to be larger than that indicated in Figure 6.2 (NRC 1996). Furthermore, fishery selectivity estimates from Ianelli et al. (1999) were allowed to vary over time to reflect the fact that the fleet composition has changed over time from foreign vessels to joint venture operations to the current domestic fleet. This increases the overall variance of the model. Another effect of time-varying fishery selectivity can change the interpretation of “available” biomass and simple exploitation rates comparing total catch compared to age 3 and older biomass. For example, in 1974 about 23% of the “available” biomass was aged 1 and 2. This was quite high and compares to an average of 3% for the entire period 1964-1999. This is due to the fact that the 1972 year class was quite strong and that the gear selectivity at that time was more concentrated on young pollock.

At present, biomass estimates or indices are available for 35 of the 39 species or species groups listed in Table 2.7. This represents approximately 97% of the estimated total biomass. For approximately 17 out of 35 of these stocks, biomass by age is not available. However, no groundfish stock in the BSAI or GOA is currently being subjected to overfishing (a fishing mortality rate higher than the maximum allowable rate) and regardless of the level of information on each species, given an absence of a history of overfishing, it is unlikely that any stock would be in an overfished condition defined using the single species criteria (biomass has fallen so low that a special rebuilding plan is needed). Again, to address the question of whether harvests based on imperfect biomass information for groundfish stocks affects listed species (for example biomass estimates are not available for 4 of the 39 species in Table 2.7), it is important to go back to the ecosystem concept and relate it back to foraging behavior of the listed species. Material in section 4 describes the variability in fish species found in the diets of marine mammals. The stocks for which the least information is available are the most lightly fished and least abundant species. Therefore, the present inability to determine the status of certain stocks is not likely to be a problem for listed species.

6.3.2.5 Stock recruitment

Recruitment is the only source of replenishment for the numbers of individuals in the fished portion of a population. Biomass may be increased by somatic growth, but the biomass of a cohort is also a function of the number of individuals in that cohort. Thus, recruitment can be viewed as one process by which fished populations are maintained and their future status assured. The factors and processes that determine recruitment have been a source of extensive discussion and debate in fisheries biology. The debate has focused largely on two questions: (1) is the process of recruitment density-independent or density-dependent, and (2) if density-dependent, what is the nature of the relation between recruitment and stock size.

The regulations implementing the BSAI and GOA FMPs are based on the assumption that recruitment is essentially a density-independent phenomenon. That is, environmental factors are considered to be the principal determinants of the size of a recruited age class for the BSAI and GOA groundfish stocks. Thus, the size of a recruiting cohort is independent of the size of the stock that produced it (at least when the stock size is 20% of its unfished biomass). In addition, recruitment is also assumed to be independent of time or year - i.e., recruitment does not exhibit any trends over time. Examples of such trends would include increasing or decreasing recruitment over time, increasing or decreasing variation in recruitment over time, or auto-correlation (connectivity between points in time series).

The harvest policy, under the FMP, asserts that as long as a stock is maintained at or above a minimal size (½ B_{MSY}), recruitment will be unaffected and the stock is healthy. These policies are based on a single-species approach to fisheries management designed to be precautionary. However, if recruitment is a declining function of stock size (i.e., recruitment is more likely to be small when stock size is small), or if recruitment is declining over time for other or unknown reasons, then the population may be more likely to become overfished. We consider this possibility in section 6.3.3 (below) on setting the TAC.

When spawner-recruitment relationships are uncertain, the F_{ABC} and F_{OFL} are based on estimates of current stock status and considerations of spawning biomass per recruit. A designation of the form "$F_{X\%}$" refers to the F associated with an equilibrium level of spawning per recruit (SPR) equal to $X\%$ of the equilibrium level of spawning per recruit in the absence of any fishing. The use of SPR analyses to derive biological reference points for fisheries management has undergone broad scientific review and is used to form the basis of harvest control rules in several systems throughout the world (Clark, 1991; Clark, 1993; Thompson, 1993). The use of $F_{35\%}$, as a proxy for F_{MSY} stems from the work of Clark (1991) who showed that a large fraction of the potential yield from a typical groundfish stock could be obtained at a rate of $F_{35\%}$ across a discrete set of plausible stock-recruitment relationships, including both Ricker and Beverton-Holt forms. Subsequent analyses showed that $F_{40\%}$ would reduce the probability of low biomass if recruitment was highly variable or autocorrelated (Clark 1993). Research continues to refine our biological reference points. For example recent analyses have focused on considerations of reproductive rates at low stock sizes (Myers et al. 1996) and applications of Clark's general approach to species that possess similar life history characteristics (Dorn In Review).

The concern for listed species that prey on fish is that if spawning-recruitment relationships are uncertain, or if the recruitment is small when stock size is small, or if recruitment is declining over time for other or unknown reasons, then the population may be more likely to be unknowingly overfished, and prey availability reduced. However, the concepts discussed in the above paragraphs show that NMFS has adopted a long-term harvest strategy based on general principles of population growth that minimizes the risk of recruitment overfishing. The approach expressly considers the need to maintain spawning stocks above some threshold and recognizes the considerable interannual variability in recruitment resulting primarily from environmental factors. Assessment scientists consider the influence of parameter selection within their models to provide the best possible estimate of stock status. This is particularly true in the case of assessments for important Steller sea lion forage species such as walleye pollock, Pacific cod and Atka mackerel. The influences of key parameters such as natural mortality, on perceptions of stock status are analyzed within the SAFE reports, but generally in a single species context. Analyses include formally addressing uncertainty surrounding M using Bayesian meta-analysis (e.g., Thompson et al. 1999) or attempts to formally address time trends in natural mortality by key predators (e,g, Livingston and Methot 1998, Hollowed et. al. 2000). Therefore, the present long-term harvest strategy minimizes the possibility of overfishing, and given the best available information would not present a significant problem for species listed under the ESA in terms of the total stock size and recruitment. Although, it would not control specifically for localized depletions that could lead to unsuccessful foraging.

6.3.2.6 Natural mortality

Natural mortality (M) refers to the rate of decline of a fished stock as a consequence of natural processes. These include predation by other fishes, marine mammals, and seabirds, as well as some level of mortality due to disease, injury, starvation, etc. The relation between M and fishing mortality (F) is an important consideration in the fishery management strategy. Ironically, natural mortality is one of the most difficult parameters of a population to estimate.

Figure 22 in the BSAI FMP (p. 179; reproduced here as Figure 6.3), shows how mortality of target (prey) species is partitioned among various users of that prey species. However, this figure doesn't capture the concept that other consumers may require certain prey densities to meet their foraging needs. Adverse effects from a listed species point of view would occur if foraging was not successful. These predators are challenged by "catchability" in the same manner as the fishing fleet. "Catchability" is the part of the stock that is caught by a defined unit of effort. The concept is well established in fisheries management, and well recognized in the field of optimal foraging. While catchability by the fishery may increase with declining stock size, prey availability for Steller sea lions will likely decrease, as discussed below.

The effect of reductions in prey biomass on other consumers in the environment has received little treatment in traditional fisheries management. Sea lions, or other ecosystem consumers, do not have the technological advantages of fishing fleets or the ability to change strategies, and have limited physiological reserves to cope with declining availability. Adding fishing mortality to natural mortality reduces the availability of prey to other consumers. When biomass reaches a threshold, predators are no longer able to successfully forage for that prey, even if considerable biomass remains in the system. This explains the fact that carrying capacity for these consumers will go to zero before prey biomass in the system goes to zero. Thus, natural mortality of target/prey stocks can not be partitioned as simply as the allocation portrayed in Figure 6.3 without consequences for the other consumers in the ecosystem. As far as effects on protected species, overall biomass goals alone may not be as adequate for other consumers as it is for fishermen. Availability implies things like spatial and temporal distribution in relation to the predator, this would be important as well.

Models to estimate stock abundance and to make short-term projections of BSAI and GOA target stocks are typically based on a constant natural mortality rate. These natural mortality rates are usually estimated independently of the assessment model, and are based on published correlations between *M* and more easily observed life history characteristics, such as the maximum observed age or reproductive effort). Typically the results from several methods are evaluated for consistency and to obtain a range for further analysis. Once a working value of *M* is established, it is usually carried over from one assessment to the next to provide consistency in management advice.

The estimation of natural mortality in fish stocks is far from constant, and this variability is extensive enough that it should not be ignored. More analysis is generally required for within-stock variability (both trends and variance) for exploited fish stocks. Most assessment scientists would agree with this statement, and conduct such analysis whenever the necessary data are available. For most stocks, however, the data are sufficient to support only a rough estimate of a constant natural mortality rate for adult fish. Simulation and estimation trials for an age-structured assessment model showed that even a constant natural mortality rate could not be reliably estimated, with the possible exception of cases where the catch-at-age data extend back to the beginning of the fishery. Assessment models can be used to evaluate the plausibility of different values for *M* using techniques such as likelihood profiling (Hilborn and Walters 1992), or by taking into account the uncertainty in *M* using Bayesian methods (see Thompson et al. 1999 and Sigler et al. 1999 for applications using Pacific cod and sablefish, respectively).

Multispecies assessment models (such as MSVPA) explicitly account for mortality by predators. These models require additional assumptions concerning how species interact, and require consumption estimates derived from stomach content sampling, which tends to be limited in spatial and temporal scope and subject to potential bias (differential digestion rates, etc). Typically these models show much higher juvenile mortality (Livingston and Methot 1998, Livingston and Jurado-Molina 2000), but when the fishery takes larger fish than the predators, the potential impact on short-term management advice is minor. However, when the fishery and the predator take similar-sized fish (Hollowed et al. 2000), these models may produce contradictory estimates of natural mortality of adult fish relative to those used in single-species models, with corresponding uncertainty about management advice.

Stock assessment models are used to project these stocks based on the assumption of constant natural mortality. In the case of BSAI and GOA groundfish, TACs are set each year at values consistent with the harvest control rules and other provisions of the FMPs (e.g., the OY caps). For some stocks in some years, this amounts to fishing at the maximum permissible ABC. In such instances, the recommended fishing mortality rate typically varies directly with *M*. For example, if the intent is to fish at a rate of $F_{40\%}$ and *M* happens to be over-estimated while all other parameters are estimated without error, the recommended fishing mortality rate will exceed the true value of $F_{40\%}$. However, over-estimation of *M* leads not only to errors in the estimate of

$F_{40\%}$ but to errors in the estimate of stock size as well. Errors in estimated stock size resulting from over-estimation of *M* can be either positive (Thompson 1994) or negative (Thompson 1994). The combined effects of these two errors can result in a recommended short-term catch that is either higher (Thompson 1994) or lower (Thompson 1994) than the short-term catch corresponding to the intended harvest strategy. In the long term, however, catch tends not to be sensitive to error in *M* except when gross under-estimates occur, in which case catches tend to be lower than those corresponding to the intended harvest strategy. Because the relationship between the estimate of *M* and the recommended catch is complicated, trends and variance in this parameter are evaluated and the resulting uncertainty incorporated into the TAC setting process. Stock assessment scientists typically pay special attention to this issue. Toward this end, SAFE reports are required to address alternative estimates of M and its effects on model outputs.

6.3.2.7 Uncertainty

Uncertainty is inherent throughout the process by which TACs are set. The primary means by which assessment uncertainty is conveyed is through the SAFE report. Assessment uncertainties include both errors in observation (e.g., biomass estimates from surveys) and process errors.

One stock assessment modeling format used to assess some North Pacific groundfish stocks, AD Model Builder, explicitly computes variance estimates on certain model outputs. An illustration of the variance in one model output, yield, for the EBS pollock stock was presented by Ianelli et al. (1999). Their Figure 1.26 (reproduced here as Fig. 6.4) indicates the uncertainty in expected yield under three fishing mortality rates, F_{MSY}, $F_{40\%}$, and $F_{30\%}$. Under the $F_{40\%}$ regime, the mean estimated yield was 1.013 mmt. The 50% confidence limits for this estimate, however, were 0.6 mmt and 1.7 mmt. The standard 95% confidence limits for the estimate were about 0.2 mmt and some value greater than 3.0 mmt. These wide confidence limits suggest that yields are estimated with uncertainty and this should be recognized by decision-makers, and incorporated into the overall management approach. Further, the analysis points out that there is about a 30% chance that harvesting at the point estimate for *F* would result in overfishing. Again, this analysis was peformed for EBS pollock, the stock for which we have the most information. We would expect the uncertainty for other stocks to be even higher than for pollock. The use of modeling formats that permit computation of confidence limits on model outputs is encouraged, as is the explicit recognition of uncertainty in the setting of TACs.

6.3.3 Setting the catch specifications (TAC)

The process that determines TAC is a significant determinant of the magnitude of fishery effects on the target species, listed species, critical habitat, and the ecosystems. The reductions in the biomass and prey availability described earlier are a direct consequence of the TAC-setting process. That is, the long-term reduction in standing biomass with all its ecological consequences follows directly from the catch in accordance with the TACs. In this section, we focus on the effects of the TAC-setting process on the target stocks themselves.

Recall from section 2 (Description of the Action) that the TAC setting process actually involves setting an allowable biological catch (ABC) and an overfishing level (OFL) for a stock, together with an evaluation of the stock’s Minimum Stock Size Threshold (MSST). These values are determined or evaluated first, with the intent of setting a catch target to achieve and a limit to avoid. That is, the first part of the process is intended to identify the level of catch that allows the maximum yield while protecting the target stock. The next step is to consider the ABC and OFL in the context of social, economic, and ecological factors, and set the TAC accordingly.

6.3.3.1 Theoretical framework and assumptions

The TAC-setting framework established by regulations and applied in the management process is considered sufficient to protect the target stocks from overfishing and from an overfished state (as defined earlier). The framework adjusts the allowable harvest level for each stock based on knowledge of the stock's status relative to its estimated status if it had not been fished. The framework incorporates three operating principles: 1) the future status of each stock is determined by recruitment, 2) the status of each stock can be reliably assessed, and 3) the harvest rates established in the framework are sufficiently precautionary to protect the target stocks.

The theoretical framework for setting catch levels is illustrated in Figure 6.5. The *Y* axis in the figure is fishing mortality rate (*F*). ABCs and OFLs are based on fishing mortality rate, which is determined as a function of the status (biomass) of each target stock. For the majority of stocks, ABC is based on an $F_{40\%}$ rate (i.e., would reduce the spawning biomass to 40% of its unfished level) and OFL is based on an $F_{35\%}$ rate (would reduce the spawning biomass to 35% of its unfished level). The *X* axis in Figure 6.5 is the biomass (*B*), and points on the *X* axis include the biomass of the target stock as projected under a no-fishing scenario (B_{NF}), B_{MSY}, ½ B_{MSY}, and $0.05B_{MSY}$. If a harvested stock is above B_{MSY} (tiers one and two) or its risk-averse target biomass level, $B_{35\%}$ (tier three), then the recommended fishing mortality rate is set to achieve $F_{40\%}$ (or reduce the stock to $B_{40\%}$). If the stock is between B_{MSY} and ½ B_{MSY}, then the stock is simulated to determine whether it is overfished. If it is overfished, then a rebuilding plan is required within one year. If it is not overfished, then the fishing mortality rate is still lowered in a linear fashion, as indicated in Figure 6.5. If the stock is below ½ B_{MSY}, the fishing mortality rate is reduced (again, linearly), the stock is declared overfished, and a rebuilding plan is required. As described below, this framework cannot be applied to stocks in tiers 4 to 6.

6.3.3.2 Random recruitment

Short-term stock projections and estimation of $B_{40\%}$ are performed using estimates of recruitment. In the absence of a discernible stock-recruitment relation or a temporal trend in the recruitment data, recruitment is modeled as a randomly generated number from a stationary distribution constructed from estimates of previous recruitment (over a specified range of time). If recruitment is a function of spawning biomass, or exhibits a declining trend over time, then this assumption of random recruitment independent of stock biomass over the observed time period may be violated. The consequences of such a violation may be an increase in the level of conservatism afforded by the harvest control rules. For example, if recruitment varies directly with stock size and most estimates of recruitment come from stock sizes in excess of $B_{40\%}$, the level of recruitment at $B_{40\%}$ will be over-estimated, thereby causing $B_{40\%}$ itself to be overestimated, which in turn will cause the current stock size to appear lower relative to $B_{40\%}$ than is actually the case.

To test these two assumptions we examined stock-recruitment relationships and conducted time series analysis for the 17 stocks for which recruitment data was available. Stock-recruitment relationships were examined using data from 1985 to 1999 (Figs. 6.6 and 6.7) and, indeed, for many of the target stocks, the evidence does not indicate a strong or obvious drop in recruitment with declining spawning stock biomass. For some stocks, the evidence is even to the contrary. However, for two stocks, BSAI Greenland turbot (Fig. 6.6 - Turbot) and GOA Pacific cod (Fig.

6.7), the data do give some preliminary indication that recruitment may vary directly with stock size over the observed range. It is important to remember, though, that apparent correlations between stock and recruitment can be deceptive due to the time series nature of the process, and that estimates of the slope obtained from plots such as those shown in Figs. 6.6 and 6.7 tend to be biased.

With respect to time-series analyses of recruitment levels, two tests for stationarity in the data were conducted (i.e., to test the assumption that recruitment can be modeled as though it were drawn randomly from a stationary or fixed distribution). The recruitment series are plotted in Figures 6.8 and 6.9, and the results are listed in Table 6.1. The tests suggested that the null hypothesis of stationarity could be rejected while the null hypothesis of non-stationarity could not be rejected for the following stocks: EBS yellowfin sole, EBS arrowtooth flounder, EBS rock sole, BSAI/GOA sablefish, AI Atka mackerel, GOA arrowtooth flounder, and GOA Pacific ocean perch. Conversely, the tests suggested that the null hypothesis of non-stationarity could be rejected while the null hypothesis of stationarity could not be rejected for the following stocks: EBS Greenland turbot and GOA pollock. The tests suggested that neither the null hypothesis of stationarity nor the null hypothesis of non-stationarity could be rejected for the following stocks: BSAI Pacific cod, BSAI Alaska plaice, AI Pacific ocean perch, GOA Pacific cod, and GOA thornyheads. Paradoxically, however, the tests suggested that *both* the null hypothesis of stationarity *and* the null hypothesis of non-stationarity could be rejected in the case of EBS Pacific ocean perch, indicating that the proper interpretation of these tests may require further study.

Violations of the assumption that recruitment can be modeled as a random draw from a stationary distribution could lead to overestimation of expected future recruitment and an underestimation of vulnerability to continued fishing. If recruitment is a function of stock size, or if it exhibits a declining trend over time, then the stock may not be sufficiently protected under the existing management scheme. Recall that the status of each stock is evaluated annually relative to its estimated unfished level (B_{NF}). Recall also that B_{NF} is estimated by applying constant values for somatic growth and natural mortality to observed recruitment for each age class, and then summing the expected biomass of each age class for the year in question. Importantly, B_{NF} is a function of recruitment under this approach. If recruitment is declining for any reason (e.g., as a function of stock size or some unexplained temporal trend), then B_{NF} will also decline. Thus, the standard by which stock status is determined could decline as the stock itself declines. The case of Greenland turbot illustrates the potential for such a “sliding” standard. For this stock, recruitment has declined over time (Fig. 6.10a) in a fashion that appears to be related to stock size (Fig. 6.10b). Estimated values of B_{NF} for this species have also declined over time, so that the ratio of the stock biomass to B_{NF} has remained unchanged in spite of a significant decline in the stock biomass over the past 15 years (Fig. 6.10c). That is, the status of Greenland turbot has been determined by comparing the size of the stock with a standard that declines with stock size. Thus, it appears that, at least for some stocks, recruitment may not be reliably and accurately modeled as a random draw from a stationary distribution based on previous observations. Therefore, the existing management strategy may not be sufficiently protective in those cases where recruitment exhibits a pattern as a function of stock size or time.

Any model of a phenomenon as complex as fish recruitment will always omit some causative factors. The question is whether the effect of such omissions (as described above) carries significant risk for listed species. For some stocks where recruitment is a function of time or stock size, current models may not be risk-adverse and might lead to a possible overestimation of recruitment. There is general scientific agreement that the use of a random, stock-independent process to model short-term future recruitment does not carry significant risk for single-species groundfish management. These errors might be important if they involved stocks important to the survival and recovery of listed species. However, the level of risk would have to be evaluated in light of the ecosystem as a whole. As noted these errors would only potentially occur for some stocks with certain characteristics, and listed species under consideration in this opinion forage on multiple species. Again, the important question is not whether these modeling efforts are adequate for their intended purpose in fishery management, it is whether these efforts affect listed species in terms of the spatial and temporal availability of prey resources.

6.3.3.3 Target harvest rates

The TAC-setting framework establishes $B_{40\%}$ as a reference point in defining the maximum permissible value of ABC. Stocks above that level may be reduced through harvesting. Stocks below that level may still be harvested, but at reduced rates to allow the stock to recover over time to a level considered safe. As they are written, the regulations would allow for a stock to be harvested until it reached 2% of its unfished level. On the surface, this approach would appear to not be sufficiently precautionary to assure that fish stocks are adequately protected from overfishing. This could unknowingly result in a reduced prey availability to other predators including listed species. However, the overall management approach does include checks to reduce the probability that a stock will reach such a low level. Particularly, catch would fall almost quadratically with spawning biomass, meaning that catch would be constrained to a very small level long before a stock fell to 2% of its estimated unfished level. At present, no stocks in tiers 1-3 have come anywhere close to the 2% level in the history of the FMPs. However it is possible to reach that level, indicating that as far as the FMP process, potential effects on ESA-listed species that are in competition for the target species may warrant a more conservative limit for how low a stock can theoretically fall.

Stocks in tiers one to three can be evaluated with respect to the reference points in Figure 6.5 (B_{MSY}, or the proxy $B_{40\%}$, ½ B_{MSY}, and $0.05B_{MSY}$). None of these values can be estimated for stocks in tier four. Thus, the status of stocks in tier four can not be determined relative to an unfished level, nor can they be determined relative to their MSST.

Stocks in tier five can not be assessed with respect to their unfished level or their MSST. These stocks can be harvested at an F_{ABC} of $0.75*M$. To evaluate the potential effect of this strategy on a tier 5 stock, an example was developed using an M value of 0.3, age of recruitment of three, and a growth schedule consistent with pollock (Ianelli et al. 1999). Harvesting at $F = M * 0.75$ would reduce the spawning stock biomass to about 50% of its unfished level under this scenario. The intent of the guidelines for tier five was to approximate the $B_{40\%}$ strategy, based on the idea that harvesting at $F=M$ would produce $F_{30\%}$. On that basis, the guidelines for tier five also do not appear to be precautionary as they aim at the same harvest level on the basis of less information.

Stocks in tier six also can not be assessed with respect to their unfished level or their MSST. Only one stock, squid, falls into tier six. The tier 6 guidelines suggest that the OFL should be set at the mean catch from 1978 to 1995, unless an alternative (unspecified) level is set by the Council's SSC. The ABC level is then set at 0.75*OFL. While these guidelines would not necessarily insure the protection of a stock in tier 6, catches of squid in the BSAI and GOA (less than 2,000 mt in 1999) are relatively low compared to squid biomass estimates based on predation models in the eastern Bering Sea (Sobelevsky 1996). The guidelines are based on the assumption that a stock that has tolerated a certain mean level of catch can continue to tolerate that level (or that level times 0.75) indefinitely. While in general, these harvest guidelines may not be sufficiently precautionary to assure that stocks in tier six are adequately protected, the only stock currently in tier six, squid, does not appear to be overfished.

6.3.3.4 Consideration of ecological factors

The MSA and resulting regulations require that relevant social, economic, and ecological factors be considered in the setting of optimum yield for a fishery. The regulations (50 CFR § 600.310 (f)(3)(iii)) provide the following examples of ecological factors:

> "stock size and age composition, the vulnerability of incidental or unregulated stocks in a mixed-stock fishery, predator-prey or competitive interactions, and dependence of marine mammals and birds or endangered species on a stock of fish. Also important are ecological or environmental conditions that stress marine organisms such as natural or manmade changes in wetlands or nursery grounds, and effects of pollutants on habitat and stocks."

The BSAI FMP notes that the implementation of the fishery management plan does not cause adverse impacts on the environment. The FMP states (p. 1):

> "Implementation of this fishery management plan within the limit of its constraints is presumed not to cause adverse impacts on the environment. Conservation measures are provided for species for which they are deemed necessary. Those measures and the conduct of the fishery as outlined will be beneficial to the ocean environment affected, to demersal and pelagic fishes, and to the human environment."

Thus the FMP process considers the species managed under it as parts of functioning ecosystems. However, ecosystem management is extremely complex. In setting the harvest rate, managers also attempt to be sufficiently protective of the larger ecosystem in which the harvesting occurs. An Ecosystems Considerations section has been added to the SAFE documents since 1995. However, it is unclear how the SAFE authors identify the uncertainty inherent in ecosystem analyses discussed above or how they incorporate that information into the management process. For example, it is unclear how the 25% (BSAI Atka mackerel) to 60% (BSAI pollock) reduction in spawning biomass per recruit of target stocks was incorporated into the SAFE report. Section 7 of the ESA allows for a dynamic process to continually re-evaluate strategies to further minimize the impacts of human activities on listed species. An expanded discussion of the possible ecosystem effects of fishing is discussed in section 6.5.3.

6.3.4 Implementation of the fishery

The potential direct and indirect effects of fisheries on the marine ecosystem vary considerably by access, fleet capacity, time/area management measures and gear type employed in the fishery. The primary effects are related to spatial and temporal dispersion of the catch, and the effects on habitat by depleting prey, interfering with other consumers including Steller sea lions, and physically altering bottom habitat. These effects are of concern for listed species and critical habitat designated for Steller sea lions.

6.3.4.1 Access to the fisheries

Access to the fisheries determines the number of participants and the nature of competition among fishery participants for the catch. The catch is available to all participants until the TAC is caught and the fishery must be closed. The result is a competitive “race for fish” that emphasizes fishing capacity and speed, and increases the likelihood of temporal and spatial concentration of catch. This discourages selectivity of catch (i.e., searching for the best conditions to enhance product quality and avoid adverse effects), deters temporal and spatial dispersion of catch, and reduces emphasis on fishing efficiency. It also potentially increases risks to the safety of fishery participants by creating an incentive for small vessels to fish under adverse conditions if they wish to compete for the catch. With regards to Steller sea lions it requires a compressed fishing schedule, often in space and time, that has the potential to locally deplete prey availability to foraging sea lions.

Some alternatives to traditional processes include license limitation programs (which limit the number of participants), cooperatives (that may disperse catch among members so that they can operate without the constraints of the race for fish), and individual fishery quota systems (that establish or distribute individual quotas among a limited number of fishery participants so that they may devise the best method of fishing without the need to compete for a limited catch). These alternatives are generally referred to as forms of rationalization of the fisheries, and have been applied to the sablefish fishery and, to some degree, to the BSAI pollock fishery (through cooperatives allowed under the American Fisheries Act of 1998). It seems clear that cooperatives following the implementation of the AFA (see discussion in section 5) resulted in a decrease in adverse impacts on the western population of Steller sea lions. The pollock fishery was not only slower in the BSAI in 1999 and 2000 due to AFA, it also employed fewer boats and had less discards. Methods that encourage fishermen to work together to solve these problems on a voluntary basis have promise and are often superior in situations where enforcement is difficult.

6.3.4.2 Fleet capacity

The capacity of a fishery fleet determines the rate at which the catch can be taken, but also determines the economic burden of fishing that must be balanced by fishery income to make a profit and stay in business. The existing BSAI and GOA fleets currently exceed the minimum capacity required to catch the TACs . As a consequence, daily catch rates are high and some fisheries last only a matter of days (or even hours). This race for fish results in a temporal concentration of catch (e.g., GOA pollock), increased pressure to maximize catch quotas, increased risk of environmental effects, and increased risk to the safety of fishery participants.

The number of vessels (and their harvesting capacity) influences the removal rate of groundfish in the BSAI and GOA. The number of vessels participating in groundfish fisheries in the GOA dropped from 1,571 in 1994 to 1,140 in 1998. However, it is difficult to equate this directly with effort because a number of the small boats were replaced by larger vessels. Overall, the tonnage of vessels in the GOA dropped from about 84,000 in 1994, to 67,500 in 1998. In the BSAI, 337 vessels participated in the groundfish fishery in 1998, about the same amount as in 1994. The fleet consists of much larger vessels than in the GOA.

Vessel size or processing capacity may affect the location and timing of the catch of groundfish. Larger vessels are more able to fish offshore, outside of critical habitat because of increased sea worthiness, ability to process fish, and extended crew carrying capacity. Small vessels, such as the GOA fleet, are limited to coastal areas (often inside critical habitat for Steller sea lions), which may increase competitive interactions between commercial fisheries and Steller sea lions. However, it would be possible to mitigate some of this effect through allocation strategies. For example, limited available TAC inside critical habitat could be allocated only to smaller vessels, because larger vessels are capable of fishing safely farther from shore.

6.3.4.3 Gear types authorized by the FMPs

The various gear types used in these fisheries (trawl, pot, hook-and-line, and jig) have differential effects on the environment. Table 6.2 reviews some considerations pertinent to the assessment of gear type effects. The table clearly indicates that trawl fishing is the dominant gear in these fisheries, accounting for 86% of the catch in the BSAI and 73% in the GOA. In the BSAI, annual allocations are generally specified by gear type whereas in the GOA, most of the fisheries are open to the vessels using any gear type based on license limitation programs only.

The possible effects on bottom habitat by various gear types is presently being investigated, with most of the research on habitat effects focused on bottom trawl gear effects on benthic substrate and communities. For trawl gear, current studies have shown that the use of benthic gear reduces biodiversity and habitat complexity in trawled areas (Auster and Langton, 1999) but the long-term effects, if any, are unknown. About half of the fish harvested in the BSAI and GOA is with pelagic gear, which generally does not come in contact with the bottom. Little research has been conducted on hook-and-line or pot gear effects, which clearly limits our ability to describe the possible impacts by those gear types. We know that such fixed gear does, in fact, affect the bottom, snagging on corals, dislodging, or compacting other objects (anecdotal information), but the significance of these effects can not be quantified on the basis of the current information. These effects are the subject of a comprehensive examination of the effects of fishing on habitat that are contained in an SEIS being drafted by NMFS. Whatever the outcome of this examination, it is not likely that these effects on bottom habitat would have any negative impact on listed species in the Action Area, or adversely impact critical habitat in any manner that would diminish its value for both the survival and recovery of Steller sea lions.

The rate of biomass removal inside critical habitat varies considerably by gear types (Table 6.3). Figures 6.11 and 6.12 display the harvest rate by gear type for both the BSAI and GOA (top panel) and the resulting cumulative catch by week (bottom panel) in 1999. The BSAI is characterized by two pulses of fishing, driven largely by the trawl sector. Trawl removals reached 100,000 mt per week in both the spring and fall time periods. The trawl peak is evident in the cumulative catch (bottom panel) marked as the A and B time periods where the slope of the line is greatest. The hook-and-line sector removed about 5,000 mt per week during the first half of the year, and about the same rate in a second season in late September, October, and early November. The hook-and-line sector results in a relatively constant removal rate and a cumulative catch with a more constant slope (Figure 6.11b). The pot and jig sectors compose much less of the catch in the BSAI, the pot sector takes most of its catch in April and May after the crab seasons close. Similar patterns are observed in the GOA, but the B season in the GOA (Figure 6.12b) is much longer than in the BSAI and is composed of a number of spikes starting in July and running through November, with rates of about 10-15,000 mt per week. While the majority of the catch occurs from trawling, pot and hook-and-line gear represent a higher proportion of the catch than in the BSAI.

In terms of effects on ESA-listed species, the slower and more dispersed nature of the hook and line and pot fisheries make localized depletion less likely than would be possible with trawl gear.

In addition, fleet capacity is currently much smaller, although hook and line and pot capacity could grow in the future if circumstances favor use of those gears.

6.3.4.4 Time/area catch management

Time/area management measures are promulgated for 3 primary reasons: prohibited species bycatch management, habitat protection, and catch dispersion. Examples of prohibited species bycatch management areas include the chum salmon and red king crab savings areas. Habitat protection areas include the Pribilof Islands pelagic trawl closure to protect blue king crab habitat and the trawl exclusion zones around Steller sea lion rookeries and haulouts. Furthermore, ABCs and TACs for many species, including Atka mackerel, many rockfish, pollock, Pacific cod, are allocated among existing management areas to disperse catch throughout the range of the species.

The management areas used to disperse catch in the Aleutian Islands (areas 541, 542, 543, inside/outside critical habitat for Atka mackerel, rookery and haulout closures) are currently more extensive than those used to disperse catch of pollock in the Bering Sea (Steller Sea Lion Conservation Area, rookery and haulout closures). The limited time/area management applied to the Bering Sea results in a potential for spatial and temporal concentration of catch due, in part, to a mismatch of scales between the area over which resources are surveyed and the area over which catches are removed. The entire eastern Bering Sea shelf is used to estimate total biomass, but few mechanisms exist to distribute the catch over the same area. As a consequence, catch may become concentrated in time and space, with the exception of mandated seasonal distributions of pollock catches. The areas used to disperse catch in the GOA are more detailed but because annual surveys are not performed and there is uncertainty about seasonal movements, interannual or seasonal changes in target stock distributions could result in removal rates that are not proportional to the stock in each area. Furthermore, analysis of the portion of the target stocks within critical habitat have only recently been used in fishery management to estimate the level of biomass inside critical habitat. Also, there are no present control areas for assessing the effects of fishing.

The spatial patterns of the groundfish fisheries suggest that there is a demand for common resources by fisheries and Steller sea lions. In the BSAI, the portion of each groundfish catch taken in 1999 from critical habitat ranged from 1% for the yellowfin sole fishery to 74% for the sablefish fishery (Fig. 6.13a). By amount, the tonnage removed from critical habitat in each fishery ranged from 657 mt for yellowfin sole and 332,251mt for pollock (Fig. 6.13a). The portion of BSAI pollock, cod, and Atka mackerel catch combined from critical habitat has increased from 12% in 1980 (about the beginning of the joint-venture fishery) to a peak of about 66% in 1995, and then dropped to 37% in 1999 (Fig. 6.14a).

Between 1995 and 1999, about 49% of the total groundfish harvest in the BSAI was taken from critical habitat that has been designated for Steller sea lions (Table 6.3). About 14% of this catch was taken within 20 nm of sea lion rookeries and haulouts in the Bering Sea and 10 nm of rookeries and haulouts in the Aleutian Islands area. The pot sector was the most concentrated in critical habitat (81%) followed by trawl, and then hook-and-line (longline). However, the magnitude of the trawl catch in critical habitat was much greater than pot, about 430,000 mt compared to about 14,000 mt (in 1999). Hook-and-line catch was more dispersed outside of critical habitat on average, and accounts for about 75,000 mt taken outside of critical habitat and about 25,000 mt inside (in 1999). The possible effects of these other gear types were dwarfed by the biomass removed by the trawl sector in 1999, which removed 1,286,852 mt.

In 1998, the NPFMC implemented management measures to redistribute the Atka mackerel catch inside and outside of critical habitat over a four-year period. In the first year (1999), these measures reduced Atka mackerel catches in critical habitat compared to historic patterns; in 2002, the measures should reduce Atka mackerel catches in critical habitat by about 50% from historic levels and would allow 40% of the Atka mackerel catch from inside critical habitat. Management measures implemented in 1999 for the pollock fisheries were intended to reduce the spatial and temporal compression of the fisheries. As a consequence of these measures, the percent catch of all species in critical habitat decreased from about 53% before 1999 to 34% in 1999.

In the GOA, analysis of the historic distribution of catch inside and outside of critical habitat is more complicated than the BSAI. The GOA fisheries are prosecuted by a small boat fleet which has much lower overall observer coverage. The result is that the analysis of fishing effort is skewed by vessels larger than 125 ft (which have a higher observer coverage). Vessels under 60 ft are not required to carry observers. Because smaller boats are more likely to fish inside critical habitat, and larger boats are more likely to fish further offshore, the resulting spatial analyses tend to underestimate the catch from critical habitat, this would be important in assessing effects on listed species.

In 1999, the portion of each groundfish catch taken from GOA critical habitat ranged from 5% for the other rockfish fishery to 81% for the pollock fishery (Fig. 6.13b). By amount, the tonnage removed in each GOA fishery ranged from 89 mt for Atka mackerel to 77,663 mt for pollock (Fig. 6.13b). The portion of the GOA pollock and cod fisheries combined from critical habitat has increased from 19% in 1980 to 65% in 1999 (Fig. 6.14b).

In the period from 1995-1999, the average catch from critical habitat for all sectors was 54% of the total catch, about 48% of the total catch was within 20 nm of listed rookeries and haulouts. The pot sector was the most concentrated in critical habitat (71%), followed by trawl, and then hook-and-line. However, as in the BSAI, the magnitude of the trawl catch in critical habitat was much greater than pot, about 100,000 mt compared to about 10,000 mt (in 1999). Hook-and-line catch is more dispersed outside of critical habitat on average, and accounts for about 20,000 mt of catch outside of critical habitat and about 7,500 mt inside (in 1999). The possible effects of these other gear types are significantly less than the magnitude of biomass removals by the trawl sector; trawl catch in 1999 was 180,000 mt.

Management measures were implemented in 1999 to disperse the GOA pollock fisheries spatially and temporally. Before 1999, the catch of all species averaged about 55% in critical habitat; in 1999, the catch was about 52% in critical habitat. The reduction was small for several reasons. First, the pollock management measures attempted to increase fishing in the Shelikof Strait conservation area (critical habitat) to distribute the catch in accordance with the distribution of the stock. Second, trawl prohibitions around rookeries and haulouts only extend out to 10 nm. Thus, the critical habitat areas from 10 nm to 20 nm were not protected and the catch actually increased in those areas from 1999.

Temporal patterns of the groundfish fisheries can have the same effects as spatial concentration: fisheries may become so concentrated in time that prey resources are depleted relative to the needs of other predators in the ecosystem. Because the needs of other predators may change with the seasons, temporal concentration is of greater concern when those needs are perceived to be the greatest. For example, Steller sea lions appear to be most sensitive during the winter when adult, female, sea lions may be pregnant with one fetus and lactating to support a pup. Pups may be making the difficult transition from nutritional dependence on their mother to nutritional independence. Juvenile sea lions that have been weaned and are feeding on their own are vulnerable to changed in food supply because of their smaller size and greater energy requirements.

The temporal distribution of the BSAI fisheries is determined primarily by the pollock fisheries (Fig. 6.15). In general, the fisheries are concentrated in fall and late winter periods with relatively little fishing in the spring/summer (Fig. 6.15). Daily catch rates inside critical habitat have been reduced by about 50% since 1995, and a portion of the catch has been shifted to areas outside of critical habitat.

In the GOA, the smaller quotas and relatively large fishing capacity have resulted in a pattern of short, pulsed fishing that has changed little over the past five years, both inside and outside of critical habitat (Fig. 6.15). A number of fisheries with split seasons and bycatch apportionments tend to spread these pulses out over the year. The most seasonal catch occurs in the Pacific cod fishery which is harvested primarily in the winter/spring period around March. The rate of removal for the GOA fisheries varies by year, with maximum rates between 3,000 and 8,000 mt per day. The higher rates are from short pollock openings, on the order of days to just over a week in many cases. The primary change illustrated in Figure 6.15 appears to be that highly pulsed pollock fishing was avoided in 1999. The GOA pollock fishery was split into four seasons beginning in 1999, but the third and fourth seasons were separated by only a matter of days, and effectively constitute one season.

As with many protected species and fisheries interactions, fishermen are often exploiting the same areas of the ocean and times of year as the protected species–both “predators” are taking advantage of the most productive areas with greatest catchability. Management measures that spread effort in time and space would be expected to reduce impacts.

6.3.4.5 Bycatch

Catch of non-target species (bycatch) occurs during fishing. NOAA (1998) uses the following terms to describe bycatch.

> **Bycatch** — defined as the discarded catch of any living marine resource plus retained incidental catch and unobserved mortality due to a direct encounter with fishing gear. Information on bycatch, either incidental or of prohibited species, retained or discarded, is difficult to obtain. Sampling rates for bycatch may be lower than for target catch, and because fishermen may have incentives to under-report discarded bycatch, total estimates of bycatch may not be reliable.
>
> Trawl fisheries account for most of the bycatch of prohibited species caught in both the BSAI and GOA. Bycatch of salmon species in the trawl fisheries could result in the take of ESA listed salmon originating in Washington and Oregon waters, and is a matter of concern to the Council and NMFS. Halibut is a significant bycatch species in the hook-and-line fisheries and often acts to limit the total removals of groundfish due to the attainment of halibut mortality caps. There is a small bycatch of crab in the pot fisheries.

Bycatch regulations involve a complex suite of measures to minimize bycatch of incidental species, prohibited species, and protected species. This suite of measures includes gear allocations, seasons, bycatch limits, and discard rules. Some of the rules are fixed in regulation and others are determined annually during the TAC setting process. Bycatch is generally an important consideration in any measures that change the prosecution of a fishery.

Discarded catch — defined as living marine resources discarded whole at sea or elsewhere, including those released alive. In 1999, about 1.3 mmt of groundfish was harvested in the BSAI, of which about 9.6% was discarded. The highest discard rate was in the catcher/processor sector (14.7%). In the GOA, about 227,000 mt of groundfish was harvested, of which about 11% was discarded. Again, the highest discard rate was in the catcher/processor sector (22%). The improved retention/improved utilization (IR/IU) program has reduced discards in the Pacific cod and pollock directed fisheries. The program is intended to expand to the rock sole and yellowfin sole fisheries in the BSAI and shallow-water flatfish in the GOA beginning in 2003.

Incidental catch — catch that is not a part of the targeted catch. This includes retained nontargeted catch and discarded catch. For example, any catch of Pacific cod after it is closed to directed fishing is considered incidental catch. Amounts can be retained up the Maximum Retainable Bycatch (MRB) limit, then further catch must be discarded.

Total catch — retained catch plus discarded catch. As discarded catch is included in the total catch, it is counted against the TAC or quota for target species. Discards are wasted in the sense that they are not utilized by the industry. However, to the extent that they are accurately reported they are still accounted for and are not additional to the TACs. A number or fisheries (e.g., some rockfish fisheries) are closed at the beginning of the year and are prosecuted entirely as a bycatch fisheries. However, management of incidental catch can be imprecise and the TACs have been exceeded for a number of species over the last few years. In the BSAI, for example, the “other red rockfish” assemblage was exceeded by 30% of its TAC in 1998, approaching the overfishing level. Once the overfishing amount is reached, management may be required to close all fisheries with bycatch of these species.

Bycatch mortality and unobserved mortality — all mortality of living marine resources associated with discarded catch plus unobserved mortality. Unobserved mortality is due to a direct encounter with fishing gear that does not result in the capture of that species by a fisherman. This includes mortality due to lost or discarded fishing gear, as well as live releases that subsequently die.

We are unable to estimate the significance of unobserved mortality. Such mortality is a matter of growing concern among stock assessment scientists as it may be underestimated, may contribute significantly to total fishing mortality, and may influence the status of stocks.

Regulatory and discretionary discards — regulatory discards are those required by regulation. Prohibited species are regulatory discards. Discretionary discards are those that are discarded because of undesirable species, size, sex, or quality, or for other reasons, including economic discards as defined in the Magnuson-Stevens Act.

Prohibited species — a species for which retention is prohibited in a specific fishery. Prohibited species are non-groundfish species that typically were fully utilized in domestic fisheries prior to the passage of the Magnuson-Stevens Act in 1976. Retention was prohibited in the foreign, joint venture, and domestic groundfish fisheries to eliminate any incentive that groundfish fishermen might otherwise have to target these species. The listed prohibited species include: Alaska king crab, Tanner and snow crab, Pacific halibut, Pacific salmon species and steelhead trout, and Pacific herring.

Trawl fisheries account for most of the bycatch of prohibited species caught in both the BSAI and GOA. The trawl Pacific cod fishery caught 1,364 mt of halibut in 1999, about 34% of all of the halibut bycatch in the BSAI. Halibut is a significant bycatch species in the hook-and-line fisheries and often acts to limit the total removals of groundfish due to the attainment of halibut mortality caps. Bycatch of salmon species in the trawl fisheries could result in the take of ESA listed salmon originating in Washington and Oregon waters, and is of special concern to the Council and NMFS. In 1999, the BSAI trawl fishery for pollock caught an estimated 10,381 chinook salmon and 44,611 "other salmon", far greater than any of the other directed fisheries. Crab bycatch occurs mostly in the trawl fisheries as well, with relatively high bycatch rates in the Pacific cod pot fishery.

Forage Fish - in the BSAI and GOA, the "forage fish" category refers to the following species assemblage:

1. *Osmeridae* (eulachon, capelin and other smelts);
2. *Myctophidae* (lanternfishes);
3. *Bathylagidae* (deep-sea smelts);
4. *Ammodytidae* (Pacific sand lance);
5. *Trichodontidae* (Pacific sandfish);
6. *Pholidae* (gunnels);
7. *Stichaeidae* (pricklebacks, warbonnets;eelblennys, cockscombs and shannys);
8. *Gonostomatidae* (bristlemouths, lightfishes; and anglemouths), and
9. The Order *Euphausiacea* (krill).

Directed fishing for forage fish is prohibited at all times in the BSAI and GOA (50 CFR 679.20(i)(3)). Aggregate forage fish incidental catch retention limits are 2% against other retained species of groundfish. Reliable biomass estimates for forage fish is not available. Additionally, catch estimates are limited because of a lack of catch accounting in the "blend" database for forage fish species. However, estimates have been obtained from the observer database indicating that incidental catch of forage fish is relatively low.

Other Species — the "other species" category includes sculpins, sharks, skates and octopus. Forage fish, as defined at 50 CFR part 679.2 are not included in the "other species" category. The TAC for "other species" equals 5 percent of the sum of TACs for all target species. A preliminary stock assessment was prepared for 2000 for the other species assemblage, in an effort to present the available information for these species and to explore the possibility of single species ABC determinations in order to ensure protection to the species.

Nonspecified Species — defined as those fish species, other than prohibited species, for which TAC has not been specified (e.g., grenadier, prowfish, lingcod). No reliable estimates for biomass or catch are available, and they are generally caught in small amounts and are not commercially valuable at this time. However, we have no way of determining whether adequate protection in the single species context is being provided for these species.

Protected species — any species that is subject to special conservation and management measures (e.g., Marine Mammal Protection Act, ESA, and Migratory Bird Treaty Act). From 1990-1995, observed minimum mortality of Steller sea lions has been estimated to be 30 animals per year (Hill and DeMaster 1999). As described in the Environmental Baseline, incidental catch of Steller sea lions was a serious problem in the 1960s and 1970s, but is no longer a major concern with respect to population level effects.

Annual bycatch of seabirds in the BSAI has been about 1 short-tailed albatross; 410 Laysan albatross; 31 black-footed albatross; 8,064 northern fulmars; 2,074 gulls; and 1,036 shearwaters. In the GOA, annual bycatch has been about 0 short-tailed albatross; 305 Laysan albatross; 611 black-footed albatross; 1,245 northern fulmars; 124 gulls; and 82 shearwaters. In 1997, NMFS required operators of hook-and-line vessels fishing for groundfish in the BSAI and GOA and federally-permitted hook-and-line vessels fishing for groundfish in Alaska waters adjacent to the BSAI and GOA to employ specified seabird avoidance measures (62 FR 23176, April 29, 1997). The purpose of these measures is to reduce seabird bycatch and incidental seabird mortality. These measures were necessary to mitigate hook-and-line fishery interactions with the short-tailed albatross and other seabird species. In 1998, NMFS required seabird avoidance measures to be used by operators of vessels fishing for Pacific halibut in U.S. Convention waters off Alaska (63 FR 11161, March 6, 1998).

Bycatch is a continuing issue for all of the FMPs in the BSAI and GOA. For the purposes of this consultation, the most significant issue is bycatch of threatened and endangered salmon in the groundfish fisheries. As we discussed in the Environmental Baseline chapter of this opinion, the available information does not allow us to characterize the stock composition of the chinook bycatch in the groundfish fisheries. Consequently, we cannot estimate how the various fisheries in the action area have affected mortality rates of threatened and endangered salmonids over time.

Despite the limited information on the distribution and abundance of Pacific salmon in the action area and the number that are taken as bycatch in groundfish fisheries, at least small numbers of these salmon can be expected to be caught as bycatch in these fisheries. In particular, we would expect the groundfish fisheries to capture and kill small numbers of Snake River fall chinook, upper Willamette River chinook salmon, Snake river spring/summer chinook salmon, and upper Columbia river spring chinook salmon in the action area. However, an evaluation of the impact of this incidental removal has been addressed in a biological opinion regarding salmon in the Pacific Northwest.

6.3.5 Monitoring

Monitoring of the fisheries is necessary to ensure that they are prosecuted in compliance with management regulations and do not threaten the health and status of the target stocks or the ecosystem, including listed species and critical habitat. Fishery effects on the target stocks are monitored by two principle methods. First, the catch is monitored by a catch accounting system to ensure that it does not exceed the TAC by excessive amounts. Second, the target stocks are surveyed during a set of research cruises that include annual summer bottom trawl surveys in the BSAI, triennial summer bottom trawl surveys in the GOA and Aleutian Islands (which will become biennial), annual winter hydroacoustic surveys in Shelikof Strait of the GOA, annual summer longline surveys (for sablefish), winter hydroacoustic surveys in the Bogoslof area, and several additional surveys being considered for the near future.

The objective of the groundfish catch accounting system is to comprehensively account for fishing mortality in the groundfish fisheries. Observers based on catcher-processor and mothership vessels collect data on total catch. Unobserved catcher-processor vessels are required to maintain a daily logbook that details their retained catch and discards. For vessels delivering to shoreside processors the retained, or landed, catch is determined using State of Alaska certified scales at the processor. The at-sea discards of groundfish by the catcher vessels is estimated by expanding discard rates on observed vessels to the fishery as a whole.

Processor check-in reports provide NMFS with information on the current fishery participants from whom catch reports are expected. NMFS staff monitor the incoming catch reports for completeness. NMFS also regularly compares the information reported to NMFS with the State of Alaska groundfish fish tickets to ensure completeness of the catch accounting database from shoreside processors. NMFS has a high degree of confidence that the catch accounting system succeeds in collecting comprehensive data on groundfish catch.

Prohibited species catches (PSC) are estimated from averaged observer sampling data, and therefore the PSC estimates are probably better for fisheries with a higher level of coverage. Because observer coverage is based on vessel length, fisheries comprised primarily of vessels under 60' in length lack observer coverage. Examples include the hook-and-line demersal shelf rockfish fishery in the eastern Gulf of Alaska and the BSAI fixed gear Pacific cod fishery for vessels less than 60'. If observer data is available from a similar fishery that has observed vessels, those data are used to estimate PSC for the unobserved fishery.

Pacific cod is a unique groundfish in that significant amounts of cod bycatch occur in non-groundfish fisheries – specifically the longline Pacific halibut fishery and the pot crab fisheries. The crab fisheries have State observers and some data on Pacific cod bycatch has been collected. The longline Pacific halibut fishery does not have an observer program, so information on Pacific cod bycatch is largely anecdotal. This is not a deficiency in the groundfish fishery catch accounting system as the crab and Pacific halibut fisheries are managed separately. However, mortality of Pacific cod in these non-groundfish fisheries could affect Pacific cod stock assessments, and should be considered in stock assessment. In the 1995 GOA SAFE report, an attempt was made to estimate the Pacific cod bycatch taken in the GOA Pacific halibut fishery (Thompson and Zenger 1995). In that assessment, the 1988-1994 average estimate of bycatch was just over 4,000 t, compared to directed Pacific cod catches in the approximate range of 40,000-80,000 t during the same period (i.e., the bycatch amounted to approximately 5-10% of the directed catch). In the BSAI, where the Pacific halibut catch is much smaller, it is assumed that the bycatch of Pacific cod is also much smaller.

The observer program is a crucial element of the catch accounting system for the fisheries and has generally been highly successful. However, the program has some deficiencies that confound the monitoring of fishery effects. Observer coverage is based on vessel length, and is required 100% of the time for vessels over 125 ft (see Table 6.4). For vessels between 125 ft and 60 ft, observers are required 30% of the time, and the actual time is at the discretion of the vessel operator. Observers are not required for vessels under 60 ft. Because fleet composition varies considerably between the BSAI and GOA groundfish fisheries (the BSAI fleet is comprised of larger vessels), observer coverage is generally better for the BSAI and less complete for the GOA. The lack of information for the GOA fleet has been problematic because the smaller vessels that are not observed are more likely to fish in Steller sea lion critical habitat, but data on those smaller vessels is not available.

In addition, the length-based requirements for observer coverage shift observations toward larger vessels that participate in single species fisheries with low bycatch rates (e.g., pollock). Less sampling occurs for smaller vessels that participate in fisheries with more diverse catches and higher bycatch. Where bycatch may be higher and observer coverage lower, confidence in discard rate is reduced. When vessels are not observed, their bycatch is estimated on the basis of observed vessels. This approach assumes that vessels without observers behave in a similar manner to vessels with observers. Records from other fisheries have demonstrated that this is not likely to be true, in which case other mechanisms may be required for confidently estimating bycatch.

With the exception of the above issues, the combination of data from the catch accounting and the stock assessment surveys provides a seemingly comprehensive system for tracking the catch, status, and trends of the BSAI and GOA target stocks. Improvements upon monitoring techniques are constantly being implemented as part of the FMPs. It is highly unlikely that any listed species would be jeopardized as a result of overfishing quotas or groundfish stocks as a result of inadequate monitoring of the fisheries.

The second significant element of monitoring involves assessment of significant fishery-related effects on the ecosystem, including non-target species, listed species, and critical habitat. The Ecosystem Considerations Chapter of the annual Stock Assessment and Fishery Evaluation Report of the NPFMC summarizes much of the monitoring activities involving other aspects of the ecosystem. Monitoring of climate changes, zooplankton and phytoplankton production, trophic relationships, benthic communities and habitat, and marine mammal and seabirds is summarized there. The document presents indices of changes in the status of some of these components and also attempts to develop ecosystem-based management indicators in an effort to track the efficacy of past management efforts. Again, an expanded discussion of the possible ecosystem effects of fishing is presented in section 6.5.3.

6.4 Direct Effects of the FMPs on Listed Species and their Environment

6.4.1 Effects of the global fishery exploitation strategy on listed species

By design, fishing significantly reduces the spawning stock biomass from an "unfished" level to a "fished" level. The relevant question is whether fishing under these global (e.g., large scale such as BSAI or GOA wide) exploitation strategies reduces the environmental carrying capacity of listed species by adversely affecting the ecosystem on which they depend for survival.

6.4.1.1 Long-term effects of a single-species groundfish exploitation strategy

Fishery management actions are intended to allow for the removal of fish biomass in a manner that will result in a long-term, consistent yield to the human population. This strategy supposes that there is "surplus" fish production beyond that required to ensure that, on average, successive generations of a species will replace or surpass themselves. Fisheries models predict that "surplus" production will be maximized at intermediate stock sizes because high stock densities result in more competition for resources which reduces the reproductive rate of the population (Ricker 1975). In a single species context, it is generally considered that this "surplus" production can be safely removed without adversely impacting that stock or the ecosystem; this assumption is analyzed in the following sections.

The fundamental dynamics of the BSAI and GOA groundfish stocks provide a means for evaluating the long-term effects of fishing over multiple years. The availability of this stock to other consumers in the marine ecosystem (e.g., marine mammals, seabirds, other fish) is determined, in part, by the stock's standing biomass. Figure 6.1b contrasts the theoretical female spawning biomass by age in a fished and an unfished population based on the B40% harvest strategy. This figure suggests that there could be significant reductions in the amount of prey available to other consumers in the ecosystem. In Figure 6.1c, we see that for EBS pollock in 1999, that there have in fact been significant reductions especially in the older half of the population (this effect is discussed further in section 6.4.2 below).

To further demonstrate the reduction in spawning biomass resulting from fisheries in the BSAI and GOA we used recently developed stock assessments that hindcast groundfish population abundance and age structure and compare the fished population with simulations of the stocks without fishing. The biomass of unfished populations was estimated using the estimates of annual recruitment from each stock assessment and subjecting each cohort to natural mortality and somatic growth only. The structure of the fished population was that estimated from the stock assessment process and reflected the effects of the entire fishing history. All other aspects of the two populations, including average weight at age, the proportion of females in the population, the proportion of females mature at age, and natural mortality, were identical in the two data sets. For this analysis, we assumed that the time series of annual recruitment was the same in the unfished and fished scenarios. The results are illustrated in Figure 6.16 for the BSAI stocks and Figure 6.17 for GOA stocks in 1999. Comparisons are made between spawning biomass in the fished and unfished scenarios.

For example, the female spawning biomass of BSAI pollock in 1999 was 43% of its unfished level (as determined by current fisheries models), cod was 50%, and Atka mackerel was 66% (see Table 6.5). In the GOA in 1999, pollock female spawning biomass was at 61% of its unfished level and cod was 57%. Differences between observed biomasses and those expected in the absence of fishing, indicates that fishing likely have considerably reduced the potential spawning stock biomass of all species. This cumulative effect has occurred over the last 20 years (Figures 6.16 and 6.17). This long-term reduction is reasonably likely to reduce the availability of prey to other components of the ecosystem. Whether the expected unfished biomass would have been fully realized or made available to another predator like Steller sea lions, can not be determined. Additionally, because the time series for the modeling exercise began in 1978, after many years of heavy fishing, we may be underestimating the unfished biomass. However, given these caveats, it does represent our best estimate based upon the best available scientific and commercial data.

One approach to estimate the cumulative effects of multiple fisheries on prey availability is to sum the difference between the fished and unfished biomasses for all FMP species. For the BSAI in 1999, the combined female spawning biomass for pollock, cod, and Atka mackerel was 45% of the expected unfished level. For all species that can be assessed with age-structured models, the female spawning biomass was 54% of the expected unfished level, while total biomass was 58% of the unfished level. For the GOA in 1999, the combination of female spawning biomass and total biomass for pollock and cod was 59% and 46% of the expected unfished level, and 78% for all stocks analyzed with age-structured models (Fig. 6.17). If arrowtooth flounder, neither a major target of the fisheries nor a major prey item for Steller sea lions, is removed from the calculation, then the combined female spawning biomass in the GOA in 1999 was 61% of its expected unfished level.

These results indicate that the $B_{40\%}$ strategy had not been fully realized for most target stocks at the end of the time series (1999). Stocks may not have been fished at $F_{40\%}$ for a variety of social, economic, or ecological reasons such as prohibited species bycatch, or low market demand. Nevertheless, the differences between observed biomasses expected in the absence of fishing indicate that fishing has considerably reduced the potential spawning stock biomass of each species over the last 20 years. Figure 6.18 illustrates the reduction in eastern Bering Sea pollock biomass by cohort resulting from this exploitation strategy applied over the period from 1982 to 1998. This long-term reduction is reasonably likely to reduce significantly the availability of prey to other components of the ecosystem, such as Steller sea lions. In effect, fisheries remove fish from the population before they are “lost” to natural mortality (e.g., other consumers of groundfish).

These results are based on the same single species models that are used for annual stock assessment. The models do not include compensatory or depensatory mechanisms that, potentially, could mitigate or compound the actual reduction resulting from fishing. Such mechanisms may result from complex interactions that characterize these marine communities and ecosystems, including predator-prey interactions, competition, changes in age structure, density dependence, or other forms of ecological interaction. Efforts to model multi-species interactions are being developed for the purpose of understanding the potential consequences of the existing fishery management approach. For example, one model of the eastern Bering Sea indicates that in the long-term, the predators that benefit most when prey are not removed by fishing are those that consume the youngest prey of a certain species (Jurado-Molina and Livingston 2000). If this is the case and management changes resulted in greater availability of pollock, then predators of small pollock such as fur seals, adult pollock, arrowtooth flounder, and to some extent Steller sea lions, may benefit more than predators that target large pollock. Other modeling exercises indicate that compensation may reduce the actual difference between spawning biomass estimates under fishing and no fishing scenarios (P. Livingston, pers. comm.). While some degree of compensation may be likely, it is also possible that reductions of 40% to 60% in the potential spawning biomass of major forage species could have significant consequences for other components of the ecosystem.

Therefore, multi-species models help identify areas of needed research and identify possible responses of the ecosystem to fishing if predator-prey interactions are the main driving force without much spatial dynamics. However, their predictions are still relatively uncertain for use in management. They can not, for example, be used to reliably describe the response of these marine communities and ecosystems to the reduction of multiple groundfish stocks as predicted by single species models. Despite the uncertainty in the applicability of these models, such exercises provide an important step forward in our attempts to understand ecosystem dynamics and the consequences of management actions. For purposes of this consultation, the directions of biomass change shown by single-species models, remain the best determinant of groundfish stock status for this analysis and determining the effects on listed species. However, having discussed biomass in total terms and based on these single species strategies and models, it is necessary to restate issues raised earlier:

1. Evaluations should be made in an ecosystem context. It is the complex and life stage of prey species available that would affect foraging success.

2. Estimates of food requirements for sea lions (Appendix 3) given current population size are below
available biomass even at current fishing mortality, making the case for the hypothesis that temporal and spatial factors (localized depletions) are affecting their ability to forage effectively . Food requirements are discussed in greater detail in section 6.4.3.10

6.4.1.2 Changes in groundfish age distribution

Fishing the same cohorts of a prey stock year after year not only reduces the biomass of the stock, but also changes its age distribution. Over time, a cohort is repeatedly subjected to fishing mortality, thus, older fish become increasingly rare, and the age distribution shifts toward younger cohorts and a younger mean age. Figure 6.1b illustrates this shift for a hypothetical stock with constant recruitment fished under an $F_{40\%}$ exploitation strategy, and Figures 6.1c and 6.4 illustrate this shift for the 1999 EBS pollock stock. For eastern Bering Sea pollock, the mean age of the stock in 1999 would be 3.64 years without fishing compared to 2.65 years with fishing. For eastern Bering Sea pollock, the mean age for fish at least two years old would be 4.69 years without fishing compared to 3.48 years under an F40% exploitation strategy. Therefore, the “average” individual in the population is more than a year younger, and, more importantly perhaps to a predator, 30% less in mean weight, as far as the effect on Steller sea lions, it would require them to expend more energy foraging for some energy input. Because of the high recruitment variability of pollock, age structure in any given year can be quite unlike the equilibrium pattern, both for fished and unfished populations.

For the Gulf of Alaska the mean age of pollock increased from 3.8 years to 5.5 years from 1991 to 1995 as the strong 1988 year class progressed through the population, then declined to 3.9 years in 1996 with the recruitment of the 1994 year class (Fig. 6.19). Pollock predators have evolved different strategies for coping with this variability, either by consuming a wide spectrum of sizes, by switching to alternate prey, or by conserving energy reserves during times of reduced pollock availability.

This potential for reduction in the average age of fished populations (removal of older fish) could impact listed species by changing the distribution of the fish stock. A reduced average age of fished population may shift the spatial distribution of the stock toward habitats occupied by younger fish. For instance, the geographic distribution eastern Bering Sea pollock varies by age with younger fish found more to the northwestern portion of the eastern Bering Sea shelf. Older, mature fish seasonally move between winter spawning sites in the southeastern Bering Sea and along the outer shelf and summer feeding areas on the middle to outer shelf to the west and northwest. Because the distributions of younger and older fish differ, removal of the older fish will result in a corresponding change in the overall stock distribution (i.e., to one more consistent with the younger fish). This could result in changes in availability of prey to other consumers, particularly those tied to specific geographic features. To our knowledge, the potential consequences of a shift in distribution of fish stocks in the BSAI and GOA have not been analyzed.

6.4.1.3 Changes in reproductive capacity

The shift in age distribution described above may affect the reproductive capacity of a fish stock because younger fish are generally less fecund. Beverton and Holt (1957) deduced for fish that the volume of mature ovaries is proportional to the total body volume. For pollock, there is a 9% increase in eggs/kg body weight for age-15 pollock relative to age-4 pollock. Given an $F_{40\%}$ harvest rate, where female spawning biomass per recruit was reduced to 40% of the unfished biomass, egg production per recruit was reduced by 61% (Ianelli et al.1999).

Models which extend spawning biomass per recruit analysis to account for maternal influences indicate a tendency for mature female biomass to underestimate reproductive output by not taking in account the higher quality of reproductive products of older females. Because the abundance of older females is substantially reduced by fishing, harvest policies are potentially more aggressive than intended because mature biomass is used as a proxy for reproductive output. Research into the reproductive biology of pollock and other North Pacific groundfish stocks is needed to assess the importance of maternal influences on reproductive output.

6.4.2 Direct effects of fishing on short term/local prey availability

Competition has been defined in many ways. Although the various definitions have important differences, each definition has two basic elements (a) competition occurs between two or more individuals (or populations) that actively demand a common resource and, (b) in meeting those demands, reduce a resource's availability to other individuals or populations or that the resource is in short supply relative to the number seeking it. We will evaluate the information available to determine if it allows us to conclude that the fisheries compete with Steller sea lions.

The data necessary to resolve whether groundfish fisheries of the BSAI and GOA compete with listed species is sparse. First of all, we do not have comprehensive information on the structure and composition of the marine ecosystem before commercial exploitation of fisheries began, nor do we have information on the population cycles of fish, marine mammals, and seabirds over long periods of time that would provide a solid foundation for this type of analysis. Nevertheless, these effects are not merely theoretical; competition between fisheries, marine mammals, and seabirds have been observed worldwide. Based on these studies we believe competition could exist between groundfish fisheries, marine mammals, and seabirds in the BSAI and GOA.

Competition between the groundfish fisheries and non-human predators in the marine ecosystem of the BSAI and GOA can occur at different spatial and temporal scales. At the macro-scale, potential impacts of fishing include competition for a common resource and/or shifts in predator prey relationships resulting from direct mortality and by shifts in the carrying capacity. These impacts are superimposed on a natural system that is fluctuating due to external forcing at the seasonal, interannual and interdecadal time scales. Differentiating fishery induced shifts in fish distribution from natural shifts due to changes in oceanographic conditions is an active field of research in the marine community. At current harvest levels, the impacts of commercial harvest on the macro-scale distribution of walleye pollock and Pacific cod are not easy to distinguish.

Competition can also occur on a meso-scale if the fisheries affect the distribution or abundance of groundfish in a region (such as Shelikof Strait or Bristol Bay). Finally competition can occur on a micro-scale if fishing vessels affect the distribution and abundance of groundfish in specific locations. With decreasing spatial scale, there is a corresponding decrease in the temporal dynamics of competition: the effects of fisheries on the distribution and abundance of fish species have shorter duration as spatial scales decreases.

6.4.2.1 Active demand for a common resource

Competition between fisheries, marine mammals, and seabirds has a long history and has been described from different perspectives. On one hand, fishermen have observed the numbers of target species that have been consumed by marine mammals and seabirds and treated the mammals and birds as economic competitors for their catch (Furness 1984). For example, in the 1980s, the British government considered reducing the grey seal population at colonies around Britain to increase the quantity of commercial fish species (Furness 1984). On the other hand, biologists and conservationists have observed the large amount of biomass that is removed from marine ecosystems by fisheries and have been concerned that the fisheries compete with marine mammal and seabird populations.

In the Environmental Baseline, it was noted that fishermen historically viewed Steller sea lions and other pinnipeds as nuisances or competitors, partially because they competed with the fishermen for fish (Mathisen et al. 1962). As a result, the federal and state government sanctioned efforts to reduce the size of the sea lion population through bounty programs, controlled hunts, and indiscriminate shooting until the sea lions were protected by the MMPA in 1972. The total number of sea lions killed between 1900 and 2000 is unknown, but Alverson (1992) suggested that 34,000 or more Steller sea lions were killed intentionally from 1960 to 1990. During this period, fishermen were seen killing adult sea lions at rookeries, haulout sites, and in the water near boats.

The Environmental Baseline also noted that large numbers of Steller sea lions had been caught incidentally in foreign commercial trawl fisheries in the BSAI and GOA since those fisheries developed in the 1950s (Loughlin and Nelson 1986, Perez and Loughlin 1991). From 1960 to 1990, more than 50,000 Steller sea lions were caught in trawl gear or almost 40% of the estimated sea lion mortality during that period (Alverson 1992). Perez and Loughlin (1991) concluded that incidental take contributed to the decline of Steller sea lions by causing the sea lions to decline by 16% in the BSAI and 6% in the GOA.

Finally, in the Status of Species and Environmental Baseline chapters, we presented data that showed an overlap between Steller sea lion diets and commercial catch of groundfish in the Bering Sea, Aleutian Islands, and Gulf of Alaska (see Fig. 4.5 and Tables 4.4 and 5.2). Combining this dietary overlap with the evidence of direct, local interactions between fishermen and Steller sea lions over almost three decades of fishing suggests that these two consumers - Steller sea lions and fishermen - actively demand a common resource.

6.4.2.2 Depletion of resources

Marine consumers deplete the biomass of their prey on local scales. Although reductions in biomass at these spatial scales have the shortest duration, they can affect the foraging success of other, individual consumers of the prey species. In 1963, Ashmole suggested that seabirds could deplete the prey base around their nesting colonies, which would reduce the supply of food available to the entire colony and reduce breeding success by limiting food available to fledglings. Ashmole (1963) called this depletion a “halo” around the colony that contained low densities of prey. Furness (1984a) concluded that seabirds can consume almost one-third of the pelagic fish production within 45 kilometers of their nesting colonies, which would place them in competition with commercial fisheries, predatory fish, and marine mammals if they consumed the same sizes of prey. Seabirds in colonies along coastal Oregon can consume as much as 22 percent of the fish production around their colonies.

If seabirds can sufficiently deplete prey resources around their colonies to compete with other members of those colonies it is reasonable to expect commercial fleets, with the kind of fishing power in which an individual net's catch area encompasses 1.5 acres (Springer 1992), would remove more of their target species and any bycatch from the water column and also deplete prey in their fishing grounds.

Public testimony that several fishermen provided to the NPFMC at its June 2000 meeting provides additional support for concluding that fishing vessels deplete the biomass of groundfish in the action area. While testimony made during a Council meeting is not a substitute for well designed, scientific experiments, the information reported to the Council by fishermen is consistent with the conclusion that highlights the small-scale effects of fishing vessels: the fisheries can cause schooling fish to disaggregate at least over the period of minutes to hours. Fishing causes dense schools of prey species to scatter which affects the foraging behavior of marine mammals and seabirds that target aggregated prey. However, any analysis of this type of effect has to consider how quickly those schools would re-aggregate. Vessel traffic alone may temporarily cause fish to compress into tighter deeper schools or split them into smaller concentrations (Laevastu and Favorite 1988). The passage of one trawl through a school of Pacific whiting was found to create a "hole" in the school due to removal of fish and their avoidance of the gear (Nunnallee 1991). In this study, however, the school structure returned to its pre-disturbance shape and density within tens of minutes after a vessel moved through a school. Repeated trawling by many vessels over several days on fish school structure could make them scatter. Most importantly it could affect Steller sea lion foraging at a local level, although the extent of this effect is not known.

In previous biological opinions, NMFS indicated that rapid removals of large amounts of fish can reduce their densities. If the density of these fish fell below ecological thresholds for predators, prey, and competing species, we called this phenomenon "localized depletion" but did not define the spatial scale for the term (NMFS 1998, 1999). We will continue to use the term "localized depletion," but only to refer to micro- or meso-scale competition. Previous opinions discounted the possibility of macro-scale competition, but we consider that possibility in this analysis.

6.4.2.3 Groundfish depletions at the Action Area or global scale

The FMPs for groundfish in the BSAI and GOA have adopted a management strategy that is designed to reduce the spawning biomass of target fish stocks. As a result of this management strategy, the female spawning biomass of pollock in the BSAI in 1999 was 43% of what it would have been if there had been no fishing during the past two decades, or its unfished level as if fishing had not occurred since 1977. Further, cod was 50%, and Atka mackerel was 66%. In the GOA in 1999, the female spawning biomass of pollock was at 61% of this unfished level, and cod at 57%. For the BSAI in 1999, the combined female spawning biomass for pollock, cod, and Atka mackerel was 45% of the expected unfished level. For all species that can be assessed with age-structured models, the female spawning biomass was 54% of the expected unfished level. For the GOA in 1999, the combination of female spawning biomass for pollock and cod was 59% of the expected unfished level, and 78% for all stocks analyzed with age-structured models.

6.4.2.4 Regional-scale localized depletions of groundfish

As discussed in the Environmental Baseline chapter and previous biological opinions (NMFS 1998a), the groundfish fisheries in the action area have depleted groundfish in large sections of the action area (to an extent greater than the global depletion described above). One example is the Donut Hole fishery for pollock, which was conducted by trawl vessels from Japan, the ROK, Poland, the People's Republic of China, and the former Soviet Union. From the mid-1980s to 1989, annual harvests in the Donut Hole rose to about 1.5 million metric tons from the mid-1980s to 1989. In 1991, the harvest was under 300,000 metric tons and under 11,000 metric tons in 1992, before fishing was suspended in the area in 1993 to allow the stock to rebuild. The fishery has not resumed since 1993 as the stocks are still low in abundance. The historical biomass trend for the pollock stock in the Donut Hole fishery, as measured by the spawning biomass in the Bogoslof area, shows a general declining trend as follows: 2.4 mmt (1988), 2.13 mmt (1989), 1.29 mmt (1991), 0.94 mmt (1992), 0.64 mmt (1993), 0.94 mmt (1994), 1.1 mmt (1995), 0.68 mmt (1996), 0.39 mmt (1997), 0.49 mmt (1998), 0.48 mmt (1999), and 0.30 mmt (2000). In addition, all trial fishing operations since 1997 have encountered little or no pollock in the central Bering Sea.

As in the above cases, fishing may hasten the decline of stocks that are already declining due to natural reasons. Shelikof Strait pollock is an example of this phenomenon (Fritz et al. 1995, National Research Council 1997). A fishery developed after a large spawning aggregation was discovered in the Strait in the late 1970s. Pollock catches in the Gulf of Alaska increased from less than 100,000 metric tons to more than 300,000 metric tons, although harvest rates remained essentially constant and at what was considered a sustainable level. Because of declining recruitment and fishing removals, the exploitable biomass of pollock in the Gulf of Alaska declined from 3 million tons in 1981 to less than 1 million in 1993 (NPFMC 1993).

Localized depletions associated with the Atka mackerel fishery based on in-season changes in CPUE of the Atka mackerel fishery were identified at three BSAI locations (Seguam Bank, Petrel Bank, and Kiska Island) and one location in the GOA from 1992 to 1995. During a review of these fisheries, it was recognized that rates of removal exceeded rates of immigration. Comparing biomass estimates between years, it became apparent that temporary reductions in the sizes of local Atka mackerel populations could affect other Atka mackerel predators, such as the Steller sea lions. Subsequent Leslie depletion analyses were completed for 37 time-area fisheries in 1986-97. The areas analyzed included east and west of Buldir Island, west of Kiska Island, two areas south of Amchitka Island, north of the Delarof Islands, the east side of Tanaga Pass, and south of Seguam Island. With an alpha value of 0.05, a total of 17 of the 37 time-area fisheries yielded statistically significant relationships between cumulative catch and CPUE. The CPUE increased significantly in one case and declined significantly in 16 cases. In general, the greater the total catch in an area, the more likely CPUE declined significantly.

These assumptions appeared to be reasonable for the Atka mackerel fish stock in the central and western Aleutian Islands. Mackerel are found in well-defined habitat and the fishery operates at relatively constant locations. The duration of the fishery is relatively short so that natural mortality and migration into and out of the fish stocks are likely limited. Catchability could change over the course of the fishery, but if such changes occur, say as a result of dispersion or altered schooling behavior, those changes could also have detrimental affects on foraging sea lions. Finally, the use of CPUE as direct measure of fish density or abundance has problems, but CPUE is commonly used as a reliable index of density or abundance.

In this case, the fishery might have resulted in a decreased ability of foraging Steller sea lions to secure enough prey. As a result, in 1999 and 2000, NMFS and the NPFMC made changes to the Atka mackerel fisheries in the BSAI to reduce the potential and intensity of competitive interactions with endangered Steller sea lions. Two fishery exclusion zones were extended from being effective January through April, to the remainder of the year, and the TAC was split into 2 seasons. This had the effect of spatially and temporally dispersing the fishery to prevent localized depletion due to pulse fishing. The TAC was also reduced with a phased-in schedule so that the proportion of catch occurring in Steller sea lion critical habitat would be progressively reduced from nearly 80% of the TAC being taken inside critical habitat to 40% in 2002.

6.4.2.5 Disturbance to groundfish schooling patterns caused by fishing

Sensitivity of listed species to disturbance associated with commercial fishing varies by species, individual, age, sex, season, reproductive state, habitat, and the degree to which they have been sensitized or habituated to disturbance. For example, Calkins and Pitcher (1982) found that disturbance from aircraft and vessel traffic has extremely variable effects on hauled-out sea lions. Sea lion reaction to occasional disturbances ranges from no reaction at all to complete and immediate departure from the haulout area. Johnson et al. (1989) evaluated the vulnerability of Steller sea lions on rookeries and haulouts, and also noted a variable response to noise and disturbance. While sea lions have continued to use some areas after repeated disturbance, they have temporarily or permanently abandoned others (Thorsteinson and Lensink 1962, Kenyon 1962).

With respect to Steller sea lions, the issue of disturbance of foraging patterns has been closely related to the issue of temporal concentration of the fisheries. The concentration of fishing effort into short periods of time may increase the likelihood or intensity of disturbance during the fishery, followed by a period of relatively little or no disturbance. On the other hand, fisheries that are broadly distributed over time may cause a low, but prolonged, level of disturbance. Because temporal concentration may have greater significance in terms of creating localized depletions of prey, new management measures have emphasized the need to disperse the fisheries over time.

The potential for disturbance or interference competition may be more significant when prey resources are concentrated in a small area over a short period of time. Salmon and herring fisheries, for example, tend to occur in pulses to take advantage of the brief availability of prey concentrations. Other predators, including Steller sea lions, may be excluded from foraging opportunities by concentrated fishing activity. This issue will be considered again in the chapter on Cumulative Effects.

Current fishery (and sea lion) management measures do not assume that disturbance effects from fishing on foraging efficiency of Steller sea lions are negligible. The rationale behind establishment of trawl exclusion zones around rookeries in 1991-93, and pollock trawl exclusion zones around haulouts in 1999- 2000, was in part, based on reducing disturbance near important terrestrial habitats. Similarly, dispersal of catch and effort in space and time was intended to both decrease the likelihood of localized depletion and reduce the local intensity of fishing (and its disturbance).   The level of potential competition, and the effects of vessels in, and around, foraging sea lions, seems to be variable.

6.4.2.6 Niche overlap between fisheries and listed species

For the purposes of choosing a suitable marine mammal/fishery case for determining whether niche overlap is significant, we applied the qualitative criteria developed by Lowry et al. (1982). To determine the likelihood and relative severity of indirect effects of fisheries on marine mammals, Lowry established criteria based on each marine mammal's diet (with respect to species consumed, size, and composition of prey), feeding strategy, and the importance of the BSAI as a foraging area. This approach is applicable for adjacent waters such as the GOA because many of the same marine mammals found in the BSAI are found in the GOA as well and their diets are comparable.

Only one of the ESA-listed marine mammal species consumes groundfish species as a large part of their diet and does so in areas coincident with Alaska groundfish fisheries; the Steller sea lion. The remaining species were either distributed across areas not regularly used by groundfish fisheries, or they more often use different prey resources.

An extensive body of analytical work on the potential competitive interactions of Steller sea lions with pollock or Atka mackerel fisheries has been assembled in recent years (e.g., Loughlin and Merrick 1989; Ferrero and Fritz 1994; Fritz et al. (1995); and Fritz and Ferrero 1998). These fisheries were the obvious starting place for analyses of interactions because their target species are the most prevalent items in the diet of Steller sea lions in the GOA and the BSAI, respectively (NMFS 1998). However, there are many other species targeted by the Alaska groundfish fisheries in the BSAI and the GOA that are also eaten by Steller sea lions. The question of how much overlap actually occurs, however, is highly relevant to determining the effects of these fisheries and the FMP process on Steller sea lions. Therefore, we examined the extent to which Steller sea lions rely more on some of these species than others. Further, are those important prey items consumed coincident with the location, timing or pattern of fisheries removals.

The following represents the process used to determine which fisheries may be adversely affecting Steller sea lions and whether or not those affects are likely to jeopardize their continued existence or adversely modify their critical habitat.   Seven questions were posed for each FMP managed fish species in the fishery management areas. If question 1 was answered “No,” then the answers to questions 2-7 were also “No,” so the concern level was nil, thus scoring a “0" total. Steller sea lions did not eat the targeted fish species and no grounds for a competitive interaction existed. If question 1 was “Yes”, it was scored 1 point; remaining questions 2-6 scored 1 point for a “Yes” and zero points for a “No”. If question 7 was yes, it scored 2 points to underscore concern for potential effects of localized depletion.

1. Do Steller sea lions forage on the target fish species?

2. Do Steller sea lions forage on the target fish species at a rate of at least 10% occurrence?

3. If yes to Number 2, does the size of Steller sea lion prey overlap with the size caught by commercial fisheries?

4. If yes to Number 2,does the fishery overlap spatially with the area used by Steller sea lions to forage on this species?

5. If yes to Number 2, Does the fishery operate at the same time Steller sea lions are foraging on the fish species?

6. If yes to Number 2, Does the fishery operate at the same depth range that Steller sea lions are using to forage on the fish species?

7. If yes to 1-6, does that fishery operate in a spatially or temporally compressed manner in Steller sea lion critical habitat?

Steller sea lion food habits data in NMFS (1998, 1999) and NMFS data(unpublished data - results of food habits analyses based on Steller sea lion scat collections) were used for this analysis along with the fishery distribution information in Fritz *et al*. 1998, to answer the above questions. Table 4.5 provides a summary of the scat collections data which typify the overall results.

Results of the rating test (Table 6.6) indicated that nine fishery/Steller sea lion combinations suggested no interactions (i.e., scored "0"), 23 scored "1" or "2" and 5 scored "8", the highest possible point total. Those fisheries with the high scores were pollock (BSAI and GOA, Pacific cod (BSAI and GOA) and Atka Mackerel (AI). We considered those with only scant overlap with the fisheries as indicated by scores of 2 or less to have only limited effects on Steller sea lion forage availability and, as such, do not contribute to jeopardy or adverse modification.

Although the prey item occurrence summary in Table 4.5 was only one of the elements used to determine the degree of competitive overlap between fisheries and Steller sea lions, commentary on the relevance of species with greater than 10% occurrence but low overall scores is warranted. For instance, arrowtooth flounder was found in 22.2% of samples collected in the GOA but it is not flagged as a management concern. This is because this species is not a fisheries target, instead caught as bycatch. Further, the bycatch of arrowtooth is expected to be reduced anyway as a function of measures that reduce the harvest of Pacific cod, one of the principle sources of that bycatch.

In summary, based on best available scientific and commercial data, the fisheries as authorized under the FMPs compete with Steller sea lions for common resources. Fisheries and Steller sea lions both consume pollock, Atka mackerel, and Pacific cod. The high degree of overlap between these fisheries and the foraging needs of Steller sea lions points to competitive interactions on a number of scales or axes. However, the potential for competition at the local scale could be much larger than any of the global effects given the available biomass and large TACs in these regions and the very small areas that we have observed these TACs to be taken.

6.4.3 Effects of global, regional, and local groundfish exploitation: Steller sea lion case study

Our information leads us to believe that fisheries do not compete with other listed species, but may with Steller sea lions. Therefore, an examination of specific interactions between sea lions and the fisheries is warranted.

The scope of this opinion was designed to be comprehensive. Previous biological opinions focused on individual fisheries within the FMPs rather than the whole. Conservation measures and reasonable and prudent alternatives were considered adequate in that context, but in light of this comprehensive analysis on continued fishing authorized by the FMPs and the FMP process considered in this biological opinion, those measures are no longer considered adequate to avoid jeopardizing endangered Steller sea lions and adversely modifying their designated critical habitat.

With respect to competition or niche overlap, the existing conservation measures for listed species (as required by previous biological opinions and the RFRPAs) represent a compilation of efforts intended to partition fisheries from removing prey from Steller sea lion critical habitat, and to disperse fisheries in space and time to reduce their effect on prey availability for foraging Steller sea lions. While these strategies are scientifically sound and defensible, and the analysis in this opinion supports the concept that localized depletion (spatial and temporal factors) may be at the heart of the problem, the application of those measures has not resulted in an improvement in Steller sea lion population response. Even though changes in the population trajectory would not be seen for a decade or more, monitoring of rookeries should have given some indication of improvements, such as increases in pup counts.

6.4.3.1 Specific fisheries which compete with Steller sea lions

Previous biological opinions did not adequately address the effects of fisheries other than those targeting pollock and Atka mackerel. While Steller sea lion diet is dominated by these two species for much of the year, they also consume many other species that are harvested commercially. The current injunction on fisheries inside critical habitat implicates all trawl fisheries, independent of an analysis of their interactions with Steller sea lions (Greenpeace v. NMFS, 106 F. Supp. 2d. 1066) In addition, gear types other than trawl fisheries have also been concluded in this consultation as they are removing groundfish biomass in certain times and areas where Steller sea lions co- occur. Consequently, the scope of this biological opinion and the resulting effects analysis is much broader, and identified the pollock, Atka mackerel and Pacific cod fisheries as competitors with Steller sea lions.

6.4.3.2 Radius of current closure areas around rookeries and haulouts

In 1999, the RFRPAs established pollock trawl exclusion zones for the GOA at 10 nm while those in the eastern Bering Sea were set at 20 nm. The use of different size buffer zones for the two areas was based on the idea that smaller zones (10 nm) were adequate to encompass the adjacent shelf habitat considered to be especially important to Steller sea lions in the GOA.

The efficacy of this approach was analyzed by examining the extent of shallow (<200 m) vs. deep water adjacent to each haulout or rookery identified in the RFRPAs using GIS analysis techniques (NMFS unpubl. report1999). The results indicate that the 20 nm boundaries for the EBS protected most of the shelf waters adjacent to rookeries and haulouts, but that 10 nm areas in the GOA (or in the Aleutian Islands) did not satisfy the original intent of the earlier biological opinion to create no trawling zones that encompassed important shelf waters adjacent to rookeries and haulouts. Rather, the 10 nm pollock trawl exclusion zones allowed for substantial fishing in Steller sea lion critical habitat from 10 to 20 nm where disruptions of the prey field and reduced biomass could affect critical foraging of Steller sea lions in vulnerable life stages. Based on this new information, descriptions of foraging behavior and what little satellite data is available on Steller sea lions as presented in section 4, and the broader consideration of all the groundfish FMPs and the FMP process that is the scope of this biological opinion, the radius of exclusion zones should be expanded to 20 nm to encompass all critical habitat around their rookeries and major haulouts. A precautionary strategy to protect substantial portions of critical habitat is warranted, with less restrictive measures in more expansive and less used habitats in the greater parts of the Bering Sea and Gulf of Alaska.

6.4.3.3 Extent of closure areas across critical habitat

Based on the foraging distribution of Steller sea lions (see section 4.8), NMFS designated critical habitat for the species on August 27, 1993 (58 FR 45269). NMFS used both observations and incidental take of Steller sea lions to determine the appropriate area to list as critical habitat under the ESA. The critical habitat boundary was not intended to include the entire geographic area used by foraging Steller sea lions. As required by the ESA, critical habitat must include only those areas necessary for the conservation of the species. When designating critical habitat in 1993, NMFS acknowledged that other aquatic habitats within their range are essential to Steller sea lions for foraging. Three relatively large foraging areas were also listed as critical habitat in addition to the 20 nm boundaries around listed rookeries and haulouts (i.e., Seguam Pass, the Bogoslof Foraging Area in the southeastern Bering Sea, and Shelikof Strait Foraging Area).

Previous opinions focused on protection of immediate critical habitat around rookeries and haulouts, and placed less emphasis on the outer margins of the 20 nm foraging zones around rookeries or foraging areas. Our understanding of Steller sea lion foraging distribution is based on sightings at sea or observations of foraging behavior (or presumed foraging behavior) in areas such as the southeastern Bering Sea, NMFS unpublished data from the Platform-of-Opportunity Program [POP]), records of incidental take in fisheries, and satellite-linked telemetry studies.

The results of the telemetry studies suggest that foraging distributions vary by individual, size or age, season, site, and reproductive status. Those reports have served as the basis for much of our understanding of Steller sea lion foraging ecology. The early deployments emphasized adult females with pups during the breeding season simply because at the time those animals were most accessible and their status and foraging ecology were of prime interest. Research has focused on animals less than 4 years old during fall through early spring for both NMFS and ADFG deployments. For adult females, the current information suggests that they remain within 20 nm during the breeding season, as well as other seasons if they are nursing a pup. Once the breeding season ends (late July/early August) this general pattern may change. The current tagging data suggests that adult females without pups can forage extensively outside of critical habitat. Although the data are severely limited 55 percent of satellite positions “hits” at sea for this age group from October through December occur outside of critical habitat. Since most of the animals instrumented have been either females or pups, the data may not accurately represent the male portion of the population, which we also believe are much more likely to disperse over larger areas. Finally, the telemetry data available is difficult to interpret regarding the importance of foraging areas outside of critical habitat, because animals must swim a minimum of 20 nm to get out of critical habitat and 20 nm back through critical habitat to get to their destination. In contrast to waters considered critical habitat, the Bering Sea and Gulf of Alaska are large bodies of water allowing for wide dispersal of animals and fish. Consequently, it may be less likely that individual animals and individual fishermen would be concentrated in any one area at any one time.

Based on this entire suite of information, substantial individual variation in distance traveled occurs for foraging Steller sea lions. Overall, the available data suggest two types of foraging patterns: 1) foraging around rookeries and haulouts that is crucial for adult females with pups, pups, and juveniles, and 2) less concentrated foraging that may occur over much larger areas where these and other animals may range to find the optimal foraging conditions once they are no longer tied to rookeries and haulouts for reproductive or survival purposes. Sea lions disperse widely to forage throughout much of the BSAI and the GOA. Such broad dispersal may be essential to sea lion populations to take advantage of distant food resources and, as a consequence, limit intra-specific competition near rookeries and haulouts. The pattern of foraging (as determined from observations) seems to follow the continental shelf break (i.e. the 200 m isobath) suggesting the type of foraging locations preferred as opposed to the need to travel specific distances from rookeries or haulouts. This makes logical sense because the oceanographic conditions along continental shelf breaks tend to be highly productive environments. This continental shelf break foraging areas is consistent with the designated critical habitat zones in the GOA, but extend well beyond critical habitat and designated foraging areas in the BSAI. For that reason, it is necessary to protect significant portions of critical habitat around rookeries and haulouts, and designated foraging areas, in the GOA in a similar manner to those in the BSAI.

6.4.3.4 Temporal dispersion of fishing effort

Currently a patchwork of measures are in place for temporal dispersion of pollock and Atka mackerel fisheries, and none (except those which seasonally allocate halibut bycatch) are in place for Pacific cod fisheries. For pollock in the EBS, there are 4 seasonal harvest limits for pollock inside the Sea lion Conservation Area (SCA). Seasonal harvest limits within the SCA are not required to be taken in the SCA, they are simply limits so that any of the allowance could be taken outside. Outside the SCA, there were only 2 seasons, one which spans the A and B seasons inside the SCA, and the other which spans the C and D seasons. Because the fishery could shift catch from SCA to the area outside of the SCA, in 1999 and 2000 the fishery caught the entire B season SCA allowance (scheduled for release on April 1) outside (available January 20). The roe season results in an economic incentive for fishermen to foregoe taking fish in critical habitat in favor of fishing outside, which would be a positive effect as long as fishing didn’t concentrate right on the edge of critical habitat, forming an impermeable barrier to fish. This resulted in an A-season fishery in 1999 and 2000 that had only marginally more temporal dispersion than in 1998 (Figure 6.15a). In 1999, there was proportionally more pollock caught in late-February and early March than in 1998, but little or no catch beyond mid-March. For pollock in the GOA, the season start dates are January 20, March 15, August 20, and October 1, with 30%, 15%, 30%, and 25% of the pollock TAC assigned to each season, respectively. For Atka mackerel fisheries, the new current management measures implement two seasons. Currently, there are no seasons for Pacific cod fisheries.

6.4.3.5 Consideration of effects at multiple scales

Previous biological opinions and the RFRPAs have considered the impacts of fisheries on only the regional level, or the scale represented by the management area. The RFRPAs for the pollock fishery and the changes made to the Atka mackerel fishery apportion TAC to large management areas (such as 3-digit statistical areas or the SCA) based on the best available estimates of seasonal biomass distribution. However, fishery impacts at smaller scales, such as those of individual foraging sea lions, were not considered in previous opinions to the extent that they we are in this biological opinion. Consideration of the impacts of fisheries at more than one scale (including the FMP scale) is a new feature of this biological opinion.

6.4.3.6 Seasonal vs. year round closures

In previous biological opinions, NMFS closed waters around many of the rookeries and haulouts only on a seasonal basis. NMFS has recognized that the sensitivity of sea lions to competition from fisheries may be exaggerated during certain times of the year. Reproduction likely places a considerable physiological or metabolic burden on adult females throughout their annual cycle. Following birth of a pup, the female must acquire sufficient nutrients and energy to support both herself and her pup. The added demand may persist until the next reproductive season, or longer, and is exaggerated by the rigors and requirements of winter conditions. The metabolic requirements of a female that has given birth and then become pregnant again are increased further to the extent that lactation and pregnancy overlap and the female must support her young-of-the-year, the developing fetus, and herself. And again, she must do so through the winter season when metabolic requirements are likely to be exaggerated by harsh environmental conditions. Results from research support, and our previous management actions recognize, that the winter period is a time of great metabolic demands and prey requirements. However, changes in behavior, foraging patterns, distribution, and metabolic/physiologic requirements during the Steller sea lion annual cycle are all pertinent to consideration of the potential impact of prey removal by commercial fisheries. Steller sea lions, at least adult females and immature animals, are not like some marine mammals that store large amounts of fat to allow periods of fasting. Rather, they need more or less continuous access to food resources throughout the year.

This transition of pups from their mothers to nutritional independence is likely confounded by a number of seasonal factors. Weaned pups are independent of their mothers, but may not have developed adequate foraging skills. They must learn those skills, and their ability to do so determines, at least in part, whether they will survive to reproductive maturity. Seasonal changes may severely confound foraging conditions and requirements, and may be accompanied by changing prey concentrations and distributions, and activities of the fisheries around foraging areas. Spring is also important as pregnant females will be attempting to maximize their physical condition to increase the likelihood of a large, healthy pup (which may be an important determinant of the subsequent growth and survival of that pup). Similarly, those females that have been nursing a pup for the previous year and are about to give birth may wean the first pup completely, leaving that pup to survive solely on the basis of its own foraging skills. Thus, food availability is surely crucial year-round. For that reason, there is a recognized need to protect foraging areas for sea lions on an annual basis, rather than seasonal as recommended in previous biological opinions.

6.4.3.7 Distribution of catch outside closed areas in the EBS

Critical habitat was in part defined as those waters within 20 nm of rookeries and haulouts, and some more distant areas, that contained features, principally fish, that were “critical” to the survival and recovery of Steller sea lions. However, the extent of critical habitat is not, and by law cannot, be the entire geographic area over which the species ranges (see discussion above). There is a large body of evidence, principally from the Platform of Opportunity database, that Steller sea lions forage well beyond the bounds of critical habitat. In the EBS, there are numerous recent (1990s) sightings of Steller sea lions on the expansive outer continental shelf to the north and west of the SCA, Based solely on fish distribution, it could be expected that Steller sea lions would forage throughout this area. In the summer, approximately half of the pollock and Pacific cod adult biomass is located west of 170W, and a considerable proportion of juvenile biomass of both species is located there as well. However, implementation of the AFA, thanks to fishermen cooperatives, has resulted in a much more evenly distributed fishery along the entire continental shelf edge in the Bering Sea.

Effects of the AFA on temporal and spatial dispersion

Pre-AFA. In the years up to and including 1998, the BSAI pollock fishery was characterized by an open access race for fish within the inshore and offshore sectors of the fishery. The seasons were of limited length as vessels raced to catch their quota. The pollock roe fishery on the Eastern Bering Sea shelf had been concentrated primarily north and west of Unimak Island. There also had been A season effort along the 200 m contour between Unimak Island and the Pribilof Islands (through 1999). This concentrated catch associated with productive areas surrounding oceanographic features such as the 200 m curve may have resulted in localized depletions of pollock (Appendix 4). This is particularly true in the area just north of Unimak Island in late-January through mid-February and to a lesser extent in the area surrounding the 200 m curve southeast of the Pribilof Islands (near Pribilof Canyon) in early February and again in early March.

Post-AFA In the 2000 pollock fishery, approximately 98 percent of the pollock TAC was allocated to cooperatives (or CDQ groups), and RPAs were in place to disperse effort temporally and spatially, in order to protect Steller sea lions. The 2000 Steller sea lion protection measures were somewhat modified from 1999. The fishery inside the SCA was divided into four seasons. The first two seasons, the A and B season began on January 20 and April 15, respectively. Two non-roe seasons, the C and D season began on June 10 and August 20, respectively. The fishery outside the SCA was divided into just two seasons the A/B season roe fishery and the C/D season non-roe fishery. Catch rates decreased as each cooperative harvested its individual allocation making inseason closure notices unnecessary in fisheries other than the small remaining open access inshore fishery which accounted for approximately 2.5% of the TAC.

Appendix 4 illustrates minimal concentrations of catch in the horseshoe area north of Unalaska Island and in the area northwest of Unimak Island during the 2000 A/B season. However, in general, effort appears to be dispersed throughout critical habitat and the areas to the northeast. Examination of the fishery in 10-day fishing periods indicate similar dispersed patterns of fishing with no concentrated effort in any of the 10-day periods. No consistent pattern emerges throughout the season; the fishery appears to be prosecuted in several areas in each of the periods. Animated maps showing fishing patterns in 10-day periods are displayed on the NMFS AFSC web site: www.refm.noaa.gov/stocks/cpue/ebharvests.html.

The incentives to disperse fishing effort for BSAI pollock under the AFA, along with other measures like seasonal allocations of TAC, are expected to continue to disperse fishing in the future.

6.4.3.8 Aleutian Islands closure

As part of the RFRPAs, NMFS closed the Aleutian Islands area to all directed fishing for pollock. This aspect of the RFRPAs was adopted by NMFS after it had been initially proposed by the NPFMC. While the merits of such a regulation were not described in any detail in the description of the RFRPAs, the NPFMC had intended that the closure of the Aleutian Islands for pollock fishing be used as part of an experiment to assess the efficacy of the RFRPAs. However, as noted earlier in this biological opinion, a majority of the fishing effort in the Aleutian Islands region is directed at species other than pollock, and in particular is directed at Atka mackerel and Pacific cod. Both of these latter two species are important prey items in the diet of Steller sea lions that forage in the vicinity of the Aleutian Islands. Therefore, NMFS has concluded that a closure of the Aleutian Islands region to only pollock fishing is an inappropriate method for conducting research on the question of whether the RFRPAs are effective. Finally, there are no data to suggest that the Aleutian Islands region represents a unique segment of the sea lion population in western Alaska or a segment of the population that, if protected, would improve the prospects of recovery for sea lions in Alaska.

6.4.3.9 Ongoing assessment of management efficacy

Steller sea lion protection measures implemented to date do not provide mechanisms to facilitate assessment of their efficacy. In essence, evaluation of success was based solely on observation of long term trends in Steller sea lion population. While providing measures adequate to avoid jeopardy and adverse modification, NMFS has agreed to develop a monitoring project that allows evaluation of the management measures and the identification of population response triggers that would facilitate future actions.

6.4.3.10 Analysis of Steller sea lion prey requirements

There is considerable uncertainty in trying to predict the spatial and temporal distribution of prey species of Steller sea lions in the GOA and the BSAI. Assessment surveys in the BSAI or GOA areas for commercially valuable groundfish are typically done annually or tri-annually. Almost exclusively, these surveys have been conducted in the summer months. Data from these surveys form the basis of the stock assessments reported in the annual SAFE reports. Unfortunately, survey-based estimates of prey abundance on a time and spatial scale adequate to predict the availability of forage to Steller sea lions (e.g., monthly) are not available. Nonetheless, it is possible using the available survey data, commercial catch data, and life history data to estimate biomass in Steller sea lion critical habitat on a monthly basis for three important prey species of the western stock of Steller sea lions (i.e., pollock, Atka mackerel, and Pacific cod) (see NMFS 2000; Appendix 3).

First of all, the ESA requires NMFS to insure that any action it authorizes does not jeopardize listed species or adversely modify their critical habitat. Although this analysis provides a reasonable answer to the question of the amount of forage necessary for Steller sea lions, it does not address the issue of adverse modification of critical habitat. The analysis searches for a ratio between total biomass and the amount consumed by sea lions so that any ratio above a certain threshold would indicate adequate forage is available – in effect it would draw a jeopardy line based on the relative availability of prey. Thus, given the ratios determined in the analysis, the "surplus" is high enough to allow unrestricted fishing up to the TAC in all seasons. However, using the most precautionary data, the results indicate a potential shortage of prey during at least one month of the year and it doesn't deal specifically with the question of localized availability of prey raised in earlier discussions. Consequently, even though a surplus is available, adverse modification may still be possible unless other measures are used to spatially or temporally disperse the fisheries. This approach would be strengthened with the addition of the following types of groundfish biomass information using surveys:

- Seasonal "global" groundfish biomass estimates using surveys,

- Spatial groundfish biomass estimates on the scale of critical habitat, and

- "Local" groundfish biomass estimates to determine the biomass available to Steller sea lions on a scale important to the species (i.e. around a particular rookeries, haulouts, or assemblages).

This approach also suffers from limited data on the foraging requirements of Steller sea lions. Two different foraging rates based on published results were presented in the analysis. However, given the uncertainty that this method can insure with the current state of knowledge that the proposed action will avoid adverse modification of critical habitat, other changes to the current management regime would be necessary to be precautionary for Steller sea lions and avoid adverse modification of critical habitat.

6.4.3.11 The California sea lion: a case study

Insight into interactions between Steller sea lions and the Alaskan groundfish fisheries might be gained by analysis of similar pinniped species in different systems. California sea lions are closely related to Steller sea lions; both are in the family Otariidae, both inhabit the North Pacific ocean, and both reside in areas that have extensive groundfish fisheries. While Steller sea lions have declined 80-90% in the last 30 years, California sea lions have been increasing at over 8% per year since 1983 (Baraff 1999). Furthermore, since the mid-1980s, many groundfish species along the US west coast (California, Oregon, and Washington) have declined dramatically, causing severe fishery restrictions for many rockfish and flatfish species. The one west coast groundfish fishery that has remained relatively robust through the 1990s is that for Pacific whiting (also known as hake). Hake is also a gadid, like walleye pollock and Pacific cod, and is an important element of the diet of California sea lions. Baraff and Loughlin (1999) and Baraff (1999) recently reviewed the potential for interaction between California sea lions and the hake fishery along the west coast. Their findings are briefly reviewed here and compared with the Steller sea lion-Alaskan groundfish fishery case that is the subject of this biological opinion.

While it is clear the California sea lions eat Pacific whiting, there are distributional differences in the patterns of the fishery and of sea lion foraging on whiting that reduce the potential for competitive overlap (Baraff and Loughlin 1999; Baraff 1999). The most important distributional difference may be that the fishery, which has been prohibited south of 39˚N since 1977, does not overlap at all with the entire range of female California sea lions, their pups, and most juveniles. This is also the area of highest estimated sea lion consumption of whiting by California sea lions, primarily juvenile whiting ages 1-3. The only potential for competitive overlap between the fishery and California sea lions is with the southward migration of males in April-June prior to the breeding season. During the remainder of the year, and for the portions of the population that would be most sensitive to prey availability (females and juveniles), there is little or no competitive overlap between the whiting fishery and California sea lions.

These patterns of whiting fishery distribution off the US west coast and California sea lion foraging on whiting contrast sharply with those observed for the pollock, Pacific cod and Atka mackerel fisheries off Alaska and Steller sea lion foraging on these species. The distribution of these Alaskan groundfish fisheries overlaps considerably with the range of the entire population of Steller sea lions, but particularly the foraging ranges of females and juveniles. Furthermore, the sizes and ages of fish targeted by both fisheries and Steller sea lions are similar. These two case studies show that the potential for competitive overlap between groundfish fisheries and pinnipeds must be examined carefully and individually.

6.5 Indirect Effects of the FMPs on Listed Species and their Environment

As we discussed in the Environmental Baseline chapter of this opinion, commercial fisheries can have numerous indirect effects that include social effects, economic effects, physical effects, chemical effects, and biotic effects. Other indirect effects of commercial fisheries include the industrial infrastructure that processes the catch and delivers the catch to markets. Fisheries can also have indirect biological effects that occur when fisheries remove large numbers of target species and non-target species (bycatch) from a marine ecosystem. These removals can change the composition of the fish community with associated effects on the distribution and abundance of prey organisms (Garrison and Link 2000). Fishery removals have the potential to remove and redirect energy, alter predator/prey relationships and community structure, and change diversity.

The social and economic effects of the Alaska groundfish fisheries in the Bering Sea, Aleutian Islands, and Gulf of Alaska are beyond the scope of this biological opinion; they will be addressed in the Environmental Impact Statement that is being prepared on the FMPs (NMFS in prep.). Instead, the following sections of this chapter will focus on the primary effects of the fisheries on water quality and the biology of the marine ecosystem.

6.5.1 Effects on water quality

Most of the groundfish caught by shore-based vessels will be processed in seafood processing facilities in the action area. The Environmental Baseline chapter of this biological opinion discussed the seafood processing facilities that have been associated with the groundfish fisheries. As discussed in the baseline, concern about the effects of fish-processing on water quality in Alaska has dated to the 1800s, but it became a public policy issue after water quality deteriorated in coastal areas. However, the adverse effects of this material tend to be highly local and usually depend on flushing rates and dispersal regimes of the receiving waters. When discharges exceed the dispersion and biodegradation rates of the receiving waters, they can build up, increase the biological oxygen demand of the receiving waters, and can produce noxious smells. The waste can cause receiving waters to become anoxic, can elevate ammonia levels, can smother benthic organisms, and attract scavengers such as gulls or rodents, which may cause public health problems.

In 1998, the AKDEC and EPA established TMDLs for Udagak Bay (Beaver Inlet on Unalaska Island in the Aleutian Islands) and King Cove lagoon in King Cove (on the Alaska Peninsula in the Aleutians East Borough) because of the effects of seafood wastes on water quality in those water bodies (EPA 1998a, 1998b). In Udagak Bay, the AKDEC concluded that the Northern Victor Partnership facility *P/V Northern Victor* produced seafood processing wastes (from Pacific cod, Pacific halibut, herring, walleye pollock, salmon, and a variety of other fish) that created a waste pile deposit of settled solid residues measuring at least 2.4 acres in area and 7 feet thick on the seafloor. ADEC concluded that the waste pile exceeded Alaska’s water quality standards for residues. For King Cove, the (ADEC) concluded that the Peter Pan Seafoods facility created a waste pile covering 11 acres of seafloor to an average depth of 3 feet.

In 1998, AKDEC's list of impaired waters also included six additional water bodies in Cold Bay, Dutch Harbor, and Kodiak that had been impaired by seafood processing, logging operations, military materiel, or fuel storage. Although total maximum daily loads have not been developed for these facilities, the effects of these facilities appear to be localized and are not expected to adversely affect threatened or endangered species under NMFS’ jurisdiction.

In addition to the facilities that have been associated with impaired waters, the Alaska Division of Environmental Health, Seafood Processing and Development issues permits to seafood processors in four general categories: canneries (retort processors), land-base processors, vessel processors, and direct-marketing processors (Table 6.7). Each of these facilities produce fresh, frozen, salted, or formulated seafood products aboard a large, floating vessels, with associated. The Alaska Division of Environmental Health is primarily concerned with ensuring that facilities do not contaminate food sources and that facilities properly manage sewage and waste.

In addition to the facilities listed in Table 6.7, the State of Alaska also issued seafood processing permits to land-based processors in Emmonak,, False Pass, Nikiski, Nome, St. Paul, Sand Point, Savoonga, Soldotna, Toksook Bay, and Whittier, Alaska. In addition, the State of Alaska issued permits to a large number of vessel processors from other states; vessel-based processors located in Seattle, Washington, constituted the majority of these processors. The effects of these facilities appear to be localized and are not expected to adversely affect threatened or endangered species under NMFS' jurisdiction.

Discards and offal production can cause local enrichment and change in species composition if discards or offal returns are concentrated there. Some evidence of those effects have previously been cited (Thomas, 1994) in areas with inadequate tidal flushing (Orcas Inlet in Prince William Sound and in Dutch Harbor) but not in the deepwater disposal site in Chiniak Bay of Kodiak Island (Stevens and Haaga, 1994). Local ocean properties (water flow and depth) and amount of water discharged per year could be important factors determining the effect of nearshore disposal on local marine habitat and communities. Changes to the processing plant at Dutch Harbor have dramatically reduced the amount of offal and ground discards discharged. Improved retention could be causing some increases in the amount of local enrichment due to disposal of increased offal from shoreside processing of newly retained fish. However, increase in offal production for the Bering Sea if all pollock, cod, rock sole and yellowfin sole were to be retained would amount to an increase of about 6% and likely would not cause a change in water quality.

With regards to listed species, therefore, it is not believe that water quality in the Action Area is impacted in such a manner that it would jeopardize listed species, or adversely modify critical habitat for Steller sea lions in a manner that would diminish its value for both survival and recovery of that species.

6.5.2 Effects on benthic habitat

Groundfish are generally associated with ocean bottoms. For example, in the action area, Pacific ocean perch and other rockfish use sea floor habitats for cover and foraging. In the pursuit of groundfish species, the fleet uses bottom trawl, pot, or longline gear that may have physical effects that damage or degrade sea floor habitat. In particular, trawls have had documented effects on sea floor habitat and biotic communities associated with that habitat. Trawls can increase turbidity that is likely to reduce or eliminate epifaunal communities. Epifauna often play key roles in influencing the structure and stability of benthic communities. They can modify benthic boundary flow characteristics which further influence sediment characteristics and the deposition of larvae. These organisms increase the diversity of sea floor habitat that provide refuges for different life stages of fish species, including fish species that are commercially harvested. De Groot (1984) and Jones (1982) report that concern about the effects of trawls on benthic communities dates from the late 1300s.

Despite this long history of concern, there has only recently been a focus on studying the effects of trawls on benthic habitats and communities. Riemann and Hoffmann (1991) and Jones (1992) reported that trawls adversely affect sea floor habitats by scraping and ploughing the bottom to depths of 30 cm as well as resuspension of sediment and destruction of bottom communities. Bergman and Hup (1992) report that a beam trawl gouges the sea floor to depths of at least 6 cm and the boards of otter trawls can create gouges as deep as 15 cm. They provided lists of benthic organisms that experience population reductions ranging from 10 to 65 percent.

Auster and Langton (1998) reviewed the indirect effects of fishing on essential fish habitat. They indicated that all studies reviewed revealed immediate effects of fishing on species composition and diversity and a reduction of habitat complexity. Short-term effects were a good indicator of long-term effects, and recovery was variable depending on habitat type, life histories of component species, and the natural disturbance regime. They also wrote that data are lacking on the spatial extent of fishing-induced disturbance, the effects of specific gear types along a gradient of fishing effort, and the linkages between habitat characteristics and the population dynamics of fishes. Trawling on sea floor habitat and benthic communities in the GOA generally disturb sea floor habitats by displacing boulders, removing epifauna, decreasing the density of sponges and anthozoans, and damaging echinoderms. However, the effect of this disturbance on fish and other living marine resources is not known.

The Ecosystems Considerations sections of the annual SAFE reports have expressed concern about the potential effects of gear on bottom habitat, but information on those effects is still very limited. Nevertheless, the current condition of bottom habitat in these regions cannot be described with sufficient detail to evaluate the overall effect of fishing gear on bottom habitat and associated marine communities.

In April 2000, the Council adopted part 1 of the HAPC initiative as Amendment 65/65 to the Bering Sea/Aleutian Islands and Gulf of Alaska groundfish FMPs. These amendments will define all corals and sponges as prohibited species. The purpose of these amendments are to prohibit a commercial fishery from developing on invertebrates that provide important habitat for fish. Retention for personal use would be allowed, but the sale, barter, trade of corals and sponges would be prohibited. Implementation into regulation is expected early in 2001.

6.5.3 Effects on the ecosystem

The groundfish fisheries in the Bering Sea, Aleutian Islands, and Gulf of Alaska have direct effects on fish population structure through the changes in the growth, mortality, production, and recruitment of target fish populations and species caught as bycatch that result from fishery removals from individual populations. Removing target species and species caught as bycatch could also have indirect effects on other members of the marine ecosystem by changing predator/prey relationships and community structure, biomass removal and redirection, and diversity.

The status quo groundfish fishery management regime has reduced spawning biomass for 17 individual groundfish stocks, on average, to about 59% of the equilibrium unfished level of those stocks. In general, fishing has the potential to influence ecosystems in several ways. Fishing may alter the amount and flow of energy in an ecosystem by removing energy and altering energetic pathways though the return of discards and fish processing offal back into the sea. The recipients, locations, and forms of this returned biomass may differ from those in an unfished system. Selective removal of species and/or sizes of organisms has the potential to change predator/prey relationships and community structure. Fishing can alter different measures of diversity. Species level diversity, or the number of species, can be altered if fishing essentially removes a species from the system. Fishing can alter functional or trophic diversity if it selectively removes a trophic guild member and changes the evenness with which biomass is distributed among a trophic guild. Certain species, such as walleye pollock, are at a central position in the food web and their abundance is an indicator of prey availability for many species. Fishing can alter genetic level diversity by selectively removing faster growing fish or removing spawning aggregations that might have different genetic characteristics than other spawning aggregations. Fishing gear may alter bottom habitat and damage benthic organisms and communities.

A great deal of literature has been written on possible indicators of ecosystem status in response to perturbations (e.g., Odum 1985). These indices can show changes in energy cycling and community structure that might occur due to some external stress such as climate or fishing. For example, fisheries might selectively remove older, more predatory individuals. Therefore, we would expect to see changes in the size diversity spectrum (the proportion of animals of various size groups in the system), mean age, or proportion of r-strategists (faster growing, more fecund species such as pollock) in the system. These changes can increase nutrient turnover rates because of the shift towards younger, smaller organisms with higher turnover rates. Total fishing removals and discards also provide a measure of the loss and re-direction of energy in the system due to human influences. Total fishing removals relative to total ecosystem energy could indicate the importance of fishing removals as a source of energy removal in an ecosystem. Changes in scavenger populations that show the same direction of change as discards could be an indicator of the degree of influence discards have on the system. Discards as a proportion of total natural detritus would also be a measure that could indicate how large discards are relative to other natural fluxes of dead organic material. Levels of total fishing removal or fishing effort could also indicate the potential for introduction of non-native species through ballast water in fishing vessels. Fishing practices can selectively remove predators or prey. Tracking the change in trophic level of the catch may provide information about the extent to which this is occurring. Thus, we will use measures of total catch, total discard, and information about the changing mean size of organisms to indicate the potential of each of the present groundfish fishery management regime to impact ecosystem energy flow and turnover.

Total catch and trophic level of the catch will also provide information about the potential to disrupt predator/prey relationships via fishing down the food web through selective removal of predators. An important factor affecting the trophic base is spatial distribution of the food. We will evaluate these factors to determine the potential of the present groundfish fishery removal levels to disrupt predator/prey relationships.

The scientific literature on diversity is somewhat mixed about what changes might be expected due to a stressor. Odum (1985) thought that species diversity (number of species) would decrease and dominance (the degree to which a particular species dominated in terms of numbers or biomass in the system) would increase if original diversity was high while the reverse might occur if original diversity was low. Genetic diversity can also be altered by humans through selective fishing (removal of faster growing individuals or certain spawning aggregations). Accidental releases of cultured fish and ocean ranching tends to reduce genetic diversity. More recently, there is growing agreement that functional (trophic) diversity might be the key attribute that lends ecosystem stability. This type of diversity ensures there are sufficient number of species that perform the same function so that if one species declines for any reason (human or climate-induced), then alternate species can maintain that particular ecosystem function and we would see less variability in ecosystem processes. However, measures of diversity are subject to bias and we do not really know how much change in diversity is acceptable. Nonetheless, we suggest possible impacts that the present federal groundfish fishery management regime may have on various diversity measures.

Quantitative measures of some of the indicators mentioned above have been summarized to show the projected change in the next five years under the present groundfish fishery management system. These include total catch, trophic level of the catch, total discards, total groundfish biomass, diversity (Simpson's richness index), trophic level of groundfish biomass, and amount of pollock or other forage for the BSAI and GOA . We will address the possible impacts of the present fishery management regime on (1) predator/prey relationships, (2) energy flow and redirection [through fishing removals and return of discards to the sea], (3) diversity, and (4) competition.

6.5.3.1 Predator/ prey relationships and cascade effects

In an ecosystem, removing or reducing the size or age structure of one population will affect other populations in the ecosystem, which will respond to changes in predator-prey dynamics, the availability of resources, or to changes in the size of other populations in the ecosystem. If the species that is removed is relatively high in the trophic structure of an ecosystem, the effects of that removal can "cascade" through an ecosystem.

Clear indications of cascading effects of fishing are discussed by Pauly (1988) who reviews an example of an indirect effect of a destructive demersal fishery in the Gulf of Thailand. Pauly (1988) documented the collapse of target species, the virtual disappearance of rays and sawfish as a result of both bycatch and the loss of their food base, accompanied by a subsequent increase in snappers and squid. There seems to be a pattern in tropical demersal fisheries in which the reduction of the target stock is followed by an increase in squid, probably because the demersal eggs and very young of the squid are released from predation.

Evidence from other ecosystems presents mixed results about the possible importance of fishing in causing population changes of the fished species' prey, predators, or competitors. Some studies showed a relationship, particularly for heavily fished areas, while others showed that the changes were more likely due to direct environmental influences on the prey, predator or competitor species rather than a food web effect. Thus, fishing does have the potential to impact food webs but each ecosystem must be examined to determine how important it is for that ecosystem.

Fisheries could alter the composition of the BSAI and GOA ecosystems in a number of ways, including enhancement of a prey species by removal of a predator, enhancement of one competitor by removal of another, and suppression of a predator by removal of prey. Examples of such effects may be more common for terrestrial species, but such effects are also observed in aquatic ecosystems. In addition to direct removal or reduction of a species, indirect consequences may accrue depending on the role of the species removed (e.g., keystone predator) and the method of removal (e.g., bottom trawling). For example, a recent report by Estes et al. (1999) suggests that killer whale predation has shifted from a diet that did not include sea otters prior to the 1990s to one that now includes sea otters. Barrett-Lennard et al. (1995) concluded that killer whale predation on a population of approximately 50,000 Steller sea lions could be one of the factors contributing to the current decline in abundance of Steller sea lions. At a minimum, we have to recognize the possibility that predation in the BSAI and GOA by killer whales on Steller sea lions, may be one of several factors inhibiting the current rate of recovery.

In the Environmental Baseline chapter, we described the dramatic changes that have occurred at the upper trophic levels of the marine ecosystem in the action area, partially caused by more than 200 years of commercial exploitation by fisheries. It would be reasonable to expect that dramatic reductions in the size of the cetacean populations in the BSAI and GOA would have effects similar to those reported from the Southern Ocean and cascade through the marine ecosystem of the action area. The extinction of Steller sea cows in the mid-1700s, had unknown impacts of the coastal and marine ecosystem of the action area, although the extinction of a species that consisted of such large animals would have had a significant effect on the structure of the coastal ecosystem. The reduction of bowhead and right whales in the Bering Sea in the 1800s could have made millions of tons of zooplankton available to other members of the marine ecosystem at that time, possibly with corresponding increases in their population size. The reduction of the fur seal population of the Pribilof Islands in the early 1800s, again, in the early 1900s, and a third time since the 1950s would have increased the biomass of their prey base. Similarly, the drastic reductions of blue whales, fin whales, humpback whales, and sei whales in the 1950s and 1960s would have made millions of tons of euphausiids and copepods available to other members of the marine ecosystems.

It would be impossible to determine which species benefitted from the biomass that became available to the marine ecosystem of the Bering Sea, Aleutian Islands, and Gulf of Alaska when almost 350,000 large whales were killed in the North Pacific over a 30-year period. Populations of planktivores like walleye pollock, Pacific cod, lanternfish, squid, sand lance, capelin, least auklet (*Aethia pusilla*), crested auklets (*A. cristatella*), and parakeet auklets (*Cyclorrhynchus psittacula*) could have benefitted from the depletion of baleen whales in the region. For the same reasons, populations of species like Risso's dolphin, Dall's porpoises, bottlenose whales, and beaked whales could have benefitted from the depletion of sperm whales in the region. The NRC (1996) believed the dramatic increase in the abundance of pollock during the 1960s was linked, in some way, to the overexploitation of pinnipeds, cetaceans, and fish during the 1950s and 1960s. Although we can be fairly certain that the reductions in marine mammal populations in the 1800s and the 1950s to 1960s changed the structure and composition of the biotic community of the action area, it is impossible to determine how the community changed.

Since the 1960s, commercial exploitation of groundfish in the action area has significantly reduced populations of some target species and species caught as bycatch. Over time, but prior to the present fishery management regime, prior to the NPFMC and prior to the current FMPS which are being considered in this biological opinion, the fisheries have depleted or overfished yellowfin sole, Pacific Ocean perch, sablefish, walleye pollock, and Pacific halibut. These depletions may have subsequently affected other members of the groundfish community and the marine ecosystem although the direction or significance of such indirect effects cannot be determined. However, under the present FMP and current fishery management regime, these depleted fish stocks have increased. Within a fished community, species that are long-lived, have delayed maturity, grow slowly, and have low reproductive output are more susceptible to the direct effects of fishing than faster-growing species with early maturity. As a result, it is reasonable to expect species like Pacific Ocean perch, sablefish, and other rockfish to take longer to recover from the historical effects of fishing, which could potentially affect the structure of the marine community for longer periods of time.

Evaluation of the present fishery management regime in the last 20 years does not show such dramatic reductions of individual populations that occurred previously. Most of the work evaluating predator/prey relationships in the EBS/AI and GOA regions in recent years has been done in the eastern Bering Sea. Evidence from retrospective and modeling studies (Hollowed et al. 1998, Livingston and Jurado-Molina, 2000) and examination of trophic guild changes (Anderson and Piatt, 1999; Livingston et al., 1999) suggest that under the present groundfish fishery management regime, there has not been clear evidence of fishing as the cause of species fluctuations through food web effects. Multispecies models have shown that although cannibalism can explain a large part of the density dependent part of the stock recruitment relationship for pollock (that is the decline in recruitment observed at high spawner biomasses), that most of the overall variability in stock and recruitment for pollock is not explained by predation but appears to be more linked to climate events (Livingston and Methot 1998).

Pollock is a key prey species of many target and nontarget species in the Bering Sea and Gulf of

Alaska (Livingston 1989, 1994) and has a central position in the food webs of those ecosystems. Modeling of predation on pollock in the eastern Bering Sea and Gulf of Alaska (Livingston and Methot 1998, Livingston and Jurado-Molina 2000, and Hollowed et al. 2000) shows that different predators may be the most important source of predation mortality during different time periods. For example, Steller sea lion predation on pollock in the Gulf of Alaska was more important in earlier years but the most important contemporary source of predation mortality on pollock is now from arrowtooth flounder. Population levels of some of these predators such as arrowtooth flounder appear unrelated to fishing removals but are more linked to environmental forces that favor the production of these species (Hollowed et al., 1998). Similarly, the fluctuations observed in species composition of trophic guilds (Livingston et al. 1999) do not appear to be related to fishing removals of competitors or prey, when analyzed at the aggregated level for the whole eastern Bering Sea. Measures of pelagic forage abundance under current fishing practices indicate in the short term that from 2001 to 2005, that the fraction of pollock in the total groundfish biomass is predicted to increase 6% in the BSAI and 29% in the GOA, in the short term. Pollock biomass is predicted to increase 12% and 47% , respectively in these areas. Stability of trophic level of the groundfish biomass and trophic level of the groundfish catch also indicate there has not been a large change due to fishing in the groundfish community structure. These have been relatively steady over the last 20 years and do not indicate successive depletion of populations or fishing down the food web effects observed in more heavily fished ecosystems of the world. This assessment is supported by the stock trajectories shown in Figure 6.16. The stock trajectory in both fished and unfished scenarios indicate similar trends. Some species have shown strong increases even when fished and declining fished stocks also declined when no fishing was assumed, although the absolute biomass level was different.

6.5.3.2 Effects on energy flow and balance

As mentioned earlier, fishing may alter the amount and flow of energy in an ecosystem by removing energy and altering energetic pathways through the return of discards and fish processing offal back into the sea. The recipients, locations, and forms of this returned biomass may differ from those in an unfished system.

A mass-balance model of the eastern Bering Sea (Trites et al. 1999) provides some information on fishing removals relative to total system production and the distribution of biomass and energy flow throughout the system in recent times. The trophic pyramids (distribution of biomass at various trophic levels) for the eastern Bering Sea ecosystem in the 1950's before the large groundfish fishery removals occurred and during the 1980's when the groundfish fishery was operating, indicate that biomass and energy flow are distributed fairly well throughout the system (see p. 28 of Trites et al. 1999). Apex predators at trophic level four do not contribute much to the biomass of the eastern Bering Sea in both time periods and most flows are contained in the lower three trophic levels. Differences in species composition of the biomass of trophic level three and four were estimated from available data and show more flows involving small pelagic fish relative to pollock in trophic level three in the 1950s and more flows through large flatfish in the 1980s in trophic level four. Although there is evidence that small pelagic fish have been more available in certain periods in the eastern Bering Sea, there is still uncertainty about the historical levels of pollock abundance prior to research surveys, which began around 1979, which could influence these views of relative contributors to the flow among trophic levels.

These mass-balance models show that the Bering Sea is a more mature (less disturbed) system compared to other shelf systems. A more mature system is one that is less disturbed according to

Odum (1985). Total catch biomass (including non-groundfish removals) as a percentage of total system biomass (excluding dead organic material known as detritus) was estimated was estimated to be 1%, a small proportion of total system biomass. Fishery removal rates are based in the most basic sense on the amount of surplus production (the excess of reproduction and growth over natural mortality) (Hilborn and Walters 1992) for fish stocks. Because there is great variability among stocks with regard to the amount of this excess production, it is likely more important that removals stay within the bounds of each individual stock's excess production (a topic that is considered in the individual stock impacts sections). From an ecosystem point of view, total fishing removals are a small proportion of the total system energy budget and are small relative to internal sources of interannual variability in production.

Fisheries can re-direct energy in the system through discarding and return of fish processing wastes to the system. These practices take energy and potentially provide them to different parts of the ecosystem relative to the natural state. For example, discards of dead flatfish or small benthic invertebrates might be consumed at the surface by scavenging birds that would normally not have access to those sources of energy. An analysis of the importance of these fisheries practices on the BS/AI and GOA ecosystems was conducted by Queirolo et al. (1995), before the improved retention requirements for pollock and cod were mandated. Total offal and discard production at that time was estimated at only 1% of the estimate of unused detritus already going to the bottom. No scavenger population increases were noted that related to changes in discard or offal production amounts. The annual consumptive capacity of scavenging birds, groundfish and crab in the eastern Bering Sea was determined to be over ten times larger than the total amount of offal and discards in the BS/AI and GOA. Finally, it appeared that the main scavengers of the fish processing offal, which primarily consisted of pollock, were also natural pollock predators. Thus, energy flow paths did not seem to be re-directed in a large way due to offal and discard production by groundfish fisheries.

Discard rates have dropped even further since the implementation of retention requirements for all pollock and cod in groundfish fisheries. Managed groundfish species discards dropped below 10% of the total catch (down from about 15% in the EBS/AI and 20% in the GOA, respectively) in 1998. The mandated retention of managed flatfish species (yellowfin sole and rock sole in the BS/AI and shallow water flatfish in the GOA) in 2003, which make up the bulk of the remaining discards of managed species, may cause the total discard amounts to decrease 28% in the BSAI in the present groundfish fishery management regime from the year 2001 to 2005. Total discards in the GOA are estimated to increase 3% in the status quo regime from 2001 to 2005 because shallow water flatfish are not a dominant source of discards in the GOA (arrowtooth flounder, grenadiers, pollock, and cod are the dominant species in the discards). The status quo regime has removed the largest potential source of energy re-direction through discards with the improved retention requirements in the eastern Bering Sea. Discards are estimated to decline to 7% of the total catch in the BSAI but will remain constant at about 17% of the total catch in the GOA, a reflection of the discard level observed in 1999. Combined evidence regarding the level of discards relative to natural sources of detritus and no evidence of changes in scavenger populations that are related to discard trends suggest that the present groundfish fishery management regime has insignificant ecosystem impacts through energy removal and re-direction.

6.5.3.3 Effects on biological diversity

Fishing can alter different measures of diversity. Species level diversity, or the number of species, can be altered if fishing essentially removes a species from the system. Fishing can alter functional or trophic diversity if it selectively removes a trophic guild member and changes the way biomass is distributed within a trophic guild. Fishing can alter genetic level diversity by selectively removing faster growing fish or removing spawning aggregations that might have different genetic characteristics than other spawning aggregations. Large, old fishes may be more heterozygous (i.e., have more genetic differences or diversity) and some stock structures may have a genetic component (see review in Jennings and Kaiser 1998), thus one would expect a decline in genetic diversity due to heavy exploitation.

Localized extinctions or depletions of stocks within species are common for freshwater and anadromous species (i.e, salmonids). For marine species, there are no known extinctions due to fishing. However, localized extirpations or depletions due to fishing have been observed in the Irish Sea and stocks of tuna in the Atlantic. Examples of severe depletions include Icelandic summer spawning herring which declined in the 1960s, Northwest Atlantic halibut which declined in the early 1900s, northern cod which was closed in 1992, several long-lived sharks, skates. However, in almost all cases, the fishing mortality rates on these local populations were extremely high prior to the collapse of the stock. These type of extinctions could be thought of as a decrease in species level diversity or the actual number of species in an area. Elasmobranchs such as shark, skate, and ray species are vulnerable to fishing removals and improvements to the groundfish fishery management regime have been proposed to provide a more precautionary basis for the management of these species. Again, these effects have occurred prior to the current management strategy being considered, prior to the current FMP. So while it can happen, and has happened under conditions where management was not precautionary, extinctions due to fishing under the current regime are not considered likely to occur. No fishing induced extinctions have been documented in the last 30 years.

Taxonomic work on some fish species (e.g., skates) is still ongoing and little survey and systematic work is being done on other ecosystem components such as benthic invertebrates that could be impacted by fishing activities. Until some of these survey and taxonomic problems are resolved, we are unable to fully assess the impacts of the status quo on species level diversity. However, it is not believed that the level of uncertainty is significant enough to result in a situation that could jeopardize listed species or adversely modify critical habitat.

Studies of other more heavily fished systems, such as the North Sea, Georges Bank, or Gulf of Thailand have shown declines in diversity related to fishing and the diversity declines were due to direct mortality of target species. Biomass diversity and evenness for trophic guilds was investigated by Livingston et al. (1999) in the eastern Bering Sea in the current regime. There appeared to be no evidence that groundfish fisheries caused declines in trophic guild diversity for the groups. For example, the biomass of diversity in the pelagic fish consumer guild was close to 1 over the period of 1979 to 1993, a reflection of the dominance of pollock in the biomass of that group. Diversity tended to decline when pollock biomass increased due to large year class production. Other groups such as the benthic infauna consumer guild and the crab/fish consumer guild had higher species biomass diversity than the pelagic fish consumer guild. Guild diversity changes were again seen when a dominant member changed in abundance. The abundance changes of those species were mostly related to recruitment changes and not to fishing. There appeared to be no fishing-induced changes in functional (trophic) diversity in the status quo alternative. Functional (trophic) diversity indicators using forecasts of groundfish biomass in the status quo alternative from 2001 to 2005 indicate an 8% decline in the diversity of groundfish biomass in the BSAI and a 3% increase in groundfish biomass diversity in the GOA. The decrease in the BSAI is primarily due to the increased dominance in pollock biomass in that region while the GOA diversity change is smaller and not linked to a particular species. Thus, there appears to be no fishing-induced changes in functional diversity.

Also, evidence so far in highly fished areas such as the North Sea suggests that there is little evidence of genetically induced change in selection for body length in cod after 40 years of exploitation. Genetic diversity has not been assessed in the status quo groundfish fishery management regime here in the BSAI and GOA but we can infer that heavy exploitation of certain spawning aggregations and heavier exploitation on older, more heterozygous individuals would have the tendency to reduce genetic diversity in fished versus unfished systems. Thus, some change in genetic diversity has possibly occurred in the BSAI and GOA but the magnitude of the impacts are not known. The North Sea work indicates the impacts might be minimal. Genetic assessment of pollock populations and subpopulations in the North Pacific shows some genetic differences between stocks but has not demonstrated any genetic variability across time within stocks that might indicate fishing influences (Bailey et al. 1996).

Therefore, in summary, the effects of fishing on biological diversity in the Action Area that might somehow result in a decreased foraging base, or ability of a listed species to forage, have indicated the following: there appears to be no fishing-induced changes in functional (trophic) diversity; and genetic differences between stocks have not demonstrated any genetic variability across time within stocks that might be attributed as an effect of fishing.

6.6 Response of Threatened and Endangered Species

In this biological opinion, we established that the various elements of the FMPs guide allocative decisions and produce annual catch specifications. The intended consequence of these catch specifications is to obtain the optimum yield for target groundfish species. TACs based on this management strategy have been in place since the late 1970s and early 1980s and can be expected to continue into the future. The consequence of the groundfish exploitation strategy is a reduction in the spawning biomass (per recruit) of the target species to 40% of their unfished level. This exploitation strategy is expected to continue and can be expected to have an effect on the marine community by changing the demographic parameters of the target fish populations (growth, mortality, production, and recruitment of target fish populations) and species caught as bycatch.

The relevant question is whether this stock-wide reduction in biomass has had an adverse effect on listed species by decreasing the effective carrying capacity for that species. In other words, does the continuous removal of target species at a conservative annual rate (in the single-species concept), the cumulative reduction of their biomass to about half of unfished levels, and the alteration of their age structure and geographic distribution affect listed species which rely upon this resource for survival and recovery in the wild? Figure 6.20 schematically illustrates the potential effects of competition on the carrying capacity of a predator such as Steller sea lions. However, there is no available information to determine the appropriate location, and relationships of the curves. We have previously stated the uncertainties with historic groundfish biomass estimates, listed species population estimates and foraging rates, and the effects of multiple regime shifts. NMFS has conducted an exhaustive search of the literature, consulted with internal and external experts, and performed a variety of new analyses to determine the effects of all of these competing factors on listed species. We find no significant, relevant evidence that the current exploitation strategy (which reduces the biomass to between 40 and 60% of the predicted unfished biomass) adversely affects listed species by reducing their likelihood for survival and recovery in the wild. However, it is our opinion that biomass reductions of important groundfish species below 40% of their unfished level would not insure the protection of listed species or their environment. The details of this conclusion will be discussed specifically for each listed species below.

6.6.1 Steller sea lions

In the Status of the Species and Environmental Baseline chapters of this opinion, we established that the endangered western population of Steller sea lions have been declining throughout their range for almost three decades. The population is approaching a 90 percent decline. Prior to the early 1970s, the primary causes of the decline may have been commercial harvests, entanglement of juvenile sea lions in commercial fishing gear, and intentional shooting by fishermen. However, since 1991 these effects have been nearly eliminated, yet the overall rate of decline has been a relatively constant 4 percent per year. The pertinent question now is what is causing this current decline?

At present, the leading hypothesis to explain the *continued* decline of the western population of Steller sea lions is primarily the nutritional stress of juveniles and to a lesser extent adult females (Merrick et al. 1987, Pitcher et al. 1998, Rosen et al. 2000a, Alaska Sea Grant 1993). Such nutritional stress indicates decreased foraging success, potentially as a consequence of environmentally-driven changes in prey availability, but also as a consequence of competition with the BSAI and GOA commercial groundfish fisheries. As described earlier in this chapter, the groundfish fisheries reduce prey availability on several scales, resulting in range-wide, regional, and local depletion of prey. Fishing activity may also preclude some sea lions from certain important foraging areas simply by disturbance, or the presence of fishing vessels, gear, and activity. Since sea lions and the fisheries may well target the same aggregations of prey, such interference may reduce foraging success even in when local prey are relatively abundant.

Juvenile Steller sea lions are particularly vulnerable to reductions in prey availability because of their inexperience at foraging (compared to adults), have relatively greater metabolic demands, are more susceptible to the rigors of seasonal climatic changes, and are more vulnerable to the risks associated with additional foraging effort (e.g., predation by killer whales). That is, juveniles experiencing reduced foraging success would have to increase their foraging time and energy expended, and by doing so would be at greater risk of predation. As the energy costs of foraging increased, they would be less likely to meet their energetic needs. If they are unable to do so, then their physical condition will deteriorate. As their condition deteriorates, their ability to forage and avoid predators would be compromised, resulting in a self-reinforcing downward spiral. The consequence would be a reduced likelihood of survival due to starvation, predation, or disease. As indicated by York (1994) the portion of juveniles lost to the population need not be large (10% to 20%) to result in a population decline.

Adult, female sea lions are also vulnerable to reductions in prey availability because they are required to forage not only for themselves, but also for their offspring. Mature adult females may be pregnant and therefore facing the demands of a growing fetus, and at the same time may be nursing offspring already born. The females that are most successful are those that contribute most to the future gene pool; i.e., produce and rear pups that survive and eventually produce pups of their own. Whereas the challenge for juvenile sea lions is survival, the challenge for adult females is to maximize their reproductive contribution to the population. As the overall reproductive contribution of adult females is a function of their survival and reproduction, and as their survival and reproduction may be affected by their nutritional condition, adult females are likely vulnerable to reductions in prey availability. With reductions in local prey availability, females may be required to commit more energy to foraging (i.e, greater energy expenditure) or may be required to conserve their energy by decreasing their contribution to their offspring, or by compromising their own condition. If they compromise their contribution to their offspring, then those offspring may be less likely to survive. If they compromise their own condition, then they may reduce the likelihood of their own survival or future reproduction. At present, we are unable to measure adult survival to determine to what extent it may be compromised by existing conditions, but as described in Chapter 4 on the Status of the Species, we have seen clear evidence that the reproductive effort and success of adult females has been compromised.

The survival and reproductive success of individual adult males may also be compromised by decreased availability of prey. However, due to the polygymous reproductive system of Steller sea lions, the effects on adult males may not be significant with respect to the whole population, as one male may successfully impregnate multiple females. Nevertheless, as rookeries decline in size to smaller and smaller numbers, the potential for adverse genetic effects may increase, in part due to reductions in the number of males successfully contributing to reproduction.

Reductions in localized prey availability for prey-limited species must, then, affect the two primary determinants of population growth for a closed population, birth and survival (or mortality). In the absence of emigration or immigration, these two life table parameters determine the growth rate of the population which, for the western population of Steller sea lions has been negative for over two decades. As a consequence, the mean number of animals at rookeries and haulouts also continues to decline. In addition to a decrease in the number of animals at local sites, secondary or compounding factors may come into play that hasten the local populations to complete abandonment or extinction. Steller sea lions are gregarious animals and may, at some point, simply abandon a site if the number of animals using the site reaches some unacceptable low number or density. Similarly, as local rookery populations dwindle, the potential for deleterious genetic consequences may increase, as the population consists of fewer and fewer numbers of successful breeding age animals. Smaller local populations may also be more susceptible to rare and random events (e.g., oil spills, landslides) that could drive a local population to extinction. Such phenomenon are not merely hypothetical, but have already begun to occur. Certain haulout sites in the GOA, for example, have been partially abandoned. The proposed closure at Cape Barnabas was strongly contested in 1998 and 1999 because few animals continue to use the site and they appear to do so only seasonally.

Population viability analyses conducted by Merrick and York (1994) indicate that the next 15-20 years may be crucial for the Steller sea lion, if the decline continues. They suggested that within this time frame, the number of adult females in the Kenai-to-Kiska region could drop to less than 5,000. Extinction rates for rookeries or clusters of rookeries could increase sharply in 40 to 50 years, and extinction throughout the entire Kenai-to-Kiska region could occur in the next 100-120 years. Because Steller sea lions are a long-lived, slow-growing species, they probably cannot recover from their current decline by more than 8% to 10% per year (under ideal conditions).

With reduced foraging conditions and declining local populations, the regional centers of population distribution may shift. The recent count data suggest that the areas experiencing the worst relative declines are at the edges of the western population. While the overall decline has remained relatively consistent at about 4 percent per year since 1991, counts at some of the trend sites in the eastern and central GOA have continued to declined by 10% to 15% per year. The most recent counts in the western Aleutians declined severely between 1998 and 2000. The western Aleutian Islands results may indicate that animals have died, moved, or are spending more time in the water. But the overall result is that the center of this declining population is shifting back to the center of the range in the eastern Aleutian Islands and western GOA. As a consequence, the population may be approaching a range contraction as a result of it collapsing towards the middle.

Finally, the response of sea lions to an increase in prey may also not be apparent for some years, although an abatement of the decline of sea lions should show up much sooner in the annual pup counts. Counts of nonpups on the rookeries may not increase until juvenile survival improves and those animals reach reproductive age. More immediate changes in number of pups born may be observed if conditions improve significantly for adult females, but the recovery of the population will require improved juvenile survival as well as increased pup production. Again, Merrick and York (1994) indicated that if the decline of the western population is not abated and its rate of increase is not improved immediately, the population could become extinct within the foreseeable future.

The western population of Steller sea lions has declined for the past 20 years due to a combination of environmental and fisheries-related factors. Under the current FMPs and resulting fisheries, we can expect this population to continue its decline. Even if fishery related impacts to Steller sea lions were eliminated completely, we would expect the decline to continue as a result of environmental pressures that are also acting upon, and reducing, the survivability of this population. We can continue to expect reduced reproductive success in adult female Steller sea lions and reduced survival of juvenile sea lions. However, we are still required under the ESA to remove any possibility of jeopardy and adverse modification from the effects of the commercial fisheries. Currently the western population of Steller sea lions is declining at between 4-7% per year. Removal of the fishery contribution to this decline is significant, will enhance the recovery of the species, but will not, necessarily reverse the decline.

In previous biological opinions and the Status of the Species and Environmental Baseline chapters of this biological opinion, we noted the increased abortion rates of adult female sea lions in the action area, which would be the normal response of an adult female under nutritional stress had to choose between nurturing an existing pup or a fetus. This would reduce the reproductive rate of the western population of Steller sea lions. We also noted the increased death rate of juvenile Steller sea lions. We believe that pups that are being weaned and juvenile sea lions that have been weaned are dying in the face of competition from the groundfish fisheries when they are unable to locate prey in the densities they need to sustain themselves. This reduces the population size of Steller sea lions and effectively reduces their reproductive rate.

Under normal circumstance, the life history of Steller sea lions would protect them from short-term declines in the reproductive success of adult females or the survival of juvenile sea lions. Steller sea lions are long-lived species with overlapping generations, a life-history strategy that protects them from short-term, environmental fluctuations. Their life history strategy would protect sea lions populations from variable survival and mortality rates caused by short-term phenomena like ENSO. However, this life-history strategy cannot protect Steller sea lions from changes in birth rates and juvenile survival that continue for two or three decades. The combined effects of reduced reproductive success and juvenile survival would be expected to reduce the size of the Steller sea lion population and continue their current rate of decline. Given the current size of the western population of Steller sea lions, further reductions in their reproductive success and juvenile survival can be expected to appreciably reduce their likelihood of survival and recovery in the wild.

There is general scientific agreement that the decline of the western population of Steller sea lions in the 1990s resulted primarily from declines in the survival of juvenile Steller sea lions and lowered reproductive success in adult females. There is also general scientific agreement that both of these problems have a dietary or nutritional component (Merrick et al. 1987, Pitcher 1998, Rosen et al. 2000a, Alaska Sea Grant 1993). There is much less agreement on whether fishery-induced changes in the forage base of Steller sea lions have contributed to and continue to contribute to the decline of Steller sea lions. The National Research Council (1996), based on the best scientific and commercial information available, concluded that the groundfish fisheries managed under the two FMPs may adversely affect

Steller sea lions by (a) competing for sea lion prey and (b) affecting the structure of the fish community in ways that reduce the availability of alternative prey.

6.6.2 Critical habitat for Steller sea lions

All major rookeries and haulouts of the western population of Steller sea lions have critical habitat associated with them that extends 3,000 feet (0.9 km) landward 3,000 feet (0.9 km) above the major rookery or haulout, and extends 20 nm (37 km) seaward in State and Federally managed waters. Specific areas that have been included in the critical habitat designation include the Shelikof Strait area in the Gulf of Alaska between the Alaska Peninsula and Tugidak, Sitkinak, Aiaktilik, Kodiak, Raspberry, Afognak and Shuyak Islands, the southwestern tip of Tugidak Island, Cape Douglas, Shuyak Island, the Bogoslof area in the Bering Sea shelf , and the Seguam Pass area.

As discussed in the Status of the Species chapter of this biological opinion, the area that is designated as critical habitat was determined using information on the life history patterns of Steller sea lions, particularly land sites where sea lions haul out to rest, pup, nurse their pups, mate, and molt. The area that is designated as critical habitat for Steller sea lions was also designed to include the primary foraging areas for Steller sea lions during periods of their annual life cycle that are critical to their reproduction: the areas used by adult females during the latter stages of pregnancy and when they are weaning pups; the areas used by pups when they begin to feed independently; and the areas used by juvenile sea lions. As such, the critical habitat that has been designated for Steller sea lions was designed to protect the prey base around sea lion rookeries and haulouts that is necessary for adult, female sea lions to survive and successfully reproduce and for juvenile sea lions to survive.

The value of the marine portions of critical habitat that has been designated for Steller sea lions will be determined by the abundance and distribution of prey species. The abundance of prey within these foraging areas, over time, would determine the number of predators they could support in that time; as the abundance increased, the area would be able to support more predators, as the abundance decreased, the area would be able to support fewer predators. Similarly, the distribution of prey species will determine whether prey are available to foraging sea lions and will determine whether they can forage successfully. Factors that would determine an area’s value to predators like Steller sea lions include the distance of prey from shore, the depth of prey in the water column, the distribution and abundance of prey, and the dispersal of prey over time and space.

In the Environmental Baseline chapter, we used the term “environmental carrying capacity” (the relationship between the distribution and abundance of prey and the number of predators an area could support at a particular time) to represent the value of critical habitat for Steller sea lions. Even without the presence of humans, other species compete with Steller sea lions for food in their designated critical habitat. Adult walleye pollock, arrowtooth flounder, Pacific cod, northern fur seals, spotted seals, harbor seals, and numerous species of seabirds compete for small pollock in the action area; harbor seals compete with sea lions for larger pollock; orcas, humpback whales, gulls, and pinnipeds compete with sea lions for species like herring and capelin; and there are similar competitive interactions for species like salmon, rockfish, and sablefish.

Based on the information available, it is also reasonable to believe that competition exists between the groundfish fisheries and non-human members of the marine ecosystem. However, the management structure that is created by the FMPs, the information that is gathered to assess the distribution and abundance of the various groundfish species, and the process that is used to specify annual total allowable catches are designed to protect populations of target groundfish species, bycatch, and the related marine ecosystem. Management actions that are applied during the fishing season have also furthered these purposes. Notwithstanding these protections, our current review suggests that the fishing power of the groundfish fleet and individual vessels can deplete the groundfish biomass on small, spatial and temporal scales that would be expected to reduce the availability of groundfish to other, non-human consumers under current management approaches.

We previously noted the amount of the groundfish harvest that occurs in critical habitat that has been designated for Steller sea lions. Between 1995 and 1999, about 49% of the total groundfish harvest in the BSAI was taken from critical habitat designated for Steller sea lions. About 14% of this catch was taken within 20 nm of sea lion rookeries and haulouts in the Bering Sea and 10 nm of rookeries and haulouts in the Aleutian Islands area. The pot sector was the most concentrated in critical habitat (up to 81%), followed by the trawl sector, and then the hook-and-line sector. However, the magnitude of the trawl catch in critical habitat was much greater than pot, about 430,000 mt as compared to about 14,000 mt, in 1999. Also in 1999, hook-and-line catch was more dispersed outside of critical habitat on average, and accounted for about 75,000 mt taken outside of critical habitat and about 25,000 mt inside. The possible effects of these other gear types were dwarfed by the biomass removed by the trawl sector in 1999, which removed 1,286,852 mt. In the BSAI, the portion of each groundfish catch taken in 1999 from critical habitat ranged from 1% for the yellowfin sole fishery to 74% for the sablefish fishery. By amount, the tonnage removed from critical habitat in each fishery ranged from 657 mt for yellowfin sole and 332,251mt for pollock. The portion of BSAI pollock, cod, and Atka mackerel fisheries combined from critical habitat has increased from 12% in 1980 (about the beginning of the joint-venture fishery) to a peak of about 66% in 1995, and then dropped to 37% in 1999.

In 1998, the NPFMC recommended changes to the Atka mackerel fishery. This fishery occurs almost exclusively in the Aleutian Islands region west of 170˚W and south of 55˚N (Figs. 2.4 or 4.7). This region (within the US EEZ) consists of 1,001,780 km^2 of ocean surface, of which 104,820 km^2 is Steller sea lion critical habitat (approximately 10 percent). The purpose of the recommended changes was to reduce the potential for competition between the Atka mackerel fishery and Steller sea lions. The evidence for such competition was based on catch-per-unit-effort data from various locations in the Aleutian Islands. The data suggested that local harvest rates were much larger than the overall target rates for the entire Aleutian Island region. Since most of the Atka mackerel catch came from Steller sea lion critical habitat (about 80% in 1995-97), the evidence for locally high harvest rates raised concerns that the fishery might be depleting local prey availability in areas considered critical for sea lion recovery.

The changes implemented in 1999 split the Atka mackerel fishery into two equal seasons (by TAC) and imposed spatial restrictions on the distribution of the fishery. The spatial measures reduced the allowable catch in critical habitat from about 80% to levels at or below 40% over the period from 1999 to 2002. Prior to 1999, a total of 17,120 km^2 (or 16%) of Aleutian Island critical habitat was closed to all trawl fisheries year round (10-nm trawl exclusion zones around important rookeries and haulouts). As a result of the Atka mackerel measures implemented in 1999, an additional 4,600 km^2 (an additional 4% of critical habitat) was closed to all trawl fisheries from January-April each year (between 10 and 20 nm around the rookeries on Seguam and Agligadak Islands). These measures also implemented a phased-in reduction in Atka mackerel catches in critical habitat compared to historic patterns; by 2002, the measures should reduce Atka mackerel catches in critical habitat by about 50% from historic levels and would allow 40% of the Atka mackerel catch from inside critical habitat.

The NPFMC also developed BSAI measures for the pollock fishery to 1) avoid competition during the early winter season by closing that period to pollock trawling, 2) avoid competition around rookeries and major haulouts by closing those areas to pollock trawling, 3) disperse the fisheries spatially, and 3) disperse the fisheries temporally. In addition, the Aleutian Islands region was closed to pollock fishing (22,000 mt were caught in the Aleutian Island region in 1998; slightly more than 2% of the BSAI pollock catch). These measures resulted in a total of 210,350 km^2 (54%) of critical habitat closed to the pollock fishery (BSAI and GOA combined). The portion of critical habitat that remained open to the pollock fishery consisted primarily of the area between 10 and 20 nm from rookeries and haulouts in the GOA and parts of the eastern Bering Sea special foraging area.

On the eastern Bering Sea shelf, both the catches of pollock and the proportion of the total catch caught in critical habitat have been reduced significantly since 1998 as a result of the NPFMC actions:

Estimated pollock catches (mt) and percent caught in the Sea Lion Conservation Area in the eastern Bering Sea

Months	1998	1999	2000
January-March	441,000 (88%)	222,300 (57%)	156,800 (39%)
January-December	642,100 (60%)	372,800 (39%)	

The NPFMC measures taken to implement the RPAs also accomplished some spatial and temporal spreading of the pollock fishery in the eastern Bering Sea (Figs. 5.1 and 5.2). In 1998, prior to the measures being implemented, the pollock fishery was concentrated into 2 seasons, each approximately 6 weeks in length in January-February and September-October (Fig. 5.3). Ninety-four percent of the pollock catch was taken in these four months (45% in January-February and 49% in September-October).

In 1999, the fishery was dispersed into March (reducing the percent taken in February) and into August. Small amounts of pollock were taken in April-July. Thus, the 1999 fishery was dispersed only slightly better than the 1998 fishery (Figs. 5.1 and 5.2). In 1998, daily catch rates averaged over 8,100 mt/day, and peaked at over 21,300 mt/day. In 1999 and 2000, average daily catch rates for January-March declined about 22% to 6,200 mt/day and 6,400 mt/day, respectively; daily maximums were 15,400 mt/day and 12,500 mt/day, respectively. These changes resulted from a combination of the RPAs and the implementation of cooperatives under the American Fisheries Act (see below).

For both the pollock and Atka mackerel fisheries, the NPFMC measures did not modify the methodology of determining the acceptable biological catch (ABC). However, as a consequence of these measures, the percent catch of all species in critical habitat decreased from about 53% before 1999 to 34% in 1999. The underlying assumption was that the total amount of the catch was not an issue, and that as long as certain periods (early winter) and areas (around rookeries and major haulouts) were protected from competition, and the catch was otherwise dispersed temporally and spatially, the fisheries would not jeopardize the Steller sea lion or other listed species, or adversely modify Steller sea lion critical habitat.

In the GOA, analysis of the historic distribution of catch inside and outside of critical habitat is more complicated than in the BSAI. Much of the GOA fisheries are prosecuted by a small boat fleet that has low or no observer coverage. These smaller boats are more likely to fish inside critical habitat for safety considerations. However, the larger boats, which are more likely to fish further offshore, also have a higher observer coverage. The result is that analyses of fishing effort are often skewed by larger vessels and catch from critical habitat is underestimated. The magnitude of this error is unclear, but nearly all boats under 60 ft may operate within 20 nm from shore, in areas designated as critical habitat.

In the period from 1995-1999, the average catch from critical habitat for all sectors was 54% of the total catch, about 48% of the total catch was within 20 nm of listed rookeries and haulouts. The pot sector was the most concentrated in critical habitat (up to 71%), followed by the trawl sector, and then the hook-and-line sector. However, as in the BSAI, the magnitude of the trawl catch in critical habitat was much greater than pot, about 100,000 mt as compared to about 10,000 mt in 1999. Also in 1999, hook-and-line catch was more dispersed outside of critical habitat on average, and accounted for about 20,000 mt of catch outside of critical habitat and about 7,500 mt inside. Again, the possible effects of these other gear types are dwarfed by the magnitude of biomass removals by the trawl sector; trawl catch in 1999 was 180,000 mt.

The potential effects of the GOA pollock fisheries were also addressed in the December 3, 1998 Biological Opinion. NMFS issued RPAs on October 15, 1999, that were designed to avoid jeopardy and adverse modification for this fishery through 2002. For the GOA, the RPAs were intended to disperse the pollock fishery temporally into four discrete seasons dispersed through the period from January 20 to November 1. For 1999, little temporal dispersion was accomplished (Fig. 5.5). For 2000, these four seasons were to begin January 20, March 15, August 20, and October 1. The catch was dispersed accordingly.

For the GOA pollock fishery, the RPAs were intended to achieve two objectives with respect to spatial dispersion. The first was to reduce pollock catches from around significant rookeries and haulouts by requiring that fishing occur outside 10 nm from these areas, and the second was to distribute the seasonal catches according to the seasonal pollock biomass distributions by area. In the GOA, survey and fishery data suggested that winter pollock fishing effort could be higher in Shelikof Strait (part of critical habitat) than had previously been observed. Surveys indicated that as much as 50% of the exploitable biomass of pollock in the GOA was inside Shelikof Strait in March, yet the recent pre-RPA winter GOA fishery did not catch 50% of its pollock from that area. Instead, the fishery worked principally in other parts of critical habitat, presumably with less available biomass, but with other advantages, such as proximity to ports. Therefore, fishing effort may have been disproportionately large in some portions of critical habitat and considerably lower in others (e.g., Shelikof Strait). To distribute the pollock catch according to the pollock distribution, the NPFMC established a separate Shelikof Strait management area (combined areas 621 and 631) and allocated approximately 50% of the A and B season quotas to it. This essentially shifted effort from one part of critical habitat to another to more closely match the winter biomass distribution. Because of this, pollock catches from critical habitat in the A and B seasons would not be expected to decline as a result of the RPAs. During the C and D seasons, the RPAs allocated TAC by fishery management area.

Pollock catches and the percent of catch removed from critical habitat in the GOA increased in 1999 and 2000 relative to 1998 (see below). Pollock catches during January-March from critical habitat have increased from almost 20,000 mt to over 34,000 mt, and the proportion caught in critical habitat increased from 70% to 97%. As stated above, this is not a surprising result since the Shelikof Strait area (critical habitat) was allocated over half of the GOA pollock TAC during the A and B seasons.

Months	Estimated Pollock Catches (mt) and Percent Caught in the Steller Sea Lion Critical Habitat in the Gulf of Alaska 1998	1999	2000
January-March	19,900 (70%)	31,700 (88%)	34,100 (97%)
January-December	99,700 (79%)	75,600 (82%)	

Contrary to the EBS, the GOA pollock fishery has generally become increasingly concentrated in smaller areas (Fig. 5.4).

In 1999, the portion of each groundfish catch taken from GOA critical habitat ranged from 5% for the other rockfish fishery to 81% for the pollock fishery. By amount, the tonnage removed in each GOA fishery ranged from 89 mt for Atka mackerel and 77,663 mt for pollock. The portion of the GOA pollock and cod fisheries combined from critical habitat has increased from 19% in 1980 to 65% in 1999. Management measures were implemented in 1999 to disperse the GOA pollock fisheries spatially and temporally as required by the 1998 Biological Opinion RPA. Before 1999, the catch of all species averaged about 55% in critical habitat; in 1999, the catch was about 52% in critical habitat.

In the Environmental Baseline and earlier in this chapter, we presented data that showed that the groundfish fisheries harvest fish species that form the principle prey of Steller sea lions. Based on these data, we concluded that Steller sea lions and fishermen actively demand a common resource and that the fisheries reduce the availability of that common resource to other consumers. The groundfish fisheries reduce the abundance or alter the distribution of several significant prey species, such as walleye pollock, Pacific cod, and Atka mackerel. Earlier in this chapter, we also noted that fisheries can cause dense schools of prey species to scatter, which affects the foraging behavior of marine mammals and seabirds that target aggregated prey. Repeatedly causing fish schools to scatter and reducing their density reduce the value of the foraging areas to Steller sea lions by increasing the amount of time and energy sea lions would have to expend to feed on available prey.

The effects described in section 6 indicate that the fisheries as currently constituted, including the conservation measures put in place in recent years, reduce the abundance of prey within local foraging areas and alter the distribution of groundfish prey in ways that can reasonably be expected to reduce the foraging effectiveness of sea lions. The reduction in foraging success affects individual animals, reducing the likelihood of their survival and successful reproduction. In turn, reductions in survival and reproduction perpetuate the decline of the population and reduce the likelihood of recovery in the wild.

6.6.3 Summary of Effects on Steller Sea Lions

Following is a summary of the effects of the action. These effects in combination with the environmental baseline form the basis for the conclusion and determine what actions are necessary to comply with section 7 (a)(2). Based on the complexity of the effects analysis this overview is intended to review the most essential elements of this chapter's explanation of the potential effects of this federal action on listed species. Since Steller sea lions are the species most likely to be impacted by these fisheries much of the focus on effects is specific to that species.

The ESA defines impacts on listed species as "take" (16 USC § 1532(19)). "Take" is further defined as to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct" and does not require that actual death occur or that the species population declines. Additionally, the FWS further defines "take" to include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, and sheltering (50 CFR § 17.3(c)). No federal agency may authorize an action which would result in the "take" of an ESA- listed species without having an "incidental take permit" authorized under section 9 of the ESA. However, any authorized "take", which is cumulative, cannot result in the action jeopardizing the continued existence of a listed species. Consequently, in coming to a conclusion under ESA, the effects analysis in a biological opinion must examine the action based on these criteria. If take causes effects on the species that exceed the jeopardy or adverse modification standard, then the measure would have to be modified by reasonable and prudent alternatives to comply with section 7 (a) (2). NMFS has demonstrated through the discussion in earlier sections that this action is likely to result in harm to Steller sea lions by competing for prey, harassing the animals because of vessel traffic, and result in some direct mortality of Steller sea lions due to entanglement in fishing gear. Specifically, there are 4 primary effects categories: effect of global biomass levels, effects of disturbance, and effects of temporal and spatial concentration of fishing.

FMP Level Effects

1. *Fisheries exploitation based on the $F_{40\%}$ strategy.*

The harvest strategy used in the BSAI and GOA has resulted in biomass reductions of Steller sea lion prey species on the order of 40-60% from that of estimated unfished levels. After careful consideration of the best available scientific and commercial data available, a link was established in this effects section between this large-scale reduction in fish biomass and the carrying capacity of Steller sea lions in the BSAI and GOA. It is NMFS opinion that these biomass reductions of Steller sea lion prey species, along with other factors such as climate change, natural predators, etc., were a significant contributing factor of the reduction and current decline of the population of Steller sea lions.

Although the current strategy maintains biomass at acceptable levels for fisheries management, the current harvest control rule in use by NMFS allows for significant variation below the target biomass level. In essence, the fishery could be conducted to the point that only 2% of the unfished biomass remained. Although this is an unlikely scenario, based on a precautionary ESA strategy, variability below a threshold fished biomass should be limited to the extent practicable. As far as the level of effect that constitutes a "take" of Steller sea lions, based on concerns of their ability to forage effectively without reducing appreciable their likelihood of survival and recovery, take could be expected to occur whenever the biomass of pollock, Pacific cod, or Atka mackerel is below $B_{40\%}$. [Refer to Section 9.2.1]

Regional Level Effects

2. *Disturbance: Fishing and vessel traffic around Steller sea lion rookeries and haulouts*.

Traffic by federally permitted vessels, and the resulting disturbance to Steller sea lions, within 3 nm miles of rookeries and haulouts adversely affects them and results in "take" of Steller sea lions because of harassment. Fishing activity for pollock, Pacific cod, and Atka mackerel within 20 nm of rookeries and haulouts effects and also results in "take" of Steller sea lions due to competition for prey resources.

Previous measures in biological opinions on these fisheries to reduce impacts on Steller sea lions did not consider all the groundfish fisheries in the scope of the action, which differs from the scope of this opinion. These measures make good biological sense but need to be expanded based on the foregoing effects analysis. Establishing additional 3 nm no-transit zones for federally permitted vessels around Steller sea lion haulouts in the BSAI and GOA and closing all rookeries and haulouts to 20 nm to directed fishing for pollock, Pacific cod, and Atka mackerel would minimize the "take" resulting from competition for prey. Further, closing portions of the critical habitat foraging areas would also be closed to directed fishing for the three species. This would considerably reduce the amount of "take" (effects) resulting from this action. [Refer to Section 9.2.2]

3. *Temporal concentration of fishing effort for pollock, Pacific cod, and Atka mackerel on a seasonal time scale.*

Based on the best available scientific and commercial data, this effects section has discussed temporal concentration of fisheries for pollock, Pacific cod, and Atka mackerel that result in high local harvest rates (i.e. localized prey depletions) which would reduce the quality of the habitat for Steller sea lions on a seasonal time scale. For example, fishing the entire TAC during the winter season, which is believed to be a biologically stressful time for juveniles, would result in an unacceptable level of "take" of those animals. Consequently, establishing summer and winter seasons for all these species would be important to preventing localized depletion. "Take" is still likely to occur as some Steller sea lions would be foraging in areas and times that the fishery operates, however, this "take" could be set to a level that would not compromise the life of individual Steller sea lions, their fecundity (breeding), or the population number when combined with other measures. [Refer to Section 9.2.3]

4. *Spatial concentration of fishing effort for pollock, Pacific cod, and Atka mackerel.*

The effects section included analysis of the best available scientific and commercial data, indicating that the spatial concentration of fisheries for pollock, Pacific cod, and Atka mackerel results in high local harvest rates. This reduces the quality of habitat for foraging Steller sea lions on a geographic scale. "Take" results from the inability of Steller sea lions to find appropriate habitat in which to forage and survive due to the modification of that habitat by these fisheries. Fishing can cause localized depletion of prey in a spatial context, making it more difficult for sea lions to forage successfully. As noted in Chapter 4, sea lions rely on certain prey densities to forage effectively.

Apportioning the annual harvest amount (TAC) to management areas and establishing harvest limits for critical habitat (i.e. open areas only) based upon the ratio of the biomass in that specific area compared to the total biomass (BSAI or GOA) would help minimize this effect. [Refer to Section 9.2.3]

6.6.4 Large cetaceans

Measuring the potential effects of the groundfish fisheries on the marine ecosystem of the action area is extremely difficult and realistically cannot be achieved with the available information. We cannot dismiss any effects that might have occurred in the past and may continue to occur. Based on the information available, it is also reasonable to consider that the groundfish fisheries and non-human members of the marine ecosystem may compete with listed whales for a limited resource. However, the direct or indirect effects of commercial fisheries in the BSAI and GOA, based on the limited information available on the status, trends, distribution, and abundance of endangered whale species in the action area and interactions between these whales and commercial fisheries, does not appear to be significant. Although we do not have the information that would be necessary to determine how endangered whales in the action area would be affected by cascade effects of these groundfish fisheries or competition, we do know that recent information on humpback [the species most likely to compete with fisheries given their dietary preferences and distribution], blue and bowhead whales suggest that these species are increasing and do not appear to be experiencing these effects to a level that would inhibit recovery or survival.

6.6.5 Pacific salmon

No stocks of Pacific salmon originating from freshwater habitat in Alaska are listed under the ESA. The ESA listed species or evolutionarily significant units (ESUs) that migrate into marine waters off Alaska, originate in freshwater habitat in Washington, Oregon, Idaho, and California. In the marine waters off Alaska, the ESA listed salmon stocks are mixed with hundreds to thousands of other stocks originating from the Columbia River, British Columbia, Alaska, and Asia. The ESA listed fish are not visually distinguishable from the other, unlisted, stocks. Mortal take of them in the salmon bycatch portion of the fisheries is assumed based on limited abundance, timing, and migration pattern information gleaned from recovery locations of coded-wire-tagged surrogate stocks.

The effects of the Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish fisheries on listed salmon were considered through informal consultations with NMFS, Northwest Region for fishing years 1992 and 1993 (February 20, 1992, April 21, 1993 respectively). Subsequent informal consultation occurred for BSAI Amendment 28 (June 7, 1993), and for GOA Amendment 31 (September 22, 1993). NMFS stated in the latter two memoranda associated with the informal consultation that it was essential that monitoring efforts be continued and that NMFS continue to seek additional information regarding potential impacts to listed fish. In a biological opinion issued the following year, NMFS stated that it believed that the potential effects of the GOA and BSAI groundfish fisheries on listed salmon warranted formal ESA section 7 consultation (NMFS 1994).

The 1994 Biological Opinion was written to determine if continuation of the groundfish fisheries in the BSAI and GOA, in 1994 and beyond, was likely to jeopardize the continued existence of Snake River sockeye salmon, Snake River spring/summer chinook salmon or Snake River fall chinook salmon or destroy or adversely modify critical habitat designated for these species. The biological opinion established specific approaches that were used to assess the effects of the proposed action on listed species. Effects are expressed in terms of numerical catch assessment, base period analysis, cumulative effects analysis, and combined effects analysis.

After reviewing the current status, trends, distribution, and abundance of Snake River fall chinook, Snake River spring/summer chinook, Puget Sound chinook, Upper Columbia River spring chinook, Upper Willamette River chinook, Lower Columbia River chinook, Upper Columbia River steelhead, Upper Willamette River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Snake River Basin steelhead, in the action area, interactions between these species and the BSAI and GOA groundfish fisheries do not appear to be significant.

6.6.6 Leatherback Turtles

Leatherback turtles are extralimital within the Action Area. They do occur, generally as stranded animals along the coastlines of southeast Alaska. However they are not considered to be abundant in the areas of the greatest level of commercial fishing of the GOA, and not considered to be found in the BSAI at all. To our knowledge there have been no takes of leatherbacks in the commercial fisheries in the BSAI and GOA. Therefore we believe the direct and indirect effects of commercial fisheries in the BSAI and GOA on this species is negligible and not likely to jeopardize its survival or recovery. We do not have the information that would be necessary to determine how leatherback turtles in the action area would be affected by cascade effects of these groundfish fisheries or competition. However, we know that this species feeds entirely on salps and jellyfish and therefore would likely benefit from any cascade effects that would filter down to the trophic level at which they forage. There is no fishery that is targeting the prey of this species.

7 CUMULATIVE EFFECTS

Cumulative effects include the effects of *future* State, tribal, local, or private actions that are reasonably certain to occur in the action area. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Past and present impacts of non-federal actions are part of the environmental baseline discussed in section 5. The following discussion will focus on just those actions that may adversely affect listed species.

7.1 Direct Effects

Perhaps the most obvious effect on listed species would be direct take. For Steller sea lions, there is a direct take in the subsistence harvest by Alaska Natives which is expected to continue into the foreseeable future. The number of sea lions harvested has declined in the past few years to somewhere around 180 animals per year. It is not clear if the decline will continue. The majority of sea lions are taken by Aleut hunters in the Aleutian and Pribilof Islands. The great majority (99%) of the statewide subsistence take was from west of 144°W long. (i.e., the range of the western population). The overall impact of the subsistence harvest on the western population will be determined by the number of animals taken, their sex and age class, and the location where they are taken. As is the case for other sources of mortality, the significance of subsistence harvesting may increase as the western population decreases in size unless the harvesting rate is reduced accordingly. However, the subsistence harvest accounts for only a relatively small portion of the animals currently lost to the population each year as described in section 5.2.2.

7.2 Indirect Effects

7.2.1 Alaska State commercial fisheries

Commercial groundfish fisheries that are managed by the State of Alaska were introduced in the *Environmental Baseline* chapter of this biological opinion. We expect those fisheries to continue into the future, with some increases if the State of Alaska develops a small boat fleet. Nevertheless, the size of the State groundfish fisheries are generally small when compared to the federal groundfish fisheries and are expected to have less impacts on listed species with respect to competition for prey and long term ecosystem impacts. The crab fishery is one of the biggest fisheries managed by the state, which is not likely to directly compete for prey with either Steller sea lions or other listed species.

Herring, salmon, Pacific cod, pollock, squid, and octopus are items found year-round in the diet of Steller sea lions. For species such as salmon and herring, they occur much more frequently in the summer as determined by analyses of scat samples from 1990-1998 (see figs 4.5 and 4.6 showing prey in scat samples). Biomass assessments and trends, stock recruitment, and escapement estimates for many of these stocks is often based on visual interpretation, escapement counts, or estimates of egg production. Reliable stock information for most of these fisheries is not available.

Perhaps the most important interaction between state fisheries and listed species may arise from the intense pattern of localized removals of spawners. Although the patterns are generally similar from one fishery to the next, the sheer number of distinct fisheries makes it difficult to describe them individually.

Likewise, each fishery is distinctly different in the number of boats, gear used, time of year, length of season, and fish species. Therefore, we will present a few examples to demonstrate some of the competitive interactions which may occur.

We have direct evidence that Alaska's herring fisheries, in particular, compete with Steller sea lions and other listed species. Steller sea lions appear to be attracted to the dense aggregations of herring that occur along some sections of the coast during the herring's short, spawning period. Because the timing of herring spawning varies, fishery managers have learned to depend on the presence of Steller sea lions to determine when herring spawning is imminent. Managers generally begin flying aerial surveys over potential herring spawning grounds well in advance of expected herring spawning events (for several weeks prior to spawning, herring are usually present near their spawning grounds, but they are too deep in the water column to be seen from aircraft). When these aerial surveys observe Steller sea lions and cetaceans on the spawning grounds, they interpret those observations as indicating the presence and impending spawning of herring (fishery managers usually note the presence of Steller sea lions in their field notebooks, occasionally recording actual counts).

Several days before spawning, herring move into shallower water and become directly detectable by aerial surveys. Under the direction of these aircraft, the fishing fleet moves into the general area where the fishery will take place. Steller sea lions have been observed in the middle of these fishing areas and have been observed leaving the spawning grounds shortly after the herring finish spawning (fishery biologists survey the biomass of the spawning deposits by SCUBA, but wait until the sea lions leave the area for safety reasons).

One example of a herring spawning event where Steller sea lion counts were quantified during aerial surveys is shown in Figure 5.10. Steller sea lions were already in the area at the time of the first ADFG aerial survey on April 19, diving on the deeply submerged herring schools, as were a number of humpback whales. Following the spawning event, large numbers of birds appeared on the beaches to feed on the herring eggs, noted in numbers of 11,000 to 20,000. Approximately 150 Steller sea lions were counted in the area. Similar descriptions of humpback whale and Steller sea lion presence on herring spawning grounds are available in field notes from other herring fishing areas (there was no fishery at Hobart Bay in the spring of 2000 because the quota had been taken in the earlier food/bait herring fishery).

The impacts of some of the State fisheries on Steller sea lions and, in some cases, humpback whales would be similar to those of the Federal fisheries: cascade effects and competition. Steller sea lions and some of the State fisheries actively demand a common resource and the fisheries reduce the availability of that common resources to Steller sea lions while they satisfy their demand for fish. The State groundfish fisheries reduce the abundance or alter the distribution of several prey species that include walleye pollock and cod. The groundfish fisheries can cause dense schools of prey species to scatter which affects the foraging behavior of marine mammals and seabirds that target aggregated prey (Brock and Riffenburgh 1960, Dayton et al. 1995, and others). Repeatedly causing fish schools to scatter and reducing their density would also reduce the value of the foraging areas to Steller sea lions by increasing the amount of time and energy and sea lion would have to expend to feed on the same number of fish. The reductions of biomass at larger spatial scales would exacerbate the effects of small-scale depletions caused by fishing; because the spawning biomass in the entire ecosystem is about half of what it would be without fishing, there are fewer spawning-aged fish to replenish areas where fishing has occurred.

Based on available data, we would expect several State groundfish fisheries, particularly the pollock and cod fisheries, to compete with foraging Steller sea lions, substantially contribute to their nutritional stress, and appreciably reduce the value of the marine portions of critical habitat that has been designated for Steller sea lions. The fisheries may reduce the abundance of prey within these marine, foraging areas and would alter the distribution of groundfish prey in ways that would reduce the effectiveness of foraging sea lions. The reduction in the abundance of prey species and the alteration of their distribution could effectively keep the carrying capacity of critical habitat for Steller sea lions below the current population size.

7.2.2 Alaska State sport fisheries

Meeting public demand for recreational fishing opportunities in Alaska while at the same time maintaining and protecting the fisheries resources has become a significant challenge for ADFG (Howe et al. 1996 “harvest, catch, and participation in Alaska sport fisheries during 1995"). Today, along with increasing tourism and continued population growth, there is increased pressure on sport fisheries, development of new fisheries, and increased crowds. At the core of sport fisheries management is the ADFG onsite “creel” surveys. ADFG staff survey fisherman as they return to the docks, requesting information on catch and time fished, as well as collecting biological samples, fish tags and other information. Additionally, the department conducts surveys through the mail requesting further information from fisherman on the annual harvest. This information is compiled and published in annual sport fishery reports (Howe et al. 1999).

Of the 469,436 anglers who fished in Alaska in 1995, about 51% were Alaska residents and 49% were nonresidents, and resulted in about 3 million angler-days fished. This resulted in 2,909,979 fish harvested which included 1,299,945 razor clams (*Siliqua patula*) and 52,905 smelt and capelin (*Osmeridae*). Of the remaining 1,657,129 harvested fish, 55% were salmon, 20% were halibut, 7% were rainbow trout, 5% were rockfish, 4% were Dolly Varden and Arctic char, 3% were grayling, and 1% were landlocked salmon. Also harvested, at much lower rates, were lingcod, whitefish, steelhead, and sheefish. Since 1985, the number of anglers fishing in Alaska has increased 35%, about 3% per year. Trends in annual catch rates are most affected by fluctuations in salmon abundance, species such as halibut and rockfish as been more consistent over the last 20 years (Howe et al., 1996).

For perspective, the sport fishery harvests about 1% (4,000 mt) of the annual State of Alaska total fish harvests, while the commercial fisheries accounted for 97% (900,000 mt) of the annual harvest in 1998, and would be expected to continue in relatively low amounts in the future. It is likely that increased levels of tourism will also increase the actual amount of fish taken for sport. However, this additional harvest would likely result in a comparatively small amount of fish taken. Plus, the nature of most of the fisheries is slow removal rates and dispersed catch. The most concentrated catches are in the salmon fisheries, however, many of these such as the Kenai fisheries, actually take place upriver outside of foraging areas of listed species considered here.

7.2.3 Alaska State subsistence harvest of groundfish in the GOA and BSAI

Subsistence hunting and fishing are important to the economies of many families and communities in Alaska. Furthermore, subsistence uses are central to the customs and traditions of many cultural groups in Alaska, including the Aleut, Athabaskan, Alutiiq, Euroamerican, Haida, Inupiat, Tlingit, Tsimshian, and Yup’ik. We can conclude that this traditional way of securing necessary resources will continue for these rural communities in Alaska. About 20% of Alaska’s population (124,367 people in 270 communities in 1998) participates in the subsistence harvest. Most of the harvest is composed of fish (about 60% by weight) and by marine mammals (14% by weight; see direct take of Steller sea lions by the subsistence fishery in section 7.1). For perspective, the subsistence fishery harvests about 2% (8,000 mt) of the annual State of Alaska total fish harvests, while the commercial fisheries account for 97% (900,000 mt) of the annual harvest in 1998. Consequently, although subsistence harvests are likely to continue into the future, and possibly grow if population increases, the amount taken for consumptive uses is very small compared to the commercial catch of fishery resources which is largely transported outside of the state (ADFG 1998 "Subsistence in Alaska: 1998 Update").

7.2.4 Alaska State oil and gas leasing

In 1896, oil claims were staked at Katalla approximately 50 miles south of Cordova. Oil was discovered there in 1902. An on-site refinery near Controller Bay produced oil for over thirty years. The refinery burned down in 1933 and was not replaced. Exploration in Cook Inlet began in 1955 on the Kenai Peninsula in the Swanson River area, and oil was discovered in 1957 which sparked an oil rush in southcentral Alaska. Today, a number of active fields produce oil in Cook Inlet, all of which is processed at the refinery at Nikiski on the Kenai Peninsula (Department of Natural Resources 2000). Estimated oil reserves in Cook Inlet are 72 million barrels of oil. Currently there are additional lease sales planned through 2005 for the Cook Inlet area, but none for areas outside of Cook Inlet which would fall within the action area.

7.2.5 Alaska State population

The effects of the human population in Alaska, past and present, was discussed in section 5.2.1. Alaska has the lowest population density of all of the states in the United States. Although Alaska's population has increased by almost 50 percent in the past 20 years, most of that increase has occurred in the Cities of Anchorage and Fairbanks. Outside of Anchorage, the largest populations occur on the Kenai Peninsula, the Island of Kodiak, Bethel, and in the Valdez - Cordova region. Outside of the City of Anchorage, few of the cities, towns, and villages would be considered urbanized. It is probable that the population in Alaska will continue to expand at a high rate, especially in urban areas. Rural areas may increase or decrease based on their ability to exploit resources such as fisheries, and secure their necessities to live in these remote areas. Many rural villages have experienced population declines, most of them in the Aleutians. To bolster these communities, the state has begun to develop local fisheries. For example, the state would to see the development of a community in Adak, to help accomplish this the state has implemented a local Adak Pacific cod fishery where vessels fishing under the federal TAC would be excluded by size in order to allow the local small boat fleet to harvest the TAC in that area. This effectively takes management control away from the federal government, concentrates catch inside of state waters (out to 3 miles), and focuses the dependance of specific coastal communities on a resource which may not be available in the future. This system may put severe pressure on fishery managers in the future to enact regulations which provide for near-shore fisheries. However, this may directly conflict with measures to limit adverse impacts to critical habitat.

In general, as the size of human communities increase, there is an accompanying increase in habitat alterations for housing, roads, commercial facilities, and other infrastructure. The impact of these activities on pristine landscapes and the biota they support increases as the size of the human population expands. As terrestrial plant communities and coastal areas are destroyed, modified, or fragmented for the construction of human communities, native plants and animals are displaced, and can become locally extinct. A detailed description of these effects on water quality is found in section 5.2.1, and is not expected to be more significant in the future given current and expected levels of federal and state regulation for waste disposal and management.

As the human population expands (as is expected mostly around the major cities), the risk of disturbance also increases. Several studies have noted the potential adverse effects of human disturbance on Steller sea lions. Calkins and Pitcher (1982) found that disturbance from aircraft and vessel traffic has extremely variable effects on hauled-out sea lions. Sea lion reaction to occasional disturbances ranges from no reaction at all to complete and immediate departure from the haulout area. The type of reaction appears to depend on a variety of factors. When sea lions are frightened off rookeries during the breeding and pupping season, pups may be trampled or even abandoned in extreme cases. Sea lions have temporarily abandoned some areas after repeated disturbance (Thorsteinson and Lensink 1962), but in other situations they have continued using areas after repeated and severe harassment. Johnson *et al*. (1989) evaluated the potential vulnerability of various Steller sea lion haulout sites and rookeries to noise and disturbance and also noted a variable effect on sea lions. Kenyon (1962) noted permanent abandonment of areas in the Pribilof Islands that were subjected to repeated disturbance. A major sea lion rookery at Cape Sarichef was abandoned after the construction of a light house at that site, but then has been used again as a haulout after the light house was no longer inhabited by humans. The consequences of such disturbance to the overall population are difficult to measure. Future disturbance may contribute to or exacerbate the decline. Disturbance may also effect listed whales, however little information exists to determine whether whale watching tours, fishing boats, or traffic in general degrades the foraging success of these animals or increases their stress level.

8 CONCLUSIONS

After reviewing the current status of endangered blue whales, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of endangered blue whales.

After reviewing the current status of endangered bowhead whales, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of endangered bowhead whales.

After reviewing the current status of endangered fin whales, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of endangered fin whales.

After reviewing the current status of endangered humpback whales, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of endangered humpback whales.

After reviewing the current status of endangered right whales, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of endangered right whales.

After reviewing the current status of endangered sei whales, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of endangered sei whales.

After reviewing the current status of endangered sperm whales, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of endangered sperm whales.

After reviewing the current status of endangered western population of Steller sea lions, the environmental baseline for the action area, the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the action, as proposed, is likely to jeopardize the continued existence of the western population of Steller sea lions.

After reviewing the current status of threatened eastern population of Steller sea lions, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of threatened eastern population of Steller sea lions.

After reviewing the current status of threatened Puget Sound chinook salmon, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Puget Sound chinook salmon.

After reviewing the current status of threatened Lower Columbia River chinook salmon, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Lower Columbia River chinook salmon.

After reviewing the current status of endangered Upper Columbia River chinook salmon, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Upper Columbia River chinook salmon.

After reviewing the current status of threatened Upper Willamette River chinook salmon, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Upper Willamette River chinook salmon.

After reviewing the current status of threatened Snake River spring/summer chinook salmon, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Snake River spring/summer chinook salmon.

After reviewing the current status of threatened Snake River fall chinook salmon, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Snake River fall chinook salmon.

After reviewing the current status of threatened Snake River sockeye salmon, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Snake River sockeye salmon.

After reviewing the current status of endangered Upper Columbia River steelhead, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the

Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Upper Columbia River steelhead.

After reviewing the current status of threatened Middle Columbia River steelhead, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Middle Columbia River steelhead.

After reviewing the current status of threatened Lower Columbia River steelhead, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Lower Columbia River steelhead.

After reviewing the current status of threatened Upper Willamette River steelhead, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Upper Willamette River steelhead.

After reviewing the current status of threatened Snake River Basin steelhead, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of Snake River Basin steelhead.

After reviewing the current status of endangered leatherback turtle, the environmental baseline for the action area, the effects of the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are not likely to jeopardize the continued existence of leatherback turtles.

After reviewing the current status of critical habitat that has been designated for the western population of Steller sea lions, the environmental baseline for the action area, the Fishery Management Plans for Alaska Groundfish in the Bering Sea and Aleutian Islands and Gulf of Alaska, and the cumulative effects, it is NMFS' biological opinion that the fishery management plans are likely to adversely modify this designated critical habitat.

9 REASONABLE AND PRUDENT ALTERNATIVE

Regulations (50 CFR §402.02) implementing section 7 of the ESA define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.

Based on the synthesis discussion in Section 6 and conclusions in Section 8, a reasonable and prudent alternative (RPA) for the groundfish fisheries in the BSAI and GOA is required to avoid: (1) jeopardy to the western stock of Steller sea lions, and (2) adverse modification of their critical habitat. The fisheries effects that give rise to these determinations include both large scale removals of Steller sea lion forage over time, and reduced availability of prey on the fishing grounds at scales of importance to individual foraging Steller sea lions, particularly in critical habitat. This RPA also establishes a monitoring scheme to inform the management process about the nature of the Steller sea lion/fishery interaction while providing a mechanism by which management success can be measured.

Based on the effects discussion found in Section 6, and NMFS determination that fishing activity under the FMPs are likely to jeopardize the continued existence of the western population of Steller sea lions and are likely to adversely modify their designated critical habitat, NMFS has developed an RPA with multiple components for the groundfish fisheries in the BSAI and GOA. The fisheries effects that give rise to these determinations include both large scale removals of Steller sea lion forage over time, and the potential for reduced availability of prey on the fishing grounds at spatial and temporal scales of importance to individual foraging Steller sea lions.

9.1 Principles for the Reasonable and Prudent Alternative

This biological opinion includes one RPA alternative, which has multiple management measures or elements that are essential to avoid the likelihood of the groundfish fisheries jeopardizing the continued existence of the endangered western population of Steller sea lions or adversely modifying its designated critical habitat. Together these measures are designed to minimize adverse effects of removing prey biomass and avoid competition. The following is a summary of the general principles used to minimize competition between fisheries and Steller sea lions:

Global Control Rule

The current control rule used to determine the allowable biological catch (ABC) for pollock, Pacific cod, and Atka mackerel in the BSAI and GOA will be revised to take into account the prey requirments of Steller sea lions. This revision will result in a more conservative catch amount (i.e., reduced fishing mortality rate) when the spawning biomass is estimated to be less than 40% of the projected unfished biomass. There would be no directed fishing for a species when the spawning biomass is estimated to be less than 20% of the projected unfished biomass. Subsequent text will explain the scientific basis for these threshold levels.

Fishing Closures to Eliminate Competition

Approximately 66% of critical habitat would be closed to directed fisheries for pollock, Pacific cod, and Atka mackerel, eliminating the possibility for competition in these areas . A description of the closed areas can be found in Table 9.1.

Closed areas can be divided into three types. The first form will be a continuation of the current 3 nm no-entry zones around rookeries. The second form of closed area is comprised of 3 nm no-fishing zones (for all federally permitted vessels) around all major haulouts that have been previously identified as either part of designated critical habitat or in the RFRPAs contained in biological opinions for the pollock fishery. The third form of closed area is a partial closure to directed fishing for pollock, Pacific cod, and Atka mackerel inside certain expanded habitat zones. These zones consist of critical habitat areas and additional Steller sea lion protection areas identified in previous biological opinions and will be referred to in this document as CH-RFRPA sites, i.e. those sites listed as critical habitat and the additional important haulouts identified in the RFRPAs.

Spatial Distribution

Seasonal harvest limits for pollock, Atka mackerel, and Pacific cod will be established for those areas of critical habitat open for fishing, based on the projected biomass in that geographic area by season. Any TAC amount available inside critical habitat can be taken outside of critical habitat during the concurrent season outside.

Temporal Distribution

Fishing for pollock, Pacific cod and Atka mackerel will be prohibited from November 1 through January 20 inside critical habitat. Additionally, fishing for these species with trawl gear will be prohibited in all areas from November 1 through January 20.

Inside critical habitat, NMFS will establish 4 equally spaced seasons for all 3 fisheries in the CH-RFRPA open zones to further ensure against high removal rates and possible localized depletions of prey in the most important area for Steller sea lions. This measure will evenly divide the combined winter allocation of 40% to the A and B seasons, and the combined fall allocation of 60% to the C and D seasons based on projected biomass in that geographic area by season. Any amount available in a CH-RFRPA zone may be taken outside of that area during the same season. For example, the critical habitat harvest limit specified for the 'B' season could be taken outside critical habitat anytime within the A/B season.

Outside of critical habitat, NMFS will establish 2 evenly spaced seasons for all 3 fisheries in the EBS, GOA, and AI (40% of the annual TAC in the A/B season, and 60% of the annual TAC in the C/D season).

9.2 Reasonable and Prudent Alternative

Before prosecuting groundfish fisheries in 2001, NMFS shall amend the FMPs for groundfish in the BSAI and GOA to include the following RPA which consists of 5 general measures, some of which contain sub-elements. NMFS may effect this amendment by working through the NPFMC, through emergency regulations, or through other action taken by the Secretary of Commerce.

9.2.1 Global Control Rule

NMFS will augment the current harvest control rule for determining ABCs with the one provided in this RPA. This change provides additional protection for Steller sea lions.

This rule will apply only to fishing mortality rates established for pollock, Pacific cod, and Atka mackerel in the GOA, AI, and EBS Bering Sea. The ABCs for pollock, Pacific cod, and Atka mackerel will continue to be determined using the best available scientific methods that involve using single, or if available, multi-species models. This measure changes current practice by adjusting the $F_{40\%}$ and F_{OFL} rates if the spawning biomass (B) is projected to be below 40% of the unfished biomass ($B_{40\%}$) in the following year. It would apply to stocks in this range are in Tier 3b. Currently, adjustments to $F_{40\%}$ and F_{OFL} rates for stocks in Tier 3b are made using the following equations, where α=0.05:

$$F_{OFL} = F_{30\%} \text{ x } (B/B_{40\%} - \alpha)/(1-\alpha)$$
$$F_{40\% \text{ (adjusted)}} = F_{40\%} \text{ x } (B/B_{40\%} - \alpha)/(1-\alpha)$$

Under this current control rule, the reduction in F below $F_{40\%}$ is linear depending on how far the stock is below $B_{40\%.}$ Using an α=0.05 means that fishing mortality rates are 0, i.e., no fishing, when the stock reaches 5% of $B_{40\%,}$ or 2% of its equilibrium unfished level.

Under the control rule contained in the RPA, α will be increased from 0.05 to 0.5 for the pollock, Atka mackerel, and Pacific cod fisheries in the EBS, GOA, and AI. When the spawning biomass falls below 40% of the unfished biomass ($B<B_{40\%}$) for any of these stocks, F will decline faster under this control rule than under the existing management regime to buffer the effects of natural variability in stoCh-RFRPA ck abundance. Furthermore, directed fishing for pollock, Pacific cod and Atka mackerel would cease if their spawning biomass fell to 20% or below of equilibrium unfished levels, or 50% of $B_{40\%}$. Consequently, fishing for pollock, Pacific cod and Atka mackerel under this control rule would cease at a population size 10 times larger than under current practices. This measure should ensure that adequate levels of each prey species are maintained for Steller sea lions.

9.2.2 Closure areas

NMFS will create closure areas. The first form of closure areas will be a continuation of the current 3 nm no-entry zones around rookeries specified as critical habitat in 50 CFR part 223. The second form of closures will be comprised of 3 nm no fishing zones for all federally permitted groundfish fishery vessels around major haulouts identified as critical habitat in 50 CFR part 226 or identified as important to the foraging needs of Steller seas lions in the 1998 Biological Opinion for the BSAI and GOA and in the RFRPAs for the pollock fishery. The areas identified as important to the foraging needs of Steller Sea lions were determined from information gathered during surveys since 1979 and included the following criteria: (1) summer haulouts with more than 200 sea lions in a summer survey, and less than 75 sea lions in winter surveys (Summer haulouts); (2) winter haulouts with less than 200 sea lions in summer surveys, and greater than 75 sea lions in a winter survey (Winter haulouts); and (3) year-round haulouts with more than 200 sea lions in a summer survey, and 75 sea lions in a winter survey. These two forms of closure areas are provided with the greatest protection, consistent with the hierarchy of protection established in this, as well as previous, biological opinions, and the importance of areas around rookeries and haulouts to the foraging needs of Steller sea lions.

The third form of closure is a system of closed CH-RFRPA zones which eliminates the possibility for competition between pollock, Pacific cod, and Atka mackerel fisheries and Steller sea lions within those areas.

4. Areas around all rookeries and haulouts sites out to 20 nm that are listed in 50 CFR part 226 as critical habitat.

5. Areas around haulout sites out to 20 nm, as identified in the 1998 Biological Opinion for the BSAI and GOA pollock fishery

3. Critical habitat pelagic foraging areas of the Shelikof Strait in the GOA, Seguam Pass in the AI, and the Sea Lion Conservation Area (SCA). The SCA is located in the EBS and is an expansion of the Bogoslof Foraging Area to include specified areas outside of critical habitat specified at 50 CFR part 226. The inclusion of areas outside of designated critical habitat prevents the potential for edge-effect depletions caused by concentrated fishing in small open areas bounded by critical habitat.

The entire area included within the CH-RFRPA zone will then be subdivided into 13 management zones. Some of these zones will be closed to all fishing for pollock, Pacific cod, and Atka mackerel, while other areas will be open for fishing provided that additional temporal measures are implemented to minimize competition with Steller sea lions. These zones are further described in Tables 9.1 and 9.2. In all, approximately 66% of the total area described below will be closed year-round to directed fishing for pollock, Pacific cod, and Atka mackerel.

9.2.3 Temporal apportionment of TACs

Fishing for pollock, Pacific cod and Atka mackerel inside critical habitat will be prohibited from November 1 through January 20. Additionally, the current trawl closure from November 1 through January 20 will be continued for all areas. Outside of critical habitat, NMFS will establish 2 evenly spaced seasons for all 3 fisheries in the EBS, GOA, and AI. An amount of the annual TAC would be apportioned to each season based on the approach used in the 1998 Biological Opinion so that 40% of the annual TAC is available in the winter season (A/B seasons) and 60% would be available in the fall season (C/D seasons). Inside critical habitat, four seasons will be established for the open CH-RFRPA zones to ensure against high removal rates and possible localized depletions of prey in the most important area for Steller sea lions. This measure will evenly subdivide the combined winter allocation of 40% to the A and B seasons (20% each to the A and B season inside CH), and the combined fall allocation of 60% to the C and D seasons (30% each to the C and D season inside CH). This inside critical habitat percentage (critical habitat was used as a proxy for the entire CH-RFRPA area) would then be multiplied by the ratio of biomass inside to biomass outside of the critical habitat area to derive the seasonal apportionment (this is discussed further below).

9.2.4 Spatial apportionment of TAC

The annual TACs will be apportioned to NMFS management areas according to the status-quo method based on estimates of the seasonal distribution of biomass. Additionally, a harvest limit would be imposed on fishing in the combined CH-RFRPA area based on the proportion of biomass estimated to be in critical habitat open to fishing to the total biomass in the overall management area (NMFS 2000). This methodology ensures that the harvest rate in critical habitat will not be greater than the global rate as determined by the global control rule.

The determination of the fraction of biomass inside critical habitat should be based on the best available information for the distribution of pollock, Pacific cod, and Atka mackerel. We have determined the proportion of TAC to assign to the open portions of critical habitat by using average (1998-99) catch in open areas as a percentage of all the combined zones (1-13) by species, season and management area (NMFS 2000). We assume that the catch distribution in 1998-99 best reflects the biomass distribution. We recognize that this method would be best replaced by a comprehensive survey program that performed surveys and estimated biomass in the winter as well as summer for all 3 species.

Further, a portion of the AI will be opened to pollock fishing that was previously closed under earlier biological opinions and the Pacific cod TAC will be split from a combined BSAI TAC to separate TACs for the EBS and the AI based on the distribution of the stock.

9.2.5 Monitoring

The action area described in Section 3 was divided into three primary blocks, referred to as blocks I, II, and III (see Fig. 9.1). Each of these blocks was further subdivided into 13 areas of the expanded critical habitat areas referred to as the CH-RFRPA (Tables 9.1 and 9.2). The following objectives were used in defining the 13 areas: (1) at least 50% of critical habitat should be closed to fishing ,(2) the area closed to fishing should protect approximately 50% of the non-pup population and 75% of the areas where pups are born, (3) the underlying trend in open and closed areas in each of the three blocks should be statistically equivalent to allow for independent evaluation of the efficacy of the RPA in the three blocks, and (4) after a period no-longer than six years of monitoring, there should be an acceptable likelihood of successfully detecting an improvement in the status of Steller sea lions in each of the three blocks. The details of the design area are provided in section 9.5.

9.2.6 Overview of the conservation impacts of the RPA

The following is a list of the management actions required under the RPA, for the GOA, EBS and AI and the impact of those actions in terms of Steller sea lions protected, portions of critical habitat and important foraging areas closed to pollock, Pacific cod and Atka mackerel fishing, resultant TAC reductions, and seasonal releases:

1. Increase the Protection on Sea Lion Forage Base	
Management Action	**Conservation Impacts of the Action**
Modify the control rule for the overall fishery harvest of the three primary prey species to rapidly reduce the harvest rate should any stock fall below the target reference level. Close the directed fishery on any stock at 20% of its unfished biomass.	* Rapidly reduces the impact of the fishery on the forage base for sea lions even if the reduction in prey species is due to non-fishing factors (i.e., environmental variability). * Reduces the maximum ABC for GOA pollock by 19,000 mt in 2001. * Reduces the maximum ABC for EBS cod by 8,800 mt in 2001. *Reduces the maximum ABC for AI Pacific cod by 1,100 mt in 2001.

2. Increase the Protection for Critical Habitat Areas Through the Use of Closures	
Management Actions	**Conservation Impacts of the Actions**
Create 3 nm no-fishing zones around 78 rookeries and haulouts in the GOA, 11 in the EBS and 50 in the AI. Pollock and Pacific cod fishery exclusion zones in 80,926 km^2 (56% of 144,511 km^2) of the critical habitat area in the GOA. Pollock, Pacific cod and Atka mackerel fishery exclusion zones in 91,844 km^2 (82% of 112,005 km^2) of the critical habitat area in the EBS. Pollock, Pacific cod, and Atka mackerel fishery exclusion zones in 62,570 km^2 (63% of 99,318 km^2) of the critical habitat area in the AI. No fishing in critical habitat for Pollock and Atka mackerel, and Pacific cod from November 1 to January 20, and no trawling for those species during this period anywhere.	* Protects all pups and non-pups in the GOA, the EBS, and the AI from fishing effects and disturbance out to 3 nm from rookeries and haulouts. * Further protects 4,068 pups and 9,016 non-pups in the GOA, 411 pups and 1,508 non-pups in the EBS, and 2,425 pups and 3,588 non-pups in the AI from fishing effects and disturbance 3-20 nm from rookeries and haulouts in closed critical habitat. * Closes areas where approximately 16% of GOA pollock and 28% of GOA Pacific cod catches, 23% of EBS pollock, 24% of EBS Pacific cod, and 2% of BSAI Atka mackerel, 53% of AI pollock, 21% of AI Pacific cod, and 44% of BSAI Atka mackerel catches have occurred (1998-99) . * Greatly reduces the interactions between fisheries and sea lions from November 1 to January 20 (22% of the year).

3. Increase the Temporal Dispersion of the Catch to Minimize the Risk of Localized Depletion of Prey Species	
Management Actions	**Conservation Impacts of the Actions**
The remaining fishing in critical habitat areas is divided into four seasons beginning January 20, April 1, June 11, and August 22. The seasonal harvest limits in critical habitat are roughly evenly distributed throughout the year and are proportional to biomass distribution. Outside of critical habitat, fishing is apportioned into two seasons, beginning January 20 and June 11, with 40% and 60% of the available ABC allocated respectively.	* Reduction in the proportion of Pacific cod taken during the winter in the GOA from 58% to 40%, in the EBS from 52% to 40% and in the AI from 64% to 40% compared to 1998. * Reduction in the proportion of the Atka mackerel catch taken in winter in the AI from 54% to 40% compared to 1998. * Protect against excessive harvest rates which may rapidly deplete concentrations of prey in and near critical habitat.
4. Spatial Distribution and Further Reduction of the Harvest of the Three Primary Prey Species Within Critical Habitat	
Management Action	**Conservation Impacts of the Action**
The allocation of ABC to the remaining open area inside critical habitat and outside critical habitat is based on the best available information on the biomass distribution between these areas.	* Reduction in percentage of pollock caught in critical habitat from 80% to 42% in the GOA, from 45% to 14% in the EBS, and from 74% to 2% compared to 1998. * Reduction in percentage of Pacific cod caught in critical habitat from 48% to 21% in the GOA, 39% to 17% in the EBS and 79% to 17% in the AI compared to 1998. * Reduction in percentage of Atka mackerel caught in critical habitat from 66% to 8% in the AI compared to 1998.
5. Provide a Basis for Developing Better Information on the Impacts of Area Closures and Other Measures	
Management Action	**Conservation Impacts of the Action**
Select area closures to provide contrast between complete closures and restricting fishing areas within critical habitat.	*Provide a stronger experimental statistical basis for the evaluation of area closures on sea lion recovery. *Provide a stronger monitoring capability through experimental design.

9.3 Implementation of the RPA

This section outlines the specific elements of the RPA that must be implemented as described here and identify those items that are frameworked. The FMP level aspect of this RPA, the global control rule, was described in section 9.2.1 and will not be further discussed here. Therefore, this section outlines the methods of implementing the project level aspects of the RPA in further detail than were described in sections 9.2.2 through 9.2.6.

The following table is a brief overview of the temporal fishing pattern required by the RPA. Season dates and percentage of the annual TAC apportioned to each season are fixed. However the catch limit in critical habitat will be a frameworked RPA so that the appropriate limit can be estimated on an annual basis during the Council's TAC specification process. This allows the incorporation of the most recent survey biomass estimates. The details of how these TAC apportionments will be determined follows for each individual species below.

	Seasons			
Area	A	B	C	D
EBS, AI, or GOA	Combined A/B season January 20 - June10 40% of annual TAC		Combined C/D season June 11 - October 31 60% of annual TAC	
CH-RFRPA	A season Jan. 20 - Mar. 31 catch limit*	B season Apr. 1 - Jun. 10 catch limit*	C season Jun. 11 - Aug. 21 catch limit*	D season Aug. 22 - Oct. 31 catch limit*

* The catch limit will be calculated as a factor of half of the combined seasonal allowance for the overall management area multiplied by the ratio of the biomass inside critical habitat to the biomass outside of critical habitat (B_{inCH}/B_{outCH})

9.3.1 Description of Measures Required in the EBS, AI and GOA

Gulf of Alaska

1. NMFS shall amend the FMP for Groundfish of the Gulf of Alaska to include a new global control rule (discussed above) and apply the global control rule if pollock or Pacific cod are determined to be in Tier 3b.

2. NMFS shall promulgate regulations that establish the following closure areas in the GOA:

   A. 3 nm no-entry zones for listed critical habitat rookeries (Table 9.3)
   2. 3 nm no fishing zones for critical habitat haulouts and those additional haulouts identified in the RFRPAs
   C. Pollock and Pacific cod fishery exclusion zones in 80,926 km^2 (56%) of the CH/RFRPA area in the GOA (Fig. 9.1 and Tables 9.1 and 9.2). CH-RFRPA areas open and closed to pollock and Pacific cod fisheries are discussed further in the context of monitoring section 9.5.

3. NMFS shall promulgate regulations to temporally allocate the TAC in the Gulf of Alaska

as follows:

A. Pollock and Pacific cod trawl fisheries shall be prohibited between November 1 - January 20.

B. Two seasons that shall begin on January 20 and June 11 for trawl fisheries and on January 1 and June 11 for non-trawl fisheries.

3. The 2 seasons shall be apportioned 40% and 60% of the TAC, respectively.

D. Four seasons in open CH-RFRPA area that shall begin, respectively, on January 20, April 1, June 11, and August 22 and shall be allocated a ratio of 20:20:30:30 of the TAC, respectively, multiplied by the ratio of biomass in the open area of CH-RFRPA to the amount of biomass in the 3-digit management area (e.g., 610, 620/630, and 640).

E. No fishing for Pacific cod in CH-RFRPA areas between November 1 - January 20.

4. NMFS shall promulgate regulations to spatially allocate the TAC in the Gulf of Alaska as follows:

A. Pollock and Pacific cod TAC shall be allocated to 3-digit management areas on a seasonal basis as currently done, e.g., statistical areas 610, 620/630, and 640.

B. Pollock harvest limits shall be specified for open CH-RFRPA areas in 610, 620, and 630 (Figure 2.5) based on the seasonal proportions of biomass within open CH-RFRPA areas to the amount in the entire 3-digit management area (average catch proportion used as a proxy for biomass).

C. Pacific cod harvest limits shall be specified for open CH-RFRPA areas in 610, 620, and 630 based on the seasonal proportions of biomass within open CH-RFRPA areas to the amount in the entire 3-digit management area (average catch proportion used as a proxy for biomass).

Eastern Bering Sea

1. NMFS shall amend the FMP for Groundfish Fisheries in the Bering Sea and Aleutian Islands Area to include a new global control rule (discussed above) and apply the global control rule if pollock or Pacific cod are determined to be in Tier 3b.

2. NMFS shall promulgate regulations that establish the following closure areas in the EBS:

A. 3 nm no-entry zones for listed critical habitat rookeries (Table 9.3).

2. 3 nm no fishing zones for critical habitat haulouts and those additional haulouts identified in the RFRPAs (Table 9.3).

C. Pollock and Pacific cod fishery exclusion zones in 91,844 km^2 (82%) of the CH-RFRPA area in the EBS (Fig. 9.1 and Table 9.1). CH-RFRPA areas open and closed to pollock and Pacific cod fisheries are discussed further in the context of the monitoring of effects in section 9.5.

3. NMFS shall promulgate regulations to temporally allocate the TAC in the EBS as follows:

A. Pollock, Atka mackerel, and Pacific cod trawl fisheries shall be prohibited between November 1 - January 20.

B. Two seasons that shall begin on January 20 and June 11 for trawl fisheries and on January 1 and June 11 for non-trawl fisheries.
3. The two seasons shall be apportioned 40% and 60% of the TAC, respectively.
D. Four seasons in open CH-RFRPA area that shall begin, respectively, on January 20, April 1, June 11, and August 22 and shall be allocated a ratio of 20:20:30:30 of the TAC, respectively, multiplied by the ratio of biomass in the open area of CH-RFRPA to the amount of biomass in the 3-digit management area.
E. No fishing for Pacific cod in CH-RFRPA areas between November 1 - January 20.

4. NMFS shall promulgate regulations to spatially allocate the TAC in the EBS as follows:

A. Pollock and Pacific cod TACs shall be allocated to open CH-RFRPA areas based on the seasonal proportions of biomass within open CH-RFRPA areas to the amount in the entire management area (average catch proportion used as a proxy for biomass).

Aleutian Islands

1. NMFS shall amend the FMP for the Groundfish Fisheries of the Bering Sea and Aleutian Islands Area to include a new global control rule (discussed above) and apply the global control rule if pollock or Pacific cod are determined to be in Tier 3b.

2. NMFS shall promulgate regulations that establish the following closure areas in the AI:

A. 3 nm no-entry zones for listed critical habitat rookeries (Table 9.3)
2. 3 nm no fishing zones for critical habitat haulouts and those additional haulouts identified in the RFRPAs
C. Pollock and Pacific cod, and Atka mackerel fishery exclusion zones in 59,794 km^2 (61%) of the CH-RFRPA area in the AI (Fig. 9.1 and Table 9.1). CH-RFRPA areas open and closed to pollock, Pacific cod, and Atka mackerel fisheries are discussed further in the context of the monitoring of effects in section 9.3.

3. NMFS shall promulgate regulations to temporally allocate TAC in the AI as follows:

A. Pollock, Atka mackerel, and Pacific cod trawl fisheries shall be prohibited between November 1 - January 20.
B. Two seasons that shall begin on January 20 and June 11 for trawl fisheries and on January 1 and June 11 for non-trawl fisheries.
3. The two seasons shall be apportioned 40% and 60% of the TAC respectively.
D. Four seasons in open CH-RFRPA area that shall begin, respectively, on January 20, April 1, June 11, and August 22 and shall be allocated a ratio of 20:20:30:30 of the TAC, respectively, multiplied by the ratio of biomass in the open area of CH-RFRPA to the amount of biomass in the 3-digit management area.
E. No fishing for Pacific cod in CH-RFRPA areas between November 1-January 20.

4. NMFS shall promulgate regulations to spatially allocate TAC in the AI as follows:

A. Pollock and Pacific cod TACs shall be apportioned to area 12 and a limit established for area inside of the CH-RFRPA area, based on seasonal biomass distribution.

B. Atka mackerel TAC shall be apportioned to 3-digit management areas as currently recommended (EBS combined with area 541). In management area 541 (and the EBS), the limit within CH-RFRPA area 12 is based on the proportion of the area < 200 m depth within area 541.

C. Atka mackerel TACs in 542 and 543 shall be apportioned to areas outside CH-RFRPA area 13 only.

9.3.2 Specifics and Examples of the RPA in EBS

The following is a description of the seasonal TAC apportionments available to the fishery inside CH-RFRPA areas and a discussion of how they are determined.

EBS Pollock

Monthly proportions of pollock biomass in critical habitat (assumed to be equivalent to the CH-RFRPA area in the EBS) were estimated by NMFS (2000). The biomass distribution in critical habitat (percentages) for the appropriate months for each season (A=Jan-Mar, B=Apr-Jun, C=Jun-Aug, and D=Aug-Oct) were averaged to get a seasonal percentage. The proportion of pollock biomass in open critical habitat (area 7) was determined using the average catch percentage in area 7 in 1998-99 multiplied by the fraction of the EBS total biomass in the CH-RFRPA area by season (Table 9.4).

For example, the area 7 A-season catch limit in open critical habitat is the product of:

52% (the percentage of biomass in CH-RFRPA in the A-season),
20% (the percentage of TAC apportioned to the A-season, or half the A/B TAC allocation of 40 %) and
70% (the percentage of 1998-99 CH-RFRPA catch caught in area 7),

which equals 7.3%.

Harvest amounts are based on an assumed 2001 TAC of 1.3 million mt. The global control rule did not modify the maximum ABC because BSAI pollock is above the B_{40} threshold.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **520,000 mt**		C + D (60 % annual TAC) **780,000 mt**	
Limit inside Area 7	max 7.3 % annual TAC **94,900 mt**	max 4.6 % annual TAC **59,800 mt**	max 0.9% annual TAC **11,700 mt**	max 1.4 % annual TAC **18,200 mt**

EBS Pacific cod

Monthly proportions of Pacific cod biomass in critical habitat (assumed to be equivalent to the CH-RFRPA area in the EBS) were estimated by NMFS (2000). The biomass distribution in critical habitat (percentages) for the appropriate months for each season (A=Jan-Mar, B=Apr-Jun, C=Jun-Aug, and D=Aug-Oct) were averaged to get a seasonal percentage. The proportion of pollock biomass in open critical habitat (area 7) was determined using the average catch percentage in area 7 in 1998-99 multiplied by the fraction of the EBS total biomass in CH-RFRPA area by season (Table 9.4)

For example, the area 7 A-season catch limit is the product of:
82% (the percentage of biomass in CH-RFRPA in the A-season),
20% (the percentage apportioned to the A-season), and
42% (the percentage of 1998-99 CH catch caught in area 7),
which equals 6.9%.

Based on the average proportions of the biomass in the Bering Sea and Aleutian Islands subareas, harvest amounts are based on the assumption that the Bering Sea represents 88 percent of the Plan Team's recommended BSAI ABC, or (.88)(188,000) = 165,440 mt. The Plan Team's recommended BSAI ABC (188,000 mt) is less than the maximum ABC derived from the Global control rule (204,618 mt), and is used accordingly.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **66,176 mt**		C + D (60 % annual TAC) **99,264 mt**	
Limit inside Area 7	max 6.9 % annual TAC **11,415 mt**	max 1.3 % annual TAC **2,151 mt**	max 2.5 % annual TAC **4,136 mt**	max 6.0 % annual TAC **9,926 mt**

9.3.3 Specifics and Examples of the RPA in the Gulf of Alaska

The following is a description of the seasonal TAC apportionments available to the fishery inside CH-RFRPA areas and a discussion of how they are determined.

GOA Pollock

Monthly proportions of pollock biomass in critical habitat (assumed to be equivalent to the CH-RFRPA areas in the GOA) were estimated by NMFS (2000). The percentages for the appropriate months for each season (A=Jan-Mar, B=Apr-Jun, C=Jun-Aug, and D=Aug-Oct) were averaged to get a seasonal percentage. The proportion of pollock biomass in areas 1, 3, and 5 were determined using the average catch percentage in areas 1, 3, and 5 in 1998-99 multiplied by the fraction of the GOA total biomass in CH-RFRPA area by season and management area (i.e. 610, 620, 630, and 640; Table 9.4).

For example, the area 5 (610) A-season catch limit is the product of:
28% (the percentage of GOA ABC allocated to 610 in the A-season),
20% (the percentage apportioned to the A-season), and
85% (the percentage of A-season pollock biomass in CH that is in area 5),
which equals 4.8%.

The 2001 GOA pollock ABC as recommended by the Plan Team is 105,810 mt. This ABC is greater than the maximum ABC derived from the global control rule (86,922 mt). For purposes of the calculations below, therefore, the assumed TAC is 86,922 mt. This is the total of the pollock ABCs for the western-central GOA (81,882 mt) plus the East Yakutat-SE Outside (6,460 mt) minus the Prince

William Sound GHL (1,420 mt). The federally managed pollock TAC in the western and central GOA is 80,462 mt; overall W-C apportionments are listed below, followed by area-specific apportionments.

GOA – Area 610 Assumes 28% of GOA ABC in area 610 during A/B; 41% of GOA ABC in area 610 during C/D

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **9,122 mt**		C + D (60 % annual TAC) **19,808 mt**	
Limit inside CH-RFPRA	max 4.8 % annual TAC **3,863 mt**	max 4.8 % annual TAC **3,863 mt**	max 2.1 % annual TAC **1,711 mt**	max 2.1 % annual TAC **1,711 mt**

GOA – Area 620 Assumes 60% of GOA ABC in area 620 during A/B; 24% of GOA ABC in area 620 during C/D.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **19,628 mt**		C + D (60 % annual TAC) **11,766 mt**	
Limit inside CH-RFPRA	max 10.7% annual TAC. **8,591 mt**	max 10.7% annual TAC **8,591 mt**	max 4.6 % annual TAC **3,665 mt**	max 4.6% annual TAC **3,665 mt**

GOA – Area 630 Assumes 8% of GOA ABC in area 630 during A/B; 32% of GOA ABC in area 630 during C/D.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **2,640mt**		C + D (60 % annual TAC) **15,512mt**	
Limit inside CH-RFPRA	max 0.1 % annual TAC **86 mt**	max 0.1 % annual TAC **86 mt**	max 2.2% annual TAC **1,800 mt**	max 2.2 % annual TAC **1,800 mt**

GOA – Area 640 Assumes 2.5% of GOA ABC in area 640

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **794 mt**		C + D (60 % annual TAC) **1,192 mt**	
Limit inside CH-RFPRA	max 0.2 % annual TAC **158 mt**	max 0.2 % annual TAC **158 mt**	max 0.3 % annual TAC **237 mt**	max 0.3 % annual TAC **237 mt**

GOA Pacific cod

Monthly proportions of Pacific cod biomass in critical habitat (assumed to be equivalent to the CH-RFRPA area in the GOA) were estimated by NMFS (2000) (Table 9.4). The percentages for the appropriate months for each season (A=Jan-Mar, B=Apr-Jun, C=Jun-Aug, and D=Aug-Oct) were averaged to get a seasonal percentage.

For example, the area 5 (610) A-season catch limit is the product of:
35% (the percentage of GOA ABC allocated to 610),
95% (the percentage in CH in the A-season in 610),
20% (the percentage apportioned to the A-season), and
25% (the percentage of 1998-99 610 A-season CH catch caught in area 5),
which equals 1.7%.

The GOA 2001 Pacific cod ABC as recommended by the Plan Team is 67,800 mt. This ABC is less than the ABC derived from the Global Control Rule (76,707 mt) and is used accordingly. This ABC level would be further reduced by up to 25% to provide for the Alaska State managed cod fishery. The apportionments below are not reduced to reflect the State water fishery.

GOA – Area 610 Amounts based on assumed GOA 2001 TAC of 24,000 mt, which is equal to the Area 610 ABC recommended by the GOA Plan Team.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **9,600 mt**		C + D (60 % annual TAC) **14,400 mt**	
Limit inside CH-RFPRA	max 1.7 % annual TAC **1,153 mt**	max 0.1 % annual TAC **68 mt**	max 0.1% annual TAC **68 mt**	max 0.1 % annual TAC **68 mt**

GOA – Area 620/630 Amounts based on assumed GOA 2001 TAC of 38,650 mt, which is equal to the Area 620/630 ABC recommended by the GOA Plan Team.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **15,460 mt**		C + D (60 % annual TAC) **23,190 mt**	
Limit inside CH-RFPRA	max 8.0 % annual TAC **5,424 mt**	max 2.2 % annual TAC **1,492 mt**	max 3.7 % annual TAC **2,508 mt**	max 3.8 % annual TAC **2,576 mt**

GOA – Area 640 Amounts based on assumed GOA 2001 TAC of 4,750 mt, which is equal to the Area 640 ABC recommended by the GOA Plan Team.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **1,900 mt**		C + D (60 % annual TAC) **2,850 mt**	
Limit inside CH-RFPRA	max 0.4 % annual TAC **271 mt**	max 0.2 % annual TAC **135 mt**	max 0.2 % annual TAC **135 mt**	max 0.3 % annual TAC **203 mt**

9.3.4 Specifics and Examples of the RPA in the AI

The following is a description of the seasonal TAC apportionments available to the fishery inside CH-RFRPA areas and a discussion of how they are determined.

AI Pollock

Monthly proportions of pollock biomass in critical habitat (assumed to be equivalent to the CH-RFRPA area in the AI) were estimated by NMFS (2000) (Table 9.4). The percentages for the appropriate months for each season (A=Jan-Mar, B=Apr-Jun, C=Jun-Aug, and D=Aug-Oct) were averaged to get a seasonal percentage. The proportion of pollock biomass in areas 12 and 13 were determined on the basis of the relative catch distributions in each area from the 1998 fishery. ABC is not apportioned among the three management areas in the Aleutian Islands.

For example, the area 12 A-season catch limit is the product of:
52% (the percentage in CH in the A-season),
8% (the percentage of pollock catch in 1998 in areas 12 and 13 that came from area 12), and
20% (the percentage apportioned to the A-season),
which is 0.9%.

In the AI, pollock ABC as recommended by the Plan Team for 2001, is 23,800 mt, which is equal to the maximum ABC derived from the global control rule and is used accordingly.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **9,520 mt**		C + D (60 % annual TAC) **14,280 mt**	
Limit inside CH-RFPRA	max 0.9 % annual TAC **214 mt**	max 1.0 % annual TAC **238 mt**	max 1.8 % annual TAC **428 mt**	max 1.7 % annual TAC **404 mt**

AI Pacific cod

Monthly proportions of Pacific cod biomass in critical habitat (assumed to be equivalent to the CH-RFRPA area in the AI) were estimated by NMFS (2000) (Table 9.4). The percentages for the appropriate months for each season (A=Jan-Mar, B=Apr-Jun, C=Jun-Aug, and D=Aug-Oct) were averaged to get a seasonal percentage. The proportion of Pacific cod biomass in areas 12 and 13 was determined on the basis of the relative catch distributions in each area from the 1998 fishery. ABC is not apportioned among the three management areas in the Aleutian Islands.

For example, the area 12 A-season catch limit is the product of:
79% (the percentage in CH in the A-season),
87% (the percentage of P. cod catch in 1998-99 in areas 12 and 13 that came from area 12), and
20% (the percentage apportioned to the A-season),
which is 13.7%.

Based on the average proportions of the biomass in the Bering Sea and Aleutian Islands subareas, harvest amounts are based on the assumption that the Aleutian Islands represents 12 percent of the Plan Team's recommended BSAI ABC, or (.12)*(188,000) = 22,560 mt. The Plan Team's recommended BSAI ABC (188,000 mt) is less than the maximum ABC derived from the global control rule (204,618 mt), and is used accordingly.

Season	A	B	C	D
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **9,024 mt**		C + D (60 % annual TAC) **13,536 mt**	
Limit inside CH-RFPRA	max 13.7 % annual TAC **3,090 mt**	max 7.4 % annual TAC **1,669 mt**	max 4.4 % annual TAC **993 mt**	max 9.7 % annual TAC **2,188 mt**

BSAI Atka mackerel

The proportion of Atka mackerel biomass within the CH-RFRPA area is not thought to vary seasonally. Furthermore, it was assumed that the proportion inside was directly proportional to the percentage of Atka mackerel habitat (< 200 m depth) in the CH-RFRPA area. Survey information provides relative biomass by 3-digit management area, and the proportions of area < 200 m depth inside the CH-RFRPA area provide the relative proportions of biomass inside. For the area outside of CH-RFRPA, the four seasons were combined by averages of the A/B and C/D seasons.

For example, the area 12 A-season catch limit is the product of:
75% (the percentage of biomass within CH-RFRPA area 12 in area 541),
20% (the percentage of ABC apportioned to the A-season), and
11% (the percentage of AI Atka mackerel biomass in area 541),
which equals 1.7%.

The BSAI Atka Mackerel ABC as recommended by the Plan Team for 2001 is 58,700 mt. This ABC is less than the ABC derived from the Global Control Rule (97,254 mt) and is used accordingly.

BSAI – Eastern Aleutians/Bering Sea (541/BS) Amounts based on assumed area 541 2001 TAC apportionment of 6,600 mt, which is the Area 541 ABC recommended by the BSAI Plan Team.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **2,640 mt**		C + D (60 % annual TAC) **3,960 mt**	
Limit inside CH-RFPRA	max 1.7 % annual TAC **998 mt**	max 1.7 % annual TAC **998 mt**	max 2.5 % annual TAC **1,468 mt**	max 2.5 % annual TAC **1,468 mt**

BSAI – Central Aleutians (542) Amounts based on assumed AI district 542 2001 TAC apportionment of 28,500 mt, which is the Area 542 ABC recommended by the BSAI Plan Team. Fishing is prohibited within CH-RFRPA areas.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **11,400 mt**		C + D (60 % annual TAC) **17,100 mt**	

BSAI – Western Aleutians (543) Amounts based on assumed area 543 2001 TAC apportionment of 23,600 mt, which is the Area 543 ABC recommended by the BSAI Plan Team. Fishing is prohibited within CH-RFRPA areas.

Season	**A**	**B**	**C**	**D**
Season dates	Jan 20 - Mar 31	Apr 1 - Jun 10	Jun 11 - Aug 21	Aug 22 - Oct 31
TAC outside CH-RFRPA	A + B (40 % annual TAC) **9,440 mt**		C + D (60 % annual TAC) **14,160 mt**	

9.4 How the RPA Avoids Jeopardy and Adverse Modification

9.4.1 The approach used

The ESA imposes on federal agencies a duty to insure that their actions will not jeopardize listed species or destroy or adversely modify their designated critical habitat. Although the ESA does not define the term “jeopardize,” implementing regulations provide:

> “Jeopardize the continued existence of” means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

50 C.F.R. § 402.02. The regulations also define “adverse modification” as:

> “Destruction or adverse modification” means a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical.

50 C.F.R. § 402.02. The ESA clearly establishes two separate standards by which agency actions must be judged. The jeopardy standard focuses on the continued existence of the listed species itself, requiring examination of the effects of agency action on the species’ reproduction, population and range. Adverse modification, in contrast, addresses the effects of agency action on the species’ habitat, focusing on impacts to the particular qualities that make the habitat critical to the survival and recovery of the listed species. Although there is considerable overlap between these two standards in our evaluation of the groundfish fisheries, our assessment of the likelihood of jeopardy examines *the population’s response* while our assessment of adverse modification examines the effects on *the availability of an adequate prey field inside critical habitat*. The adequacy of the RPA must also be evaluated in terms of these same two standards.

The preceding analysis in this biological opinion supports a determination that certain groundfish fisheries currently authorized by the FMP are likely to jeopardize the continued existence of endangered Steller sea lions and adversely modify their critical habitat. These determinations result from available evidence of competitive interaction between the fisheries for pollock, Atka mackerel and Pacific cod and Steller sea lions. This competitive interaction, occurring at the global, regional and local scales has been shown to jeopardize the continued existence of Steller sea lions by interfering with their foraging opportunities for the three major prey species resulting in reduced reproduction and survival. The reduction in survival and reproduction has enhanced decline in the numbers of sea lions relative to an unfished action area. Scientific evidence suggests that the same competitive interaction also has been shown to adversely modify the critical habitat designated for Steller sea lions by reducing the availability of the prey field at temporal and spatial scales relevant to foraging sea lions. Because this competitive interaction is the basis for both the determinations of jeopardy and adverse modification of critical habitat, the RPA avoids jeopardy and adverse modification by requiring FMP amendments that protect both the population from the adverse competitive effects of the fisheries but also protect both the availability of an adequate prey field inside critical habitat.

The global control rule is required to avoid both jeopardy and adverse modification, as detailed in subsection in section 9.4.2 (below). The *regional and local scale* effects of competitive interaction are avoided by requiring the combination of actions specified in the RPA which eliminate, or appreciably reduce, the intensity of the interactions themselves. The RPA avoids jeopardy and adverse modification, using the suite of actions contained herein, at all three scales where the competitive interactions occur, as follows.

In Section 6.4.2.6, a series of seven questions was used to identify the areas of overlap between the foraging habits of Steller sea lions and the harvesting patterns of individual groundfish fisheries. The greater the degree of overlap, reflected by affirmative answers to the seven questions, the greater the concern that competitive interaction occurred. The procedure identified the pollock, Pacific cod and Atka mackerel fisheries as having such competitive interactions with Steller sea lions (for each fishery, affirmative answers were given to all seven questions). The logic used in this biological opinion to avoid jeopardy and adverse modification, therefore, is to apply an RPA, containing multiple elements, to the very same points of overlap (reflected in the series of questions) that define the interactions in the first place. That is, the RPA prescribes actions for individual forms of overlap, which when combined, reduce the competitive interaction, independent of its sources. It is because the competitive interaction arises from multiple points of overlap, evident at global, regional and local scales, that the RPA must also require multiple actions.

While the most comprehensive approach to eliminating competition would suggest prescribing actions under the RPA that addressed every point of overlap, this is not necessary to avoid jeopardy and adverse modification, nor is it possible without the complete elimination of fisheries because the interactions with Steller sea lions arise not only from the actions of the groundfish fisheries themselves, but also from the behavior, foraging habits and life history patterns of Steller sea lions. However, a number of means of avoiding the competitive interaction are available. Questions 1 and 2 in Section 6.4.2.6 address the extent to which Steller sea lions forage on target fish species. Given the answer to questions 1 and 2 is positive, consideration of the overlaps underlying questions 3 - 7 identify those opportunities to avoid jeopardy and adverse modification by constraining, rather than eliminating fisheries for pollock, Pacific cod and Atka mackerel.

Question 3 - Prey Size Overlap

Interactions between groundfish fisheries and Steller sea lions could not be eliminated by complete separation of the two components in the size of fish caught. Fishing gear is not so selective by size that complete separation in this dimension is possible. Furthermore, since Steller sea lions eat a wide range of sizes of juvenile and adult fish, management actions addressing this problem would have to restrict fisheries to sizes smaller than juvenile fish which is an unreasonable fisheries management practice. Thus, the RPA does not attempt to eliminate interactions stemming from overlap in the size of pollock, Atka mackerel and Pacific cod consumed and harvested.

Question 4 - Spatial Overlap

Reducing competitive interactions between groundfish fisheries and Steller sea lions by spatial partitioning is a viable approach. The extent to which partitioning would be useful, however, varies with both the use of the area by the forager and the extent to which harvesting occurs in that area. For instance, complete spatial partitioning could only be accomplished by prohibiting groundfish fisheries from operating in all places where Steller sea lions forage on pollock, Pacific cod, and Atka mackerel. This would include all designated critical habitat plus adjoining areas of the continental shelf and slope in the Gulf of Alaska, Bering Sea and Aleutian Islands. However, this approach fails to account for the concept that rare instances of overlap should not be treated the same as instances of intense overlap. Instead, this RPA prescribes partitioning rules that reflect differing use of habitat by Steller sea lions. In particular, areas in close proximity to haulouts and rookeries (e.g., within 3 nm) are fully partitioned, i.e., closed to fishing, as is the majority of critical habitat.

Question 5 - Temporal Overlap

Temporal partitioning of groundfish fisheries and Steller sea lions is also a viable approach. As in the case of spatial partitioning, it must be applied when the competitive interactions are most likely to occur. There are seasonal differences in the frequency of occurrence of pollock, Pacific cod and Atka mackerel in sea lion diets that suggest a targeted application of temporal RPA actions. In particular, the RPA requires partitioning of critical habitat during the winter season as it is a particularly sensitive period for Steller sea lions.

Question 6 - Depth Overlap

Interactions between groundfish fisheries and Steller sea lions within the water column could not be completely partitioned. On a diurnal basis, fish move up and down in the water column such that their availability at depths used by sea lions would be affected if fisheries were only restricted to shallower or deeper depths. Use of the water column by fish and sea lions is not an action that can reasonably be affected through groundfish fishery management measures.

Question 7 - Overlap with Temporally/Spatially Concentrated Fisheries

Competitive interactions between groundfish fisheries and Steller sea lions that result from the temporal and spatial concentration of prey removals are addressed by the RPA. The intention of these measures is to disperse the fisheries removals in time and space, thereby reducing the likelihood that fisheries would reduce the availably of prey for Steller sea lions (i.e., cause localized depletions). In addition, the RPA disperses these fisheries both on a regional scale and at the local scale of relevance to an individual foraging sea lion. Temporal and spatial allocations of groundfish TAC that reduce the intensity of fishing effort in a particular season at the regional scale is the first of two steps. The second step is to ensure that the TAC apportionment is harvested in a dispersed manner such that the rate of removal does not exceed the rate of replenishment across local areas used by foraging Steller sea lions. This involves full protection of all rookeries and haulouts within 3 nm. The RPA also requires four seasonal harvest limits in open CH-RFRPA areas that distributes harvest over time and in a manner consistent with seasonal distribution of biomass in these areas.

As described in Section 6 of this biological opinion, the pollock cooperatives established under the AFA have resulted in significant changes to the fishing pattern of the Bering pollock fishery since 1998. These cooperatives have greatly increased the spatial and temporal dispersion of this fishery (Appendix 4). The positive correlation of dispersion of fishing effort in the Bering Sea and Aleutian Islands is expected to continue.

9.4.2 The Global Control Rule

The global control rule operates at the ecosystem or global scale, and as such, it is neither a partitioning or dispersive action. It is a revised, more precautionary adjustment procedure for pollock, Pacific cod or Atka mackerel stocks in the EBS, AI and GOA at small stock sizes (below $B_{40\%}$) than currently exists under the FMP. The effect of using the global control rule is increased likelihood that the stock is maintained at or above the target stock size by reducing the exploitation rate at low stock sizes thereby insuring a more sable source of available prey for Steller sea lions..

NMFS has concluded that the best available scientific evidence is consistent with the hypothesis that the trajectory of the western population of Steller sea lions in the absence of a groundfish fishery in the action area (GOA and BS) would only be marginally different than the trajectory of Steller sea lions under a groundfish fishery managed under the RPA described herein. NMFS would have expected the sea lion population in question to have equilibrated at a population level somewhere in the vicinity of the estimated population size between 1991 (i.e., approximately 49,000 animals) and 1998 (i.e., approximately 39,000 animals) absent a fishery, although it is certainly possible that the sea lion population absent a fishery would have continued to decline. NMFS believes that this reduced equilibrium value relative to the equilibrium value thought to exist in the 1970s was caused by a combination of changes in the ecosystem due to the regime shift as well as changes in the ecosystem caused by commercial fishing.

Specifically, after implementing the RPA and the prosecution of the groundfish fishery over the next 5 years, NMFS anticipates that the western population of sea lions will respond similarly to a population of sea lions in an unfished environment. That is, the number of sea lions in western Alaska may increase in abundance, equilibrate at its current level, or even decline in abundance, but this same population response would occur absent a fishery. This change in the underlying growth rate would primarily result from increases in survival and reproduction of sea lions in the areas closed to pollock, Pacific cod, and Atka mackerel fishing. However, NMFS expects sea lion numbers, in the parts of critical habitat open to fishing and in areas outside critical habitat open to fishing, to also benefit from this RPA.

In 2001, three stocks are projected to be below $B_{40\%}$ in 2001: GOA pollock, BSAI Pacific cod, and AI Atka mackerel. The GOA pollock ABC using the current tier 3B adjustment would have been 105,810 mt, but using the global control rule reduces the maximum ABC by almost 19,000 mt to 86,922 mt. Similarly, the maximum BSAI Pacific cod ABC using the current tier 3B adjustment would have been 213,800 mt but using the global control rule reduces the maximum ABC by about 9,200 mt. The BSAI Plan Team, however, recommended a further reduction to 188,000 mt to account for uncertainty. The BSAI Atka mackerel maximum ABC would have been 99,165 mt, but the global control rule reduces the maximum ABC to 97,250 mt. The BSAI Plan Team further reduced this amount to 59,000 mt to account for uncertainty. The remaining stocks (EBS pollock, AI pollock and GOA Pacific cod) are all projected to be above $B_{40\%}$ in 2001 and would thus require no F adjustment under the global control rule. Consequently, using the global control rule will, on average, maintain larger populations of pollock, Atka mackerel, and Pacific cod in the ecosystem as Steller sea lion prey.

9.4.3 Avoidance of niche overlap

RPA elements that completely separate sea lions and groundfish fisheries operate at global and regional scales, and in both temporal and spatial dimensions. The single temporal element that prohibits trawl fishing for pollock, Pacific cod, and Atka mackerel between November 1 and January 20 completely eliminates interactions in critical habitat between sea lions and these trawl fisheries for 22% of the year. As such, this action operates at a global or ecosystem scale. More complete separation in critical habitat is necessary in this period because sea lions at this time are most sensitive to prey availability. For the remaining 78% of the year, dispersive actions taken at finer temporal and spatial scales (discussed below) are also necessary to avoid jeopardy and adverse modification.

There are two spatial partitioning elements which operate at the regional scale. The first is the creation of 3 nm no-fishing zones around all haulouts, which will be added to the existing closures around most rookeries of the western stock of Steller sea lions. In the GOA, EBS and AI, a total of 139 3 nm no-fishing zones will exist that will completely protect all pups (most recent count of 9,373) and non-pups (most recent count of 25,187) from disturbances associated with fishing in close proximity to important terrestrial breeding and resting habitat. This action closes a total of 11,800 km^2, or 3%, of Steller sea lion critical habitat to all fishing by federally permitted vessels.

The second spatial partitioning element is the exclusion of all fisheries for pollock, Pacific cod, and Atka mackerel from approximately 66% of the CH-RFRPA areas in the GOA, EBS, and AI. This protects a total of 6,904 pups and 14,112 adult and juvenile seas lions (most recent counts) by closing a total of 223,540 km^2 from regional effects of the pollock, Pacific cod, and Atka mackerel groundfish fisheries.

9.4.4 Dispersing harvest under the RPA

The actions described above provide significant protection for Steller sea lions from the pollock, Pacific cod and Atka mackerel fisheries with respect to competitive interactions with Steller sea lions. However, other measures are necessary to avoid jeopardy and adverse modification caused by unconstrained fisheries in the remaining 34% of open critical habitat and other open times and areas. These measures disperse fishing effort at regional and local scales to reduce the effects of groundfish fisheries on prey availability for sea lions to negligible or background levels. At the regional scale, one temporal and two spatial actions are taken, while at the local scale, a single temporal measure is used.

The use of two seasonal allocations of TAC and four associated harvest limits in CH-RFRPA areas disperses fishing effort throughout the year. Season start dates are set at January 20 and June 11 for the A/B and C/D seasons respectively. TAC is allocated to two combined seasons using the guideline developed in previous biological opinions, which stated that no more than 40% of the TAC could be allocated to the first seasons in order to reduce fishing effort in the winter.

Once the seasonal TAC is set, it is spatially dispersed throughout the open CH-RFRPA fishing area based on the best estimates of seasonal biomass distribution. The RPA will limit the effects of fishing effort and resulting catch evenly in critical habitat, and provide incentives to vessels to fish outside critical habitat. Thus, within the GOA, EBS, and AI, pre-existing management areas are used to spatially allocate TAC. These include management areas 610, 620, 630, and 640 in the GOA, the EBS, and areas 541, 542, and 543 in the AI. Furthermore, harvest limits within open portions of critical habitat in each management area are set seasonally based again on our best estimates of biomass distribution. Relative to recent levels, setting of harvest limits within open critical habitat will reduce from 1998 and 1999 levels the percentage of annual pollock caught in critical habitat by 31-72%, annual Pacific cod caught in critical habitat by 27-62%, and annual Atka mackerel caught in critical habitat by 64% in the GOA, EBS, and AI.

9.5 Monitoring the effects of the action as modified by the RPA

Over the past decade the NPFMC has noted the importance of assessing the efficacy of conservation measures intended to promote the recovery of the western population of Steller sea lions. Development and implementation of further sea lion protective regulations that restrict normal fishing operations would be enhanced by the NMFS establishment of a well-designed monitoring program that would be used to ascertain the extent to which the implemented measures to promote the recovery of sea lions. To this end, NMFS has incorporated into its RPA a monitoring program that will allow for such an assessment.

As noted earlier, the approach recommended in this Biological Opinion is reasonably designed to avoid jeopardy and adverse modification of critical habitat. The overall approach of the RPA involves the following strategy: (1) protect a substantial number of the rookeries and haulouts used by Steller sea lions and the marine environment immediately offshore of these areas from disturbance associated with commercial fishing for the three primary prey species (i.e., pollock, Atka mackerel, and Pacific cod), (2) protect a substantial portion of critical habitat from the effects of commercial fishing on the three primary prey species, (3) ensure that adequate forage resources are available to support a sustained population of

Steller sea lions in excess of 34,600 animals, and (4) in areas where fishing is allowed, ensure that fishing does not create areas where Steller sea lions are not able to successfully forage.

Therefore, the RPA is designed to close adequate portions of critical habitat to commercial fishing for the three primary prey species of groundfish, while imposing restrictions on fishing operations in areas open to fishing to avoid local depletion of prey resources for Steller sea lions. This approach of creating areas open and closed to fishing operations forms the basis for the monitoring program designed to assess the efficacy of the RPA and any associated conservation measures.

As indicated earlier, the action area described in section 3 was divided into three primary blocks, referred to as blocks I, II, and III. Each of these blocks was then further subdivided into 13 CH-RFRPA areas, as described in Table 9.1. The following objectives were used in defining the 13 areas: (1) at least 50% of critical habitat should be closed to fishing; (2) the area closed to fishing should protect approximately 50% of the non-pup population and 75% of the areas where pups are born; (3) the underlying trend in open and closed areas in each of the three blocks should be statistically equivalent to allow for independent evaluation of the efficacy of the RPA in the three blocks; and (4) after a period no-longer than six years of monitoring, there should be an acceptable likelihood of successfully detecting an improvement in the status of Steller sea lions in each of the three blocks.

9.5.1 Design detail

The 13 areas depicted in Figure 9.1 were assigned to blocks as follows: Block I is comprised of areas 1, 2, 3, 4, 5, and 6; Block II comprised of 7, 8, 9, 10, 11; Block III- 12 and 13. The following areas - 1, 3, 5, 7 and 12- were assigned an open status while the remaining areas were assigned a closed status relative to fishing operations for pollock, Pacific cod and Atka mackerel. Tables 9.1, 9.2, and 9.3 provide a description of the areas within each block, the specific rookeries or haulouts enclosed, and the total area open/or closed for each block and sub area. Table 9.5 provides a summary of the non-pups, non-pup counting sites, pups, and pup counting sites by each of the 13 areas. Table 9.6 provides a summary of the number of non-pups and pups by block and open/closed areas.

9.5.2 Assumptions

Several assumptions were made in defining the blocks and areas described in section 9.5. These include the following. The first assumption is that the population trends in open and closed areas within each block are similar (see Tables 9.7 and 9.8 for summaries of non-pup count and trend data by blocks). The second assumption is that there is a comparable amount of fishing in each of the open and closed areas in each block. As displayed in Table 9.9, substantial amounts of catch are reported for each of the closed and open areas in each of the three blocks. The third assumption is that there is adequate statistical power over the next 5- 10 years to detect improvement were the subpopulations in each of the closed areas to increase their respective trends in abundance by 4% per year; this will be discussed further below. In general, after 6 years of annual surveys, there is adequate statistical power to ascertain whether the RPA contributes to the recovery of sea lions, where the underlying condition is that the fishery is contributing to the decline of sea lions in the action area, and adequate statistical power to ascertain that the RPA is not a primary factor in understanding the current decline, where the underlying condition is that the fishery is not contributing to the decline of sea lions in the action area.

9.5.3 Interpreting results of the monitoring project

As already stated, the goal of the monitoring project is to ascertain the extent to which the implemented conservation measures promote the recovery of sea lions (i.e. remove jeopardy and adverse modifiction).

Consequently, the population trend of sea lions after implementation of the conservation measures will be compared to the population trend before implementation, both in closed and open areas. This information, in combination with other studies, will allow an investigation regarding whether the conservation measures are effective.

It is expected that any effect of fishing will be removed in the closed areas. Therefore, the population trend in the closed areas is expected to improve after implementation. Similarly, the conservation measures in the open areas are also thought to be adequate to remove any major effect of fishing on sea lions. If this is true, the population trend in the open areas is also expected to improve after implementation.

Therefore, if the population trend after implementation improves relative to trends over the past decade in both the open and closed areas, this can be interpreted as evidence that the conservation measures have removed the effect of fishing. If the population trend improves in closed areas but not in open areas, this can be interpreted as evidence that fishing effects were removed in the closed area but not in the open area.

Alternatively, if fishing activities are not a contributing factor to the decline of sea lions, then the expectation is that there will be no change in the population trend in either open or closed areas. Therefore, if there is no improvement in the population trend, this can be interpreted as evidence the fishery has not been a contributing factor to the decline of sea lions.

The four possible outcomes are described in Table 9.10. Outcomes 1 and 2 are consistent with the hypothesis that the fishery is contributing to the decline of sea lions, whereas Outcomes 3 and 4 are not consistent with that hypothesis.

It is important to think about the specific interpretation of each of these possible outcomes. For example, consider the case where Outcome 1 is the result, because the population trend improves in both open and closed areas. This result would be consistent with the hypothesis that the fishery has contributed to the decline of sea lions. However, an improvement in the population trend after the implementation of conservation measures will only represent a correlation – it does not prove causation. For this reason, it will be important to consider the results of additional studies to provide additional evidence that is consistent with the hypothesis that the fishery contributed to the decline of sea lions. For example, evidence that more fish are available to sea lions in critical habitat would be an additional piece of evidence that would help to prove causation. Another example would be a decrease in a measure of foraging effort of sea lions would be an indication that more fish were available to sea lions.

There will still always be the possibility that an improvement in population trend has, by coincidence, occurred for another reason, such as an improvement in environmental conditions for sea lions that is unrelated to the fishery. For this reason, it will remain important to consider information on oceanographic conditions and other environmental variables to see if environmental conditions have happened to have undergone a large change that is coincident with the implementation of the conservation measures.

Particularly for block I (Gulf of Alaska), it may be useful to simultaneously consider trends in the eastern stock of Steller sea lions in Southeast Alaska. While environmental conditions may differ between these two areas, a concurrent improvement in the population trend (of a similar magnitude) of sea lions in Southeast Alaska would be consistent with the hypothesis that there has been an improvement in environmental conditions for sea lions in the region that is independent of the fishery in the Gulf of Alaska.

Additionally, the population trend in the closed area can be compared to the population trend in the open area. If the fishery has contributed to the decline of sea lions, and the population trend has improved in both areas, there are two possible situations. First, the population trend could be similar between the closed and open areas. This would indicate that the conservation measures in the open areas had an equivalent effect as the conservation measures put in place in the closed areas. Second, if the population trend in the closed area is greater than the population trend in the open area, this indicates the conservation measures in the open area have led to an improvement in conditions for sea lions, but not as great an improvement as was seen in the closed area.

Similar reasoning can be used in the other three possible outcomes to aid in the interpretation of the results from the monitoring program.

Criteria for concluding the population trend is better

After a specified period of time, a decision will need to be made regarding whether the population trend is better, as expected. A quantitative criteria to be used in the decision making process is described here.

Consistent survey protocols have been in place since 1991. Therefore, the period 1991-2000 can serve as a baseline of past trends in abundance. There were six surveys over this time period. A linear regression on the natural logarithm of abundance can be used to provide an estimate of the previous rate of change of the population. The exponential rate of change of a population is traditionally called r, so the old trend of the population will be called r_{old}.

New management actions will be implemented in 2001. Therefore, there is an expectation that the population trend to follow the trajectory that Stellers would follow in an unfished environment from the year 2000 onwards. If annual surveys are performed, by the year 2003 there will be 4 surveys to examine the trend of the population, with 6 surveys by year 2005 and 8 surveys by year 2007. This new trend (r_{new}) can be compared to the old trend to examine the effect of the management actions.

The verbal statement of the monitoring criteria is-

> "The new trend of the population is expected to be better than the old trend of the population."

This can be turned into a quantitative statement regarding the old and new trends of the population.

> "The new rate of change of the population, r_{new}, is expected to be greater than the old rate of change of the population, r_{old}, or
>
> $r_{new} > r_{old}$"

Both these quantities (r_{old} and r_{new}) are estimated from data, and have some uncertainty which can be represented as a distribution. It is easier to think in terms of a single distribution for a single quantity, rather than attempt to compare two distributions. Therefore, an equivalent statement is

$$r_{new} - r_{old} > 0.0$$

If the difference between the new and old growth rates is greater than 0.0, this indicates the population trend has improved. However, this would include the possibility of such a small improvement as to be of no real consequence to the population. Therefore, we can ask the question, has the population trend improved by a biologically relevant amount? An improvement of at least 0.01 (or 1% per year) would be biologically relevant. This would lead to a slight modification of the above statement.

The last piece to specify in establishing this quantitative criteria is to specify how certain the results have to be to conclude that the new trend is better than the old trend.

Statistical procedures

One standard statistical method for determining when a new trend is considered better than an old trend would be to specify a null hypothesis (H_0) that there is no difference in the trends, and then do a statistical significance test which would reject or not reject this null hypothesis. Rejection of the null hypothesis would be considered evidence that the trend has improved, and an inability to reject the null hypothesis would be considered evidence that the trend has not improved (though one should bear in mind the issue of how much statistical power there was to correctly reject a false null hypothesis – this issue will be considered below).

$$H_0: \ r_{new} - r_{old} < 0.01$$

A significance level is chosen for rejecting the null hypothesis, such as α=0.10. This means that under the null hypothesis, if the data that were observed (or more extreme data) were less that α probable, the null hypothesis would be rejected. α represents the Type I error rate, which is the probability of incorrectly rejecting a true null hypothesis.

Statistical power is the probability that a false null hypothesis will correctly be rejected. One minus power is referred to as the Type II error rate – the probability of incorrectly not rejecting a false null hypothesis. The statistical power to detect a trend is known to be a function of the precision of the abundance estimates, the magnitude of the trend, the length of the monitoring period, and the significance level chosen (Gerrodette 1987). The statistical power to detect a difference in the population trend before and after conservation measures was calculated for the open and closed area in each block (Table 9.11).

Although Table 9.11 indicates how much statistical power there is to detect an improvement in one area, it does not completely address the issue of how often one will correctly come to the correct conclusion. The 4 possible outcomes specified in Table 9.10 depend each depend upon the results of two statistical tests – the detection or not of a trend in both the closed and the open area. To directly investigate this issue, simulations were performed to determine how often one would reach the correct outcome. Because there are 4 possible different outcomes, 4 different simulations were performed with different underlying scenarios: (1) trend increases by 0.04 in both closed and open areas, (2) trend increases by 0.04 in closed area but remains the same in the open area, (3) trend remains the same in both closed and open areas, and (4) trend remains the same in the closed area but increases by 0.04 in the open area. In each scenario, the frequency with which the correct outcome was chosen was tabulated (Table 9.11).

The major issue is determining whether there is evidence that the fishery has contributed to the decline in sea lions. Making a mistake in this conclusion can be called a major error, whereas making a mistake only regarding how well the conservation measures are working in the open area can be considered a minor error, relatively speaking. For example, if the true condition is that the trend has improved in both the closed and open areas, then Outcome 1 would be the correct conclusion, concluding Outcome 2 would be a minor error, and concluding Outcome 3 or 4 would be a major error. Therefore, for each scenario, the frequency with which the conclusion was correct or only a minor error was tabulated (Table 9.12). This represents the rate at which a major error is avoided.

The probability of making an error after 6 years of data varies depending upon what actually happens, and it varies by area because the data are more or less precise in different areas. Although these error rates are not exactly Type I and II error (because they depend on more than one statistical test), they are closely related concepts. In particular, in the same way that raising the Type I error rate will lower the Type II error rate, and vice versa, there will be trade-offs between the error rates for the various outcomes.

Decision analysis

An alternative to the significance testing approach is to use decision theory (Berger 1985). The mathematical theory of decision making under uncertainty has been established for several decades (Raiffa and Schlaiffer 1961). A brief summary of the approach is this — list the possible options in the decision, assign a relative undesirability of each possible outcome under each possible decision option (referred to as the relative "loss"), calculate the probability of each outcome, then assign an expected loss to each possible decision option by summing the loss for all outcomes weighted by their respective probability. The preferred decision is the option with the smallest expected loss.

In the context here, there are four possible options for the decision, which were outlined in Table 9.10. There are also four possible true conditions that may result, which are the same four possibilities outlined in Table 9.10. If the trend actually is better in both the closed and open areas, and one then concludes that the trend is better in both areas, this is a correct decision, and there is no "loss" associated with making that decision (Table 9.13). However, arriving at any other conclusion represents an error, and so a relative loss value will be attached to each of these possible errors. To reflect the difference outlined above between major and minor errors, different relative loss values are assigned to the different types of errors. Still, considering the situation where the true condition is that the trend has improved in both the closed and open areas (Table 9.10), concluding that the trend has improved in the closed area but not the open area (Outcome 2) is a minor error, and has a relatively low loss value assigned to it. However, concluding that Outcome 3 or 4 has happened will be a major error, as the conclusion will be that the fishery has not contributed to the decline of sea lions when in fact in has. Therefore, a relatively higher loss value is assigned to these major errors (Table 9.13).

The other three columns in Table 9.13 outline the loss values that are assigned to possible errors for the three other possible true situations. Major errors are found in the upper right four boxes and in the lower left four boxes. The upper right area represents situations where the fishery has not contributed to the decline of sea lions, but a conclusion has been reached that it has. This can be termed an over-protection error – sea lions have been over-protected. The lower left area represents situations where the fishery has contributed to the decline of sea lions, but a conclusion has been reached that the fishery has not contributed – this can be termed an under-protection error. If an over-protection error is considered to be as equally bad as an under-protection error, they should be assigned the same relative loss value. This is the case in Table 9.13.

Once the loss functions are specified, the decision analysis can be performed by calculating the probability the population trend after conservation measures is greater than 0.01 better than the population trend before conservation measures. The result of the decision analysis will be to choose one of the four decision options. As was done for the significance test approach outlined above, simulations were performed for the same four scenarios to calculate the probability that the correct decision will be made in each case, for each block (Table 9.14).

The resulting probabilities of making the correct decision under the specified scenarios are a function of both the loss functions that were specified and the actual data. It can be seen that the decision analysis approach leads to some trade-offs in the error rates between the four possible outcomes. A choice of different loss functions will lead to different trade-offs in the four possible error rates, and across the three different blocks. The probability of making the correct decision will not be the same in each block, because the expected precision of the data in each block is different.

In summary, NMFS will use a statistically valid approach to ascertaining whether the results from the monitoring program are consistent with the expectation that the RPA, as implemented, to contribute to the recovery of the western population of Steller sea lions. Further, as necessary, these same data will be used in subsequent consultations to determine whether additional restrictions on the groundfish fishery in Alaska are necessary or whether restrictions implemented for the 2001 fishery could be relaxed, at least in some areas.

Because this biological opinion has concluded that continued operation of groundfish fisheries in the BSAI and GOA are likely to jeopardize the continued existence of the endangered western population of Steller sea lions and destroy or adversely modify critical habitat that has been designated for them, NMFS' Office of Sustainable Fisheries is required to notify NMFS's Office of Protected Resources of its final decision on the implementation of the reasonable and prudent alternatives (50 CFR 402.15).

9.6 Risk Analysis

The RPA proposed in this biological opinion should allow the western population of Steller sea lion to equilibrate at a population level in excess of 34,600 animals. Specifically, NMFS anticipates that the subpopulation of sea lions that primarily occupy and forage within the areas closed to fishing over the next 8 years will follow the trajectory that Stellers would follow in an unfished environment. Removing effects of fishing could result in population trends consistent with the eastern population of Steller sea lions, which are increasing in abundance at a rate of 1% - 2% per year, rather than continue to decline at approximately 3% per year. NMFS also expects that the subpopulation of sea lions that primarily occupy and forage within areas open to fishing over the next 8 years will equilibrate in abundance rather than continue to decline at approximately 2% per year. This increase in the underlying growth rate would primarily result from increases in survival and reproduction of sea lions in the areas closed to pollock, Pacific cod, and Atka mackerel fishing. However, NMFS expects sea lion numbers in the parts of critical habitat open to fishing and in areas outside critical habitat open to fishing to also benefit from elements of the RPA which require adjustments to F for fish stocks below 40% of their unfished biomass, greater evenness in the way species-specific TACs are allocated seasonally, and substantial cuts in the maximum removal rates in open critical habitat especially in the winter season, and closures within 3 nm of all rookeries and haulouts.

As an unlikely worst case scenario, only sea lions in areas closed to fishing would benefit. If the average benefit in these 8 areas were approximately equal to the magnitude of the current decline (i.e., 4% per year), the resulting population change of sea lions in the areas closed to fishing over the next 8 years would be to follow the trajectory that Steller sea lions would follow in an unfished environment, while sea lions in areas open to fishing would decline at approximately 2% per year. The underlying growth rate of the entire western population of Steller sea lion over the next 8 years would be an annual decline of 0.7% or a loss to the population over the 8 year time period of 5%. Were this scenario realized, NMFS would detect a difference in population growth rates between sea lions in the areas open to fishing and closed to fishing within the next six years and would respond by increasing the percentage of critical habitat closed to fishing or otherwise restricting one of more of the fisheries that compete with Steller sea lions for prey. Given the relatively large size of the western Steller sea lion population, a loss of animals on the order of 5% would not result in a significant increase in the likelihood that this population will become extinct in the foreseeable future.

10 INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the reasonable and prudent measures and terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by NMFS so that they become binding conditions of any grant or permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. NMFS has a continuing duty to regulate the activity covered by this incidental take statement. If NMFS (1) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, NMFS must report the progress of the action and its impacts on the species as specified in the incidental take statement. [50 CFR 402.14(I)(3)]

An incidental take statement specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary to minimize impacts and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures.

10.1 Steller Sea Lion

Amount or Extent of Incidental Take

In this biological opinion, NMFS has determined that both direct and indirect take of Steller sea lions is reasonably likely to occur. The annual direct take levels specified in previous biological opinions for BSAI and GOA groundfish fisheries were 30 and 15, respectively. The NPFMC, working with industry, has made extensive efforts to reduce the amount of direct take of Steller sea lions to the extent practicable, and therefore, NMFS expects similar direct take levels to continue.

Indirect take of Steller sea lions is much more difficult to describe. A certain percentage of the Steller sea lion population is lost each year, but NMFS is not able to enumerate that loss or to recover the bodies to determine the cause of death. It is NMFS biological opinion that the action will result in some level of sub-lethal harm throughout the range of Steller sea lions by reducing prey availability such that the animal may have to forage longer, travel to an alternate location, or abandon the trip altogether. This may result in decreased body fat, longer foraging trips which might make an animal more vulnerable to predation, and decreased fecundity. However, the RPA required by this biological opinion, is likely to reduce these events. Additionally, the large closed areas important to Steller sea lion foraging will provide a refuge for many animals from any competition at all. Therefore, although some animals are likely to be adversely affected through indirect mechanisms, this is likely to be a local and rare occurrence.

Effect of the Take

In this biological opinion, NMFS has determined that the level of anticipated take under the reasonable and prudent alternative is not likely to jeopardize the continued existence of the western population of Steller sea lions or result in the destruction or adverse modification of its designated critical habitat.

Reasonable and Prudent Measures

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize the impacts from fisheries considered in this opinion to the listed Steller sea lion.

1. NMFS shall monitor the take of Steller sea lions incidental to the BSAI and GOA groundfish fisheries.

2. NMFS shall monitor all groundfish landings.

3. NMFS shall monitor the location of all groundfish catch to determine whether the catch was taken inside critical habitat (zones 1-13) or outside of critical habitat in the BSAI or GOA.

4. NMFS shall monitor vessels fishing for groundfish inside specified closed areas for pollock, Pacific cod, and Atka mackerel (as required by the RPA) to determine if they are directed fishing for those species.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, NMFS must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

1. NMFS shall obtain counts of all Steller sea lions taken in the BSAI and GOA groundfish fisheries through its observer program. The observer program must be statistically robust enough to ensure that the direct take of Steller sea lions is accurately enumerated.

2. Monitoring of groundfish landings shall be sufficient enough to provide inseason managers with the appropriate information to determine if critical habitat harvest limits required under the RPA are exceeded. This information should also be sufficient to determine appropriate closures by sector, gear type, or region as necessary.

3. Monitoring of the location of groundfish catch shall be sufficient to provide inseason managers with statistically valid estimates of catch inside critical habitat (areas 1-13) and catch outside critical habitat by NMFS management area. This information must be robust enough to ensure that critical habitat harvest limits for Atka mackerel, Pacific cod, or pollock are not exceeded in a manner inconsistent with the RPA objective for an evenly dispersed fishery.

4. Monitoring of vessel location while directed fishing shall be sufficient to ensure that any vessel engaged in illegal activity, within a closure area for the conservation of Steller sea lions, is detected and appropriate action taken against the operators of that vessel.

10.2 Salmon

Amount or Extent of the Take

While it is not possible to identify individual listed fish that may be taken in a fishery, impacts to listed fish can be limited by specifying limits in terms of either an exploitation rate or total catch. The catch of listed fish will be limited specifically by the measures proposed to limit the total bycatch of chinook salmon. Bycatch should be minimized to the extent possible and in any case should not exceed 55,000 chinook per year in the BSAI fisheries or 40,000 chinook salmon per year in the GOA fisheries. NMFS does not anticipate that the proposed fisheries will take any steelhead ESUs.

Effect of the Take

In this biological opinion, NMFS has determined that the level of anticipated take under the reasonable and prudent alternative is not likely to jeopardize the continued existence of any listed salmon or steelhead or result in the destruction or adverse modification of designated critical habitat for those species.

Reasonable and Prudent Measures

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize the impacts from fisheries considered in this opinion to listed salmon and steelhead.

1. The NPFMC and NMFS, Alaska Region shall ensure there is sufficient NMFS-certified observer coverage such that the bycatch of chinook salmon and “other” salmon in the BSAI and GOA groundfish fisheries can be monitored on an inseason basis.

2. The NPFMC and NMFS, Alaska Region shall monitor bycatch reports inseason to ensure that the bycatch of chinook salmon does not exceed 55,000 fish per year in the BSAI fisheries and 40,000 fish per year in the GOA fisheries.

3. The NPFMC and NMFS, Alaska Region shall monitor bycatch reports of chinook salmon in the Bering Sea subarea, inseason, so that the Chinook Salmon Savings Area can be closed to directed fishing for pollock with trawl gear before the limit is exceeded.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, NMFS must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

1. NMFS’ Division of Sustainable Fisheries (Alaska Region) shall provide an annual report to the NMFS Division of Protected Resources (Alaska Region) that details the results of its monitoring of bycatch reports during each fishing season. These reports shall be submitted in writing within one month of the new fishing year (February 1), and will summarize all statistical information based on a January 1 through December 31 fishing year.

2. The NPFMC and NMFS, Alaska Region shall assess the various salmon savings areas on an annual basis during the stock assessment process to determine the efficacy of those closed areas and determine whether additional closed areas should be added to ensure that the bycatch of salmon is limited to the maximum extent practicable.

11 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. NMFS believes the following conservation recommendations should be implemented. In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

11.1 Comprehensive Assessment Process

The present fishery management regime for federal groundfish fisheries in Alaska relies heavily on the fish stock assessment advice and analysis of fishery scientists at the Alaska Fisheries Science Center and the review of this analysis and advice by the Groundfish Plan Teams of the North Pacific Fishery Management Council (Council) and their Scientific and Statistical Committee. Marine mammal and marine bird experts have been assigned membership on these review teams to help provide information on possible interactions of fisheries with other species, particularly species listed under the ESA. Stock assessment scientists develop individual stock assessments that are compiled annually into a Stock Assessment and Fishery Evaluation (SAFE) Report of the NPFMC. Marine mammal and bird population trends, environmental changes, and changes in other parts of the ecosystem are also compiled into a separate chapter of the SAFE. Although this structure allows for some communication and review of fishery removal recommendations by consulting agency representatives and exchange of listed species trends with action agency representatives, such communication occurs at a level above the development of individual stock assessment advice. As such, the SAFE Report process and associated schedule for annual harvest specifications do not formally allow for analysis of fishery removal information at a time and space scale that might be needed to determine if the present nature of fishery removals could be interfering with listed species. It also currently does not provide for sufficient inclusion of the information on fisheries and the ecosystem into the assessment process.

The changing nature of fishery removals in time and space and nature of gear used are a particular concern. Target species fisheries may change the areas and seasons fished, sizes and species composition of fish removed, and the types of gear used by area and season. These factors can alter both the direct take of listed species in fisheries and indirect effects through types, sizes, and amounts of prey removed, in addition to alteration of essential fish habitat. In order to provide timely review of possible fishery interactions with listed species (and in the future on essential fish habitat), NMFS recommends a more comprehensive stock assessment process that includes a detailed analysis in which individual stock assessments would consider:

1. When and where the stock and the fishery on that stock tends to be concentrated,

2. What quantity of target and nontarget species is removed by area and season,

3. What sizes of fish are caught by area and season,

4. What amount of direct take of marine mammals and birds by area and season, and

5. Environmental influences on fish stock distribution and abundance.

This would allow for better analysis of the possible impacts of target fisheries on listed species and the more proactive development of time/space harvest recommendations at the individual stock assessment level that would minimize fishery interactions with listed species and essential fish habitat and prevent jeopardy or modification of critical habitat of listed species in the future. Assessment of the cumulative amounts of fishery removals by species, season and area, direct takes of mammals and birds by season and area, and gear usage by season and area should also be determined since total removals of prey are also important in the assessment of fishery interactions with listed species. This would be a progressive movement towards what is now being termed a "comprehensive assessment" process that includes multispecies considerations and risk analyses inside the stock assessment process.

11.2 Minimizing the Ecosystem Effects of the "Race for Fish"

Overcapitalized fisheries or fisheries that seek fish during a narrow space/time frame because of fish aggregation, product or bycatch considerations have greater potential to produce localized depletion of fish or to interfere with predators that also take advantage of fish that concentrate at certain times. The comprehensive assessment process recommended above provides a means to identify those fisheries and to develop target fishery-specific mitigation measures. However, NMFS, working with the NPFMC, also should promote other means to reduce overcapitalization of fisheries and concentration of fisheries in time and space. Fishery rationalization programs such as the Individual Fishing Quota (IFQ) program, the Community Development Quota (CDQ) program, and the American Fisheries Act (AFA) cooperatives have shown success in reducing the "footprint" of fisheries, especially at smaller time/space scales. NMFS recommends an expansion of these type of approaches to rationalize all BSAI/GOA groundfish fisheries along with the appropriate improvements to the existing catch monitoring programs (i.e., observer program, reporting and record keeping requirements, and vessel monitoring programs).

For an interim period until these programs are instituted, NMFS recommends that non-exempt AFA catcher vessels be prohibited from participating in the directed fishery for GOA pollock and Pacific cod to help reduce harvest rates of these species. The GOA fisheries for Pacific cod and pollock have yet to be rationalized in a manner that would promote slower-paced and dispersed fishing activity.
The non-exempt AFA vessels have been determined by the NPFMC to have less dependency on the GOA fisheries relative to Bering Sea fishing activity. The critical habitat limits for GOA pollock and Pacific cod are relatively small and can be fully and effectively harvested by local area small boat fleets. While the recommendation to prohibit AFA non-exempt vessels from fishing in the GOA pollock and Pacific cod fisheries would be an allocative action, NMFS believes that this interim measure would facilitate slower catch rates within the GOA pollock and Pacific cod fisheries and help to temporally disperse fishing effort, particularly in critical habitat.

NMFS also recommends that management and stock assessment staff review the boundaries of regulatory areas in the Gulf of Alaska to determine whether management of critical habitat limitations could be facilitated by adjusting these boundaries to minimize the number of open or closed critical habitat areas that span more than one regulatory area. In particular, NMFS believes that the management of open critical habitat area 5 harvest limits could be advantaged by moving the eastern boundary of Gulf of Alaska Regulatory Area 610 eastward from 159 degrees W. Longitude to 157 degrees W. Longitude. This would provide a separation between open critical habitat area 5 and closed critical habitat area 4.

11.3 Further Exploration and Reduction of Uncertainty

There are many sources of uncertainty in the assessment of prey abundance for listed species prey population abundance. The Global Control Rule to address effects of the overall exploitation strategy on the FMP area-wide reduction of important forage has been designated as one of the necessary RPAs to mitigate jeopardy for Steller sea lions in this biological opinion. This modified control rule is proposed mainly because of our uncertainty about present estimates of fish stock biomass. However, there are other methods to reduce uncertainty in the estimation of fish population abundance. NMFS recognizes that one of the main sources of uncertainty in the determination of present biomass levels of listed species prey is the variability associated with survey biomass estimates. This uncertainty can produce unintended higher exploitation rates on these prey populations and could thus influence prey availability to listed species. If it seems more appropriate in the future, NMFS recommends the incorporation of an adjustment to accommodate uncertainty associated with survey biomass estimates as a replacement for the modified Global Control Rule. The recommended adjustment would be a reduction of the fishing mortality rate associated with the allowable biological catch (F_{ABC}) from the maximum allowable fishing mortality rate (max F_{ABC}), by an amount that varies directly with the uncertainty (variance) associated with the survey biomass estimates. This will ensure that the ABC will be reduced for those species with highly variable survey biomass estimates, as a precautionary harvest strategy. The adjustment for survey biomass uncertainty should be applied to all target species with biomass estimates.

11.4 Further Research on the Extent and Nature of Steller Sea Lion Foraging Habitat

There is still great uncertainty about the extent of Steller sea lion foraging habitat. Platform of Opportunity (POP) observations show that Steller sea lions are seen throughout much of the Bering Sea outside of the presently designated critical habitat and pelagic foraging habitat. Observations obtained from animals monitored with satellite-linked time-depth recorders has shown some percentage of animals moving outside critical habitat, but not to the extent observed in the POP data. NMFS recommends more research on the extent to which Steller sea lions utilize foraging habitat outside current critical habitat limits.

11.5 Incidental Take Statement for Alaska State Fisheries

Alaska state fisheries, particularly salmon, herring, and Pacific cod, are likely to affect Steller sea lions and thus may require an incidental take statement. Two alternatives for addressing this situation are: (1) a consultation under section 7 of the Endangered Species Act if a federal action or significant federal assistance is involved; or (2) state development of a habitat conservation plan. NMFS should assist Alaska state officials on this issue.

11.6 Information on Listed Salmon Species

The following are conservation recommendations specific to listed salmon:

1. The NPFMC and NMFS, Alaska Region should improve estimates of the region-of-origin and stock composition of the chinook salmon bycatch by increasing CWT sampling rates as part of the mandatory salmon retention program, collecting and analyzing scale samples, and employing additional stock identification techniques applicable to the problem.

2. The NPFMC and NMFS, Alaska Region should use information collected during the observer monitoring program to identify times and areas of high salmon abundance that

could be used to reduce salmon bycatch through regulatory action.

3. The NPFMC and NMFS, Alaska Region should encourage development of incentive programs designed to reduce the bycatch of salmon in the NPFMC groundfish fisheries.

11.7 Establish a NMFS Steller Sea Lion Team

NMFS should establish a Steller Sea Lion Team to be responsible for ensuring that agency activities related to Steller sea lions are adequately staffed on a full time basis and to ensure that established schedules are maintained. This team would continue to work on the solutions to fishery/sea lion interactions, oversee the review processes, and reinitiate consultation or revise the biological opinion if necessary. The team, made up of 6 to 8 individuals, would include 3 to 5 NMFS managers and scientists with both marine mammal and fishery expertise. Other team members could include scientists from the States of Alaska and Washington, university professors, environmental organizations, industry representatives, and the North Pacific Fishery Management Council.

11.8 Initiate Scientific and Public Review of the Biological Opinion

NMFS should submit the biological opinion for scientific and public review. Based on those reviews, NMFS could reinitiate consultation if needed and make any necessary regulatory changes by the beginning of the 2002 fishing year.

1. NMFS should initiate discussion with the National Academy of Sciences regarding a review of the scientific basis for the biological opinion. Several NAS groups have experience working on North Pacific issues and have provided useful reviews and recommendations for Alaskan fisheries. However, it remains uncertain whether NAS can provide the appropriate level of review with a completion date within 9 months.

2. NMFS should invite the five independent scientific experts who were retained to provide initial comments on an earlier draft of the biological opinion to review the completed document.

3. NMFS should consult with the Council to determine the best schedule for their review of the biological opinion. NMFS will present the biological opinion to the Council in December 2000.

4. NMFS should invite the State of Alaska task force, which was established to address Steller sea lions/fisheries issues, to review the biological opinion and provide their recommendations.

5. NMFS should hold public hearings on the biological opinion in Dutch Harbor, Kodiak, Sand Point, Anchorage, and Seattle. To the extent possible, these meetings should be held coincident with hearings held to facilitate the public review of the Draft Supplemental Environmental Impact Statement on the Fishery Management Plans for the federal groundfish fisheries off Alaska.

6. NMFS should consult with the Plaintiffs and others in the environmental community to determine the best schedule and mechanism for their review of the biological opinion.

11.9 Monitoring Program

NMFS should expand current programs used to assess the effectiveness of this biological opinion and its impacts on the fisheries, including:

1. The experimental design, which uses the groundfish fishery as part of the experiment, to evaluate the role of the fishery in Steller sea lion population dynamics, including the relative contribution of the fisheries among other factors that may be contributing to Steller sea lion declines.

2. The quality and quantity of data concerning social, economic, and safety impacts of the measures that result from this biological opinion on traditional fisheries in federal waters off Alaska, e.g., catch rates, seafood quality and value, and bycatch rates of prohibited and other species.

11.10 Recovery Plan

In 1992, NMFS published a final recovery plan for Steller sea lions. However, it is now out of date and the Alaska Region has begun to look at assembling a new recovery team to revise the plan. NMFS should begin this process within the next 6 months. Both industry and environmental organizations should have an opportunity to provide input.

12 REINITIATION - CLOSING STATEMENT

This concludes formal consultation on the authorization of the Bering Sea and Aleutian Islands groundfish fisheries based on the FMP for the Bering Sea and Aleutian Islands groundfish; and authorization of the Gulf of Alaska groundfish fisheries based on the FMP for groundfish of the Gulf of Alaska. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or designated critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or designated critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation of consultation.

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INDEX OF ABBREVIATIONS

ABC	Acceptable Biological Catch
ADF&G	Alaska Department of Fish and Game
AFSC	Alaska Fisheries Science Center
AFA	American Fisheries Act
AI	Aleutian Islands
AP	Advisory Panel to the NPFMC
BSAI	Bering Sea and Aleutian Islands
BSC	Bering Slope Current
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCS	California Current System
CDQ	Community Development Quota
CFR	Code of Federal Regulations
CH	Critical Habitat
CH-RFRPA	Combined CH and other haulouts
CPUE	Catch Per Unit Effort
CVOA	Catcher Vessel Operational Area
DAH	Domestic Annual Harvest
DAP	Domestic Annual Processing
DSEIS	Draft Supplemental Environmental Impact Statement
DSR	Demersal Shelf Rockfish
EA	Environmental Assessment
EBS	Eastern Bering Sea
EEZ	Exclusive Economic Zone
EFP	Exempted Fishing Permit
EIR	Economic Impact Review
EIS	Environmental Impact Statement
EIT	Echo Integration Trawl
ENSO	El Nino/Southern Oscillation
EPA	Environmental Protection
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
F	Fishing Mortality Rate
FMP	Fishery Management Plan
FO	Frequency of Occurence
FOCI	Fisheries Oceanography Coordinated Investigations
FONSI	Finding of No Significant Impact
FR	Final Rule
FRFA	Final Regulatory Flexibility Analysis
FSEIS	Final Supplemental EIS
GOA	Gulf of Alaska
IFQ	Individual Fishing Quota
INPFC	International North Pacific Fisheries Commission
IPHC	International Pacific Halibut Commission
IRFA	Initial Regulatory Flexibility Act
IWC	International Whaling Commission
JVP	Joint Venture Processing
LLP	License Limitation Program
LOA	Length Overall
M	Natural Mortality Rate
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	Maximum Sustainable Yield
mt	Metric Ton
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NPAFC	North Pacific Anadromous Fisheries Commission
NPFMC	North Pacific Fishery Management Council
OFL	Overfishing Level
OPR	NMFS Office of Protected Resources
OSF	NMFS Office of Sustainable Fisheries
OY	Optimum Yield
PDF	Probability Density Factor
PDO	Pacific Decadal Oscillations
POP	Pacific Ocean Perch
PR	Proposed Rule
PSC	Prohibited Species Catch
PWS	Prince William Sound

RFRPA	Revised Final Reasonable and Prudent Alternatives
RPA	Reasonable and Prudent Alternative(s)
RIR	Regulatory Impact Review
RKCSA	Red King Crab Savings Area
SAFE	Stock Assessment and Fishery Evaluation
SEIS	Supplemental Environmental Impact Statement
SPR	Spawning Per Recruit
SSC	Scientific and Statistical Committee to the NPFMC
TAC	Total Allowable Catch
TALFF	Total Allowable Level of Foreign Fishing
USFWS	U.S. Fish and Wildlife Service

APPENDIX 1 CONTENTS OF THE BSAI AND GOA FMPS

This appendix provides a synopsis of the contents of

(1) the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish, and

(2) the Fishery Management Plan for Groundfish of the Gulf of Alaska.

Bering Sea/Aleutian Islands

The Fishery Management Plan (FMP) for the Bering Sea/Aleutian Islands (BSAI) consists of the following sections and information.

1.0 Summary Sheet---The summary sheet is administrative and is used to identify the document as the Final Environmental Impact Statement for the implementation of the groundfish fishery in the BSAI area under the MSA. The summary describes the environmental impacts of the groundfish fishery as follows (p. 1).

> Implementation of this fishery management plan within the limit of its constraints is presumed not to cause adverse impacts on the environment. Conservation measures are provided for species for which they are deemed necessary. Those measures and the conduct of the fishery as outlined will be beneficial to the ocean environment affected, to demersal and pelagic fishes and to the human environment.

The summary sheet also includes a listing of the FMP amendments through amendment 59, implemented January 25, 1999.

2.0 Executive Summary---This section lists the management objectives to be attained (see section 2.2.1 above), and a summary of the ecological, economic, and social impacts of the plan. Under ecological impacts, the executive summary states the following (p. 13).

> In the context of long-term relationships, fishery managers are just now beginning to find out, understand and quantify the complex relations among species and between biota and the environment of the ecosystem in the Bering Sea/Aleutian Islands area. Until that understanding is more fully developed, it is not possible to predict the long-term effect on the ecosystem of the current, single-species management strategies (as opposed to the integrated ecosystem method) or of subtle environmental changes....
>
> It is generally recognized by fisheries scientists that the existing theories and models pertaining to fishery resources management suffer some fundamental inadequacies; concepts and theories must be developed to answer present and future management decisions. Until such new concepts supercede the old, the latter can still serve as a useful basis for deriving management decisions, providing their limited and underlying assumptions are recognized and evaluated with the best available information. This is the philosophy and approach used throughout this plan.

3.0 Introduction to the Plan---The introduction explains that this plan replaced the preceding Preliminary Fishery Management Plan for the Trawl and herring Gillnet Fisheries of the Bering Sea and Aleutians. The introduction also describes the geographic area covered by the plan, and the goals and secondary objectives for the plan (see section 2.2.1). Finally, the introduction provides operational definitions of terms, including overfishing and the six-tier system for setting catch targets and limits.

4.0 Description of the Fishery---This section begins with a more detailed description of the geographic areas involved or potentially affected by the BSAI groundfish fishery, and then provides a brief overview of the species and stocks taken in the fishery. The remainder of the section describes the history of exploitation, with emphasis on the foreign fisheries.

5.0 History of Management---The measures used to manage the historical fishery (both domestic and foreign) are described, together with their purposes and effectiveness.

6.0 History of Research---This section provides an overview of research conducted by the U.S. and foreign scientists prior to the implementation of the plan.

7.0 Socioeconomic Characteristics of the Domestic Fishery---The socio-economics of the fishery prior to the implementation of the plan are described in this section.

8.0 Biological and Environmental Characteristics of the Fishery---This section begins with brief summaries of the target and other species, the fisheries, and limited trophic, habitat, and life history data on each species or species complex. The section then continues with dated summaries of stock units, data sources for catch per unit effort and other biological data, quality of data, ecological relationships, environmental characteristics of the affected area, biological characteristics of the Bering Sea, and ecosystem characteristics of the Bering Sea. The FMP includes in this section two figures illustrating the relations between age and numbers and biomass of pollock (FMP Fig. 21, reproduced here as Fig. 2.1), and the relations between age and biomass of pollock as consumed by fish and birds, consumed by marine mammals, removed by the fishery, and removed by natural mortality (FMP Fig. 22, reproduced here as Fig. 2.2). The section then continues with a section on status of the stocks (which is more a discussion of the allowable biological catch [ABC], maximum sustainable yield [MSY], and optimum yield [OY]) and then a description of the overall condition of the stocks. This section then ends with a description of habitat types, essential fish habitat for BSAI groundfish, fishing and non-fishing activities that may affect essential fish habitat, habitat conservation recommendations for fishing and non-fishing activities, prey species as a component of EFH, habitat areas of particular concern, and review and revision of essential fish habitat components of the FMP.

9.0 Other Considerations Which May Affect the Fishery---This section begins with a brief discussion of the potential conflict that could arise as a result of halibut bycatch in the groundfish fisheries. Next, the implications of the Marine Mammal Protection Act are described. In this section, the plan states the following (p. 275-277).

> "... this FMP is cognizant of the ecosystem and mammal population requirements. As reported in an earlier section on "Ecosystem Characteristics," a dynamic numerical marine ecosystem mode[l] is currently in use to study ecosystem interactions, including those by marine mammals. The Plan Development Team of this FMP is acutely aware and is striving for an "ecosystem approach" for managing the marine resources. It will, however, be some time (3-5 years) before an appropriate ecosystem model has become far enough developed, and empirically tested, to

> begin to be relied upon for resource management. Until that time, single species models will be applied to the fishery resources, but in a manner that will retain balance among the various fish components, be generally conservative, and be determined to be not detrimental to current marine mammal populations. The manner in which MSY, EY, and ABC were derived for each fish stock in Annex I has indirectly taken into consideration the volume of fish needed by marine mammals for their sustenance. For example natural mortality of fish stocks is taken into consideration in stock assessments and in its present application, includes the predation component by marine mammals.... Although specific ranges of optimum sustainable population have not been clearly determined for these [marine mammal] species, the impact of fisheries can be inferred from marine mammal population trends.... Of the seven species [of pinnipeds], the sea lions and fur seals might be significantly affected by groundfish harvest levels. ...[A] 50% decline in sea lion population has been noted since the late 1950s in the eastern Aleutian Islands. The factors that may have caused this decline are not certain but probably include (1) a westward shift in distribution since population abundance to the western Aleutians appears to be high; (2) commercial fisheries interaction since groundfish (primarily pollock) forms a significant portion of their diet; (3) disease such as leptospirosis; and (4) other unknown population control factors. This decline in abundance is of concern and should be watched more closely. The proposed total groundfish OY for 1980 for the Aleutians region is below past catch levels and if the abundance of fish is limiting for sea lions in this region, this FMP should leave more fish for sea lion consumption.... Although direct competition for food fish is one of many factors that affect marine mammal populations, the other factors are not readily quantifiable. Some of these mammals may be sensitive to disturbances created by fishing activities and may leave the area under such harassments.

With reference to the Endangered Species Act, the FMP simply states (p. 277) that

> The Federal action proposed in this fishery management plan is not likely to jeopardize the continued existence of endangered or threatened species, or result in the destruction or modification of habitat critical to those species.

The remainder of this section briefly describes the potential effects of activities related and unrelated to fishing activities, including the potential for habitat alteration, offshore petroleum production, coastal development and filling, marine mining, ocean discharge and dumping, derelict fragments of fishing gear and general litter, and benthic habitat damage by bottom gear. The section ends with a bio-economic factors with an example of cohort analysis for pollock, and a description of the crab-bait trawl fishery.

<u>10.0 Optimum Yield (OY) and Total Allowable Catch (TAC)</u>---This section describes MSY and OY for the groundfish complex, TACs, requirements of the Stock Assessment and Fishery Evaluation reports, the use of reserves set aside to ensure catches are consistent with quotas, and apportionments to the fishery.

<u>11.0 Catch and Capacity Descriptors</u>---This is a dated section on catch and processing capacity as the plan was being developed.

<u>12.0 Allocations between Foreign and Domestic Fishermen</u>---This section describes past allocation of quotas between foreign and domestic sectors of the fishery.

<u>13.0 Management Regime</u>---The majority of information on management of the BSAI groundfish

fisheries is included in this section. Objectives are listed first (see section 2.2.1 above), followed by a description of management areas within the BSAI region. BSAI species are then listed in five categories: prohibited, target, other, forage fish, and nonspecified. The fishing year is defined and criteria for establishing seasons are listed. Management measures for the domestic fishery are described next, including prohibited species, time/area closures and catch limits for prohibited species. These measures also include fishing area restrictions, and a section on marine mammal conservation measures, which states the following (p. 308-309).

> Regulations implementing the FMP may include special groundfish management measures intended to afford species of marine mammals additional protection other than that provided by other legislation. These regulations may be especially necessary when marine mammal species are reduced in abundance. For example, Steller sea lions are so reduced in abundance that they have been listed as threatened within the meaning of the Endangered Species Act. Even absent such a listing, regulations may be necessary to prevent interactions between commercial fishing operations and marine mammal populations when information indicates that such interactions may adversely affect marine mammals, resulting in reduced abundance and /or reduced use of areas important to marine mammals. These areas include breeding and nursery grounds, haul out sites, and foraging areas that are important to adult and juvenile marine mammals during sensitive life stages.
>
> Regulations intended to protect marine mammals might include those that would limit fishing effort, both temporarily [sic], spatially, around areas important to marine mammals. Examples of temporal measures are seasonal apportionments of TAC specifications. Examples of spatial measures could be closures around areas important to marine mammals. The purpose of limiting fishing effort would be to prevent harvesting excessive amounts of the available TAC or seasonal apportionments thereof at any one time or in any one area.

Areas closed to trawling are listed next, followed by gear restrictions. Reporting requirements and the observer program are described, followed by a description of effort-limiting programs including fixed-gear sablefish fisheries, the moratorium on the fisheries through 1999, the license limitation program initiated in 2000, and the Community Development Quota (CDQ) program. The need and mechanisms for inseason adjustments of the fisheries are explained, followed by a description of catch allocation by gear types for the different fisheries. The inshore/offshore allocation of pollock is described next, but the FMP notes that this information has been superceded by the American Fisheries Act of 1998. Experimental fishing permits are described, followed by a dated description of the management measures for the foreign fisheries. This section ends with a list of operational needs and costs, management measures to address identified habitat problems, measures to allow gear testing, and the improved retention/improved utilization program.

<u>14.0 Relationship of Recommended Management Measures to FCMA National Standards and Other Applicable Law</u>---This section is a dated description of the relation of the FMP to other federal and state laws.

<u>15.0 Research Needs</u>---This section lists and describes areas in need of research (p. 351).

> Research will be required to: (1) find means of improving the accuracy of commercial catch statistics; (2) refine estimates of abundance and biological characteristics of stocks through research resource surveys; (3) improve the capability for predicting changes in resources

abundance, composition, and availability; (4) develop means of reducing the incidental catch of non-target species; (5) identify subpopulations; and (6) examine the direct effects of man's activities on fish habitats and ecosystems.

With respect to the sixth point, this section also states the following (p. 352).

> Research needs related to maintaining the productive capacity of fish habitat can be broadly classified as those which (a) examine the direct affects of man's activities (such as fishing, oil exploration, or coastal development), and (b) apply fisheries oceanography in an ecosystem context (such as migration and transport patterns, predator/prey relationships, life histories). Both categories of research serve to increase the understanding of natural systems and the ability to detect and measure change caused by natural or man-made forces.

<u>16.0 Statement of Council Intentions to Review the Plan after Approval by the Secretary of Commerce</u>---This section is a statement that following implementation of the plan, the Council will maintain a continuing review of the fisheries managed under this plan through four methods.[1]

<u>17.0 References</u>---This section is self explanatory.

<u>18.0 Appendices and Annexes</u>---Appendix I is a Sample Community Profile. Appendix II is an example of a Pollock Cohort Analysis. Appendix III is a description of Closed Areas. Appendix IV describes Programs Addressing Habitat of Bering Sea/Aleutian Islands Groundfish Stocks. Annex I describes the Content of Stock Assessment and Fishery Evaluation Reports. Annex II describes the Derivation of Total Allowable Level of Foreign Fishing (TALFF). Annex III provides three tables of Catch Statistics of the Bering Sea/Aleutian Groundfish Fishery. Annex IV provides Information on Marine Mammal Population.[2] Annex IV then provides brief overviews of the Steller (northern) sea lion, northern fur seal,

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[1] The four methods listed are the following.

1. Maintain close liaison with the management agencies involved, usually the Alaska Department of Fish and Game and the National Marine Fisheries Service, to monitor the development of the fisheries and the activity in the fisheries.
2. Promote research to increase their knowledge of the fishery and the resource, either through Council funding or by recommending research projects to other agencies.
3. Conduct public hearings at appropriate times and in appropriate locations, usually at the close of a fishing season and in those areas where a fishery is concentrated, to hear testimony on the effectiveness of the management plans and requests for changes.
4. Consideration of all information gained from the above activities and development if necessary, of amendments to the management plan. The Council will also hold public hearings on proposed amendments prior to forwarding them to the Secretary for possible adoption.

[2] Annex IV states the following. "Information on distribution and migration, abundance and trends, feeding habits, and any problems induced by fisheries on seven marine mammal populations in the Bering Sea/Aleutian Region was provided by the Marine Mammal Division of the Northwest and Alaska Fisheries Center and included in this annex, the information [is] summarized mainly from the annual report of the Department of Commerce on the Administrati[on] of the Marine Mammal Protection

and bearded, ringed, harbor, larga, and ribbon seals. Annex V lists literature cited. Annex VI lists species categories for the BSAI groundfish fishery. Finally, Annex VII describes Information on Important Habitat for Non-FMP Species Pacific Halibut and Pacific Herring.

Gulf of Alaska

The Fishery Management Plan (FMP) for the Gulf of Alaska (GOA) consists of the following sections and information.

1.0 Introduction---The introduction gives general background on the FMP. With respect to environmental affects, the introduction states (p. 1) that the FMP "forms the major component of an Environmental Impact Statement which assesses the effect that implementation of this plan is expected to have on the environment of the region which encompasses the Gulf of Alaska."

2.0 Goals and Objectives---The goals and objectives of the plan are listed (as listed in 2.2.1 above), together with a section on operational definition of terms. The tier system for setting catch limits is described under the definition of overfishing.

3.0 Areas and Stocks Involved---The geographic area of the GOA groundfish fishery is described, together with listings of target stocks, prohibited stocks, forage fish, and other species.

4.0 Management Measures---This section is divided into three areas: framework measures, conventional measures, and other measures. Framework measures include the procedures for setting the TAC, the optimum yield range, the Stock Assessment and Fishery Evaluation Reports, setting of reserves (to prevent fisheries from exceeding quotas), prohibited species catch limits and incentives to reduce halibut bycatch, in-season adjustment of time and area, and time/area closures. Conventional measures describe permit requirements, general restrictions (catch, processing, gear), recordkeeping and reporting requirements, gear allocations, experimental fishing permits, inshore/offshore allocation of pollock and Pacific cod, fishing seasons, observers, habitat protection, and vessel safety considerations. Other measures pertain to access limitation for fixed sablefish fisheries, the (past) moratorium on vessels entering the fisheries, and the new groundfish license limitation program, size limits, gear testing, marine mammal conservation measures, and the improved retention/improved utilization program. The statement on marine mammal conservation measures (p. 50) is the same as provided in section 13.0 of the BSAI FMP.

5.0 Information on the Fishery and Resources---This section begins with a description of the biological and environmental characteristics of the resource species, including habitat requirements by life history stage, status of stocks, and a brief description of the habitat types in the GOA. The next part of this section describes the fisheries (domestic and foreign [which no longer exists]), the socioeconomic characteristics of the resources and fisheries, interactions between and among user groups, relationship of the management plan to other existing laws and policies, enforcement requirements, financing requirements, references, essential fish habitat for GOA groundfish, and information on important habitat for non-FMP species including Pacific halibut and GOA crab species.

Act of 1972 for the period of April 1, 1977 through March 31, 1978 (DOC, 1978) and the Final Environmental Impact Statement on Consideration of a Waiver of the Moratorium and Return of Management of Certain Marine Mammals to the State of Alaska, Volumes I and II (DOC and DOI, 1977.)"

APPENDIX 2 TARGET SPECIES AND FISHERIES

This appendix presents descriptions of major target species summarizing important life history traits, trophic interactions, habitat, stock assessment. and status. Additional information is available in the 2000 Stock Assessment and Fishery Evaluation reports, available from the North Pacific Fishery Management Council (605 West 4th, Suite 306, Anchorage, Alaska 99501-2252)

Pollock

Stock Description and Life History

Pollock (*Theragra chalcogramma*) is the most abundant species within the eastern Bering Sea (EBS) and the second most abundant groundfish stock in the Gulf of Alaska (GOA). It is widely distributed throughout the North Pacific in temperate and subarctic waters (Wolotira et al. 1993). Pollock is a semidemersal schooling fish, which becomes increasingly demersal with age. Approximately 50 percent of female pollock reach maturity at age four, at a length of approximately 40 cm. Pollock spawning is pelagic and takes place in the early spring on the outer continental shelf. In the EBS, the largest concentrations occur in the southeastern area north of Unimak Pass. In the GOA, the largest spawning concentrations occur in Shelikof Strait and the Shumagin Islands (Kendall et al. 1996). Juvenile pollock are pelagic and feed primarily on copepods and euphausiids. As they age, pollock become increasingly piscivorus and can be highly cannibalistic, with smaller pollock being a major food item (Livingston 1991b). Pollock are comparatively short lived, with a fairly high natural mortality rate estimated at 0.3 (Hollowed et al. 1997, Wespestad and Terry 1984) and maximum recorded age of around 22 years.

Although stock structure of Bering Sea pollock is not well defined (Wespestad 1993), three stocks of pollock are recognized in the BSAI for management purposes: EBS, Aleutian Islands and Aleutian Basin (Wespestad et al. 1997b). Pollock in the GOA are thought to be a single stock (Alton and Megrey 1986) originating from springtime spawning in Shelikof Strait (Brodeur and Wilson 1996).

The Fishery

Pollock supports the largest fishery in Alaskan waters. In the Bering Sea/Aleutian Islands region (BSAI), pollock comprise 75-80 percent of the catch. In the GOA , pollock constitute 25-50 percent of the catch. In the BSAI, pollock can only be targeted with pelagic trawl gear to minimize the potential interaction with other groundfish species and to reduce the magnitude of bottom disturbance. Pollock are also caught with bottom-trawl gear as bycatch from other fisheries.

In the BSAI, the season has traditionally been broken into two parts, a roe season during early winter, and a surimi (imitation crab)/filet season during the second half of the year. Currently, to minimize the potential indirect interaction with Steller sea lions (*Eumetopias jubatus*), the seasons have been managed to occur over broader areas and over seasons that are less contracted in time.

BSAI pollock are caught as bycatch in other directed fisheries but because they occur primarily in well defined aggregations, the impact of this bycatch is typically minimal. Discard rates through the early 1990s (discards/retained catch) of pollock in the directed fishery have been about 7-8 percent but in 1998 dropped to 1.5 percent (Ianelli et al. 1999). This is due to the fact that in 1998, discarding of pollock was prohibited except in the fisheries where pollock are in bycatch-only status. Pollock are caught as bycatch in the trawl Pacific cod, rock sole, and yellowfin sole fisheries.

In the GOA, major exploitable concentrations are found primarily in the central and western regulatory areas (147° - 170° W). Pollock from this region are managed as a single stock that is separate from the BSAI pollock stocks (Alton and Megrey 1986). The pattern of the fishery generally reflects the broad spatial distribution of pollock throughout the Central and Western regions of the GOA. Concentrations of pollock shift to reflect the seasonal migrations to spawning locations. The fishery generally occurs at depths between 100 and 200 m (Hollowed et al. 1997). Important pollock fishery locations include Shelikof Strait, the canyon regions of the east side of Kodiak Island, and Shumagin Canyon.

Megrey (1989) documented the historical expansion of the pollock fishery in the GOA. He identified four phases of expansion, beginning with a developmental phase between 1964-1971 when the fishery was dominated by foreign trawlers that captured pollock incidentally in mixed species catches. The second phase occurred between 1972 and 1980 when directed pollock harvests were initiated by foreign and joint venture fisheries. Floating freezer-surimi trawlers were active in the GOA during the second phase of fishery development. The third phase of development occurred between 1981- 1985. This phase was characterized by joint venture operations. During this period, the Shelikof Strait spawning concentrations were discovered. Surimi production and roe harvest were emphasized during this phase of development. Foreign vessels were eliminated from the pollock fishery in the late 1980s. This phase was marked by the passage of the in-shore/off-shore amendment which mandated that 100 percent of the pollock catch would be processed at shoreside plants. During this period the fishing community moved from a bottom trawl fishery to a mid-water fishery due to management measures established to control bycatch of prohibited species. Pacific halibut (*Hippoglossus stenolepis*) taken in the pollock fishery are added to the total for the shallow water complex halibut mortality cap. When the halibut cap is reached for the shallow water complex, trawling for species in the complex is prohibited except for vessels using pelagic trawls.

Trophic Interactions

The diet of pollock in the EBS has been studied extensively (Dwyer 1984, Lang and Livingston 1996, Livingston 1991b, Livingston and DeReynier 1996, Livingston et al. 1993). These studies have shown that juvenile pollock is the dominant fish prey in the EBS; other fish are also consumed by pollock including juveniles of Pacific herring, Pacific cod, arrowtooth flounder, flathead sole, rock sole, yellowfin sole, Greenland turbot, Pacific halibut and Alaska plaice. On the shelf area of the EBS, the contribution of these other fish prey to the diet of pollock tends to be very low (i.e., usually less than 2 percent by weight of the diet; (Livingston 1991b, Livingston and DeReynier 1996, Livingston et al. 1993). However, in the deeper slope waters, deep-sea fish (myctophids and bathylagids) are a relatively important diet component (12 percent by weight), along with euphausiids, pollock, pandalid shrimp and squid (Lang and Livingston 1996).

The cannibalistic nature of pollock, particularly adults feeding on juveniles, is well-documented by field studies in the EBS (Bailey 1989, Dwyer et al. 1987, Livingston 1989b, 1991b, Livingston and DeReynier 1996, Livingston and Lang 1997, Livingston et al. 1993). As mentioned previously, cannibalism by pollock in the Aleutian Islands region has not yet been documented (Yang 1996).

Cannibalism rates in the EBS vary depending on year, season, area, and predator size (Dwyer et al. 1987, Livingston 1989b, Livingston and Lang 1997). Cannibalism rates are highest in autumn, next highest in summer, and lowest in spring. Cannibalism rates by pollock larger than 40cm are higher than those by pollock less than 40cm. Most pollock cannibalized are age-0 and age-1 fish, with most age-1 pollock being consumed northwest of the Pribilof Islands where most age-1 pollock are found. Pollock larger than 50 cm tend to consume most of the age-1 fish. Smaller pollock consume mostly age-0 fish. Although age-2 and age-3 pollock are sometimes cannibalized, the frequency of occurrence of these age groups in the stomach contents is quite low. Laboratory studies have shown the possibility of cannibalism among age-0 pollock (Sogard and Olla 1993). Field samples have confirmed this interaction, but so far this interaction appears not to be very important.

Field and laboratory studies on juvenile pollock have examined behavioral and physical factors that may influence vulnerability of juveniles to cannibalism (Bailey 1989, Olla et al. 1995, Sogard and Olla 1993, 1996). Although it had previously been hypothesized that cannibalism occurred only in areas with no thermal stratification, these recent studies show that age-0 pollock do move below the thermocline into waters inhabited by adults. Larger age-0 fish tend to move below the thermocline during the day, and all age-0 fish tend to inhabit surface waters at night for feeding. Most cannibalism may occur during the day. If food availability is high, all sizes tend to stay above the thermocline, but when food resources are low then even small age-0 fish do move towards the colder waters as an energy-conserving mechanism. Thus, prediction of cannibalism rates may require knowledge of the thermal gradient and food availability to juveniles in an area.

Various studies have modeled pollock cannibalism in either a static or dynamic fashion (Dwyer 1984, Honkalehto 1989, Knechtel and Bledsoe 1981, 1983, Laevastu and Larkins 1981, Livingston 1991a, 1994, Livingston et al. 1993). The Knechtel and Bledsoe (1983) size-structured simulations produced several conclusions regarding cannibalism. Under conditions simulating the current fishing mortality rate (F=0.3yr-1) the population tended toward equilibrium. They also found that cannibalism is a stabilizing influence, with the population showing less variation compared to simulations in which cannibalism was not included. Zooplankton populations were also simulated in the model, and Knechtel and Bledsoe concluded that food was limiting, particularly for adult pollock. Maximization of average catch occurred at an extremely high F value (F=3.0 yr-1) that is about ten times higher than the actual fishing mortality rates in the EBS. However, the interannual variation in catches under this hypothetical scenario were extremely large.

The trend in more recent modeling efforts (Honkalehto 1989, Livingston 1993, 1994) has been to examine cannibalism using more standard stock assessment procedures such as virtual population analysis or integrated catch-age models such as Methot’s (1990) synthesis model. The purpose is to obtain better estimates of juvenile pollock abundance and mortality rates, which can improve our knowledge of factors affecting recruitment of pollock into the commercial fishery at age 3. Results from Livingston (1993, 1994) highlight several points with regard to cannibalism. In the current state of the EBS, cannibalism appears to be the most important source of predation mortality for age-0 and age-1 pollock. Predation mortality rates for juvenile pollock are not constant, as assumed in most population assessment models, but vary across time mainly due to changes in predator abundance but perhaps also due to predators feeding more heavily on more abundant year classes. The decline in pollock recruitment observed at high pollock spawning biomasses appears to be due to cannibalism. There also appears to be an environmental component to juvenile pollock survival (Wespestad et al. 1997a), wherein surface currents during the first 3 months of life may transport larvae to areas more favorable to survival (e.g., away from adult predators or in areas more favorable for feeding). Estimates of total amount of pollock consumed by important groundfish predators show that cannibalism is the largest source of removal of juvenile pollock by groundfish predation (Livingston 1991a, Livingston and DeReynier 1996, Livingston et al. 1993).

Other groundfish predators of pollock include Greenland turbot, arrowtooth flounder, Pacific cod, Pacific halibut, and flathead sole (Livingston 1991a, Livingston and DeReynier 1996, Livingston et al. 1986, 1993). These species are some of the more abundant groundfish in the EBS, and pollock constitutes a large proportion of the diet for many of them. Other less abundant species that consume pollock include Alaska skate, sablefish, Pacific sandfish, and various sculpins (Livingston 1989a, Livingston and DeReynier 1996). Small amounts of juvenile pollock are even eaten by small-mouthed flounders such as yellowfin sole and rock sole (Livingston 1991a, Livingston and DeReynier 1996, Livingston et al. 1993). Age-0 and age-1 pollock are the targets of most of these groundfish predators, with the exception of Pacific cod, Pacific halibut, and Alaska skate, which may consume pollock ranging in age from age-0 to greater than age-6 depending on predator size.

Pollock is a significant prey item of marine mammals and birds in the EBS. Studies suggest that pollock is a primary prey item of northern fur seals when feeding on the shelf during summer (Sinclair et al. 1997, 1994). Squid and other small pelagic fish are also eaten by northern fur seals in slope areas or in other seasons. The main sizes of pollock consumed by fur seals range from 3-20 cm or age-0 and age-1 fish. Older age classes of pollock may appear in the diet, during years of lower abundances of young pollock (Sinclair et al. 1997). Pollock has been noted as a prey item for other marine mammals including northern fur seals, harbor seals, fin whales, minke whales, and humpback whales, but stomach samples from these species in the EBS have been very limited, so the importance of pollock in the diets has not been well-defined (Kajimura and Fowler 1984). Pollock are one of the most common prey in the diet of spotted seals and ribbon seals, which feed on pollock in the winter and spring in the areas of drifting ice (Lowry et al. 1997).

Essentially five species of piscivorus birds are dominant in the avifauna of the EBS: northern fulmar, red-legged kittiwake, black-legged kittiwake, common murre, and thick-billed murre (Kajimura and Fowler 1984, Schneider and Shuntov 1993). Pollock is sometimes the dominant component in the diets of northern fulmar, black-legged kittiwake, common murre and thick-billed murre, while red-legged kittiwakes tend to rely more heavily on myctophids (Hunt et al. 1981, Kajimura and Fowler 1984, Springer et al. 1986). Age-0 and age-1 pollock are consumed by these bird species, and the dominance of a particular pollock age-class in the diet varies by year and season. Fluctuations in chick production by kittiwakes have been linked to the availability of fatty fishes such as myctophids, capelin and Pacific sand lance (Hunt et al. 1995). Changes in the availability of prey, including pollock, to surface-feeding seabirds may be due to changes in sea surface temperatures and the locations of oceanographic features such as fronts which could influence the horizontal or vertical distribution of prey (Decker et al. 1995, Springer 1992).

The diet of pollock, particularly adults, in the GOA has not been studied as thoroughly as in the EBS. Larvae, 5-20 mm in length, consume larval and juvenile copepods and copepod eggs (Canino 1994, Kendall et al. 1987). Early juveniles (25-100 mm) of pollock in the GOA primarily eat juvenile and adult copepods, larvaceans, and euphausiids while late juveniles (100-150 mm) eat mostly euphausiids, chaetognaths, amphipods, and mysids (Brodeur and Wilson 1996, Grover 1990, Krieger 1985, Livingston 1985, Merati and Brodeur 1997, Walline 1983). Juvenile and adult pollock in southeast Alaska rely heavily on euphausiids, mysids, shrimp and fish as prey (Clausen 1983). Euphausiids and mysids are important to smaller pollock and shrimp and fish are more important to larger pollock in that area. Copepods are not a dominant prey item of pollock in the embayments of southeast Alaska but appear mostly in the summer diet. Similarly, the summer diet of pollock in the central and western GOA does not contain as much copepods (Yang 1993). Euphausiids are the dominant prey, constituting a relatively constant proportion of the diet by weight across pollock sizes groups. Shrimp and fish are the next two important prey items.

Fish prey become an increasing fraction of the pollock diet with increasing pollock size in the GOA. Over 20 different species of fish have been identified in the stomach contents of pollock from this area but the dominant fish consumed is capelin (Yang 1993). A high diversity of prey fish were also found in pollock stomachs. Commercially important fish prey included: Pacific cod, pollock, arrowtooth flounder, flathead sole , Dover sole, and Greenland halibut. Forage fish such as capelin, eulachon and Pacific sand lance, were also found in pollock stomach contents.

Dominant populations of groundfish in the GOA that prey on pollock include arrowtooth flounder, sablefish, Pacific cod, and Pacific halibut (Albers and Anderson 1985, Best and St-Pierre 1986, Jewett 1978, Yang 1993). Pollock is one of the top five prey items (by weight) for Pacific cod, arrowtooth flounder, and Pacific halibut. Other prey fish of these species include Pacific herring and capelin. Other predators of pollock include great sculpins (Carlson 1995) and shortspined thornyheads (Yang 1993). As found in the EBS, Pacific halibut and Pacific cod tend to consume larger pollock, and arrowtooth flounder consumes pollock that are mostly less than age-3. Unlike the EBS, however, the main source of predation mortality on pollock at present appears to be from the arrowtooth flounder (Livingston 1994). Stock assessment authors have attempted to incorporate predation mortality by arrowtooth flounder, Pacific halibut, and sea lions in the stock assessment for pollock in the GOA (Hollowed et al. 1997).

Research on the diets of marine mammals and birds in the GOA was less intensive for the Bering Sea, but recently has been greatly accelerated (Brodeur and Wilson 1996, Calkins 1987, DeGange and Sanger 1986, Hatch and Sanger 1992, Lowry et al. 1989, Merrick and Calkins 1996, Pitcher 1980a, 1980b, 1981) (Section 3.5). Brodeur and Wilson's (1996) review summarized both bird and mammal predation on juvenile pollock. The main piscivorus birds that consume pollock in the GOA are black-legged kittiwakes, common murre, thick-billed murre, tufted puffin, horned puffin, and probably marbled murrelet. The diets of common murres have been shown to contain around 5 percent to 15 percent age-0 pollock by weight depending on season. The tufted puffin diet is more diverse and tends to contain more pollock than that of the horned puffin (Hatch and Sanger 1992). Both horned puffins and tufted puffins consume age-0 pollock. The amount of pollock in the diet of tufted puffin varied by region in the years studied, with very low amounts in the north-central GOA and Kodiak Island areas, intermediate (5-20 percent) amounts in the Semidi and Shumagin Islands, and large amounts (25-75 percent) in the Sandman Reefs and eastern Aleutian Islands. The proportion of juvenile pollock in the diet of tufted puffin at the Semidi Islands varied by year and was related to pollock year-class abundance.

Pollock is a major prey of Steller sea lions and harbor seals in the GOA (Merrick and Calkins 1996, Pitcher 1980a, 1980b, 1981). Harbor seals tend to have a more diverse diet, and the occurrence of pollock in the diet is lower than in sea lions. Pollock is a major prey of both juvenile and adult Steller sea lions in the GOA. It appears that the proportion of animals consuming pollock increased from the 1970s to the 1980s, and this increase was most pronounced for juvenile Steller sea lions. Sizes of pollock consumed by Steller sea lions range from 5-56 cm and the size composition of pollock consumed appears to be related to the size composition of the pollock population. However, juvenile Steller sea lions consume smaller pollock on average than adults. Age-1 pollock was dominant in the diet of juvenile Steller sea lions in 1985, possibly a reflection of the abundant 1984 year class of pollock available to Steller sea lions in that year.

Stock Assessment

Currently, information on pollock in the EBS comes from the NMFS observers aboard commercial fishing vessels, annual trawl surveys, and triennial echo integration (hydroacoustic; EIT) trawl surveys. In the Aleutian Islands, information comes from observer data and triennial bottom trawl surveys. In the GOA, stock assessment information is based on observer and port sampling data, annual hydroacoustic surveys in the Shelikof Straits area, and triennial bottom trawl surveys. These different data sets are analyzed simultaneously to obtain an overall view of each stock's condition. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass may be pelagic and not available to bottom trawls and much of the Aleutian Islands shelf is untrawlable due to rough bottom.

In the EBS pollock are assessed with an age-structured model incorporating fishery data and two types of survey catch data and age compositions. Bottom trawl surveys are conducted annually during June through August and provide a consistent time series of adult population abundance from 1982-1997. EIT surveys are run every three years (typically) and provide an abundance index on more pelagic (typically younger) segments of the stock. Both surveys dispose their catches into their relative age compositions prior to analyses. Fishery data include estimates of the total catch by area/time strata and also the average body weight-at-age and relative age composition of the catch within each stratum. The results of the statistical model applied to these data are updated annually and presented in the BSAI pollock chapter of the Council's BSAI SAFE report. Also included are separate analyses on pollock stocks in the Aleutian Islands and Bogoslof areas. These analyses are constrained by data limitations and are presented relative to the status of the EBS stock. This analysis focused specifically on the EBS stock with the view that extensions to these other areas are equally applicable. The stock assessment is reviewed by the Plan Team, and by the Scientific and Statistical Committee, before being presented to the Council.

The age composition of pollock has been dominated by strong year classes—most recently there appears to be higher than average 1992 year class, and prior to that the 1989 year class was very high. The abundance of these year classes is evident from EIT and bottom trawl surveys in addition to the extensive fishery age-composition data that have been collected. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality. The fishery has tended to exhibit variable selectivity over time, but generally targets fish aged 5 years and older.

GOA pollock are also assessed with an age-structured model incorporating fishery and survey data. The data used in this analysis consist of estimates of total catch biomass, bottom trawl biomass estimates, EIT survey estimates of the spawning biomass in Shelikof Strait, egg production estimates of spawning biomass in Shelikof Strait, and fisheries catch at age and survey size and age compositions. Fishery catch statistics (including discards) are estimated by the NMFS Alaska Regional Office. These estimates are based on the best blend of observer-reported catch and weekly production reports. Age composition data are obtained from several sources including catch at age aggregated over all seasons, nations, vessel classes and International North Pacific Fisheries Commission (INPFC) statistical areas for the years, and numbers at age from the spring EIT survey and the bottom trawl surveys. An additional estimate of the age composition of the population in 1973 was available from a bottom trawl survey of the GOA. Length frequency data collected from the EIT survey are also included in the model, as is historical information on pollock size composition obtained from the Japanese Pacific ocean perch fishery from the period 1964-1975 (Hollowed et al. 1991). Recent assessments have explored the impact of predation mortality by arrowtooth flounder, Pacific halibut and Steller sea lions by incorporating time series of estimated predator biomass, the age composition of pollock consumed by predators, and estimated consumption rates (Hollowed et al. 1997).

In the GOA, ages 3 through 15 represent the recruited population, although reliable estimates of abundance for ages 2 and above exist. The age composition is dominated by a recent strong 1994 year class; large numbers from the strong 1988 year class are still in the population. The estimated mean age of the recruited portion of the population in 1999 was 4 years.

Over the last 15 years, NOAA's Fisheries Oceanography Coordinated Investigations (FOCI) targeted much of their research on understanding processes influencing recruitment of pollock in the GOA. These investigations led to the development of a conceptual model of factors influencing pollock recruitment (for complete review collection of papers (Kendall et al. 1996). Bailey et al. (1996) reviewed 10 years of data for evidence of density dependent mortality at early life stages. Their study revealed evidence of density dependent mortality only at the late larval to early juvenile stages of development. Bailey et al. (1996) hypothesize that pollock recruitment levels can be established at any early life stage (egg, larval or juvenile) depending on sufficient supply from prior stages. He labeled this hypothesis the supply dependent multiple life stage control model. In a parallel study, Megrey et al. (1996) reviewed data from FOCI studies and identified several events that are important to survival of pollock during the early life history period. These events are climatic events (Hollowed and Wooster 1995, Stabeno et al. 1995), preconditioning of the environment prior to spawning (Hermann et al. 1996), the ability of the physical environment to retain the planktonic life stages of pollock on the continental shelf (Bograd et al. 1994, Schumacher et al. 1993), and the abundance and distribution of prey and predators on the shelf (Bailey and Macklin 1994, Canino 1994, Theilacker et al. 1996). Thus, the best available data suggest that pollock year-class strength is controlled by sequences of biotic and abiotic events and that population density is only one of several factors influencing pollock production.

In both the BSAI and GOA, cumulative impacts of fishing mortality on the age composition are influenced by the selectivity of the fishery. The current age compositions of the stocks reflect a fished population with a long catch history. In any given year, the age composition of the stock is influenced by previous year-class strength. The reproductive potential of the stock in a given year is dependent on the biomass of spawners as modified by abiotic and biotic conditions. Thus, it is likely that the average age of unfished populations would have varied inter-annually due to the history of oceanic and climate conditions. The NMFS's FOCI and the Coastal Ocean Program's Southeast Bering Sea Carrying Capacity (SEBSCC) regional study focuses research on improving our understanding of mechanisms underlying annual production of pollock stocks in the GOA and EBS. NOAA's long-term goal is to improve our ability to assess quantitatively the long term impact of commercial removals of adult pollock on future recruitment by combining the findings of process-oriented research programs such as FOCI and SEBSCC with NMFS's on-going studies of species interactions, fish distributions, and abundance trends.

ABC as Recommended in the Most Recent Stock Assessments

EBS pollock fell into Tier 3a of the ABC/OFL definitions for 2000, which require reliable estimates of biomass, $B_{40\%}$, $F_{35\%}$, and $F_{40\%.}$ Under the definitions and current stock conditions, the overfishing fishing mortality rate is the $F_{35\%}$ rate which is 0.65 for pollock and equates to a yield of 1.5 million metric tons (mt) (Ianelli et al. 1999). The ABC (using $F_{ABC}= F_{40\%}$) for pollock gives a yield of 1.1 million mt. This TAC was set equal to the ABC value recognizing that the $F_{40\%}$ rate was well below estimates made for F_{MSY}. This lower level has been adjusted downwards to provide a risk-averse harvest rate which more accurately reflects the degree of uncertainty.

GOA pollock fell into Tier 3 of the ABC/OFL definitions, which require reliable estimates of biomass, $B_{40\%}$, $F_{30\%}$, and $F_{40\%}$. Under the definitions and current stock conditions, the overfishing rate is the fishing mortality rate that reduces the spawner stock biomass to 35 percent of its unfished level (the $F_{35\%}$ rate). In 1999, the full recruitment fishing mortality $F_{35\%}$ rate was 0.50 for pollock and equated to a yield of 130,758 mt for the year 2000 central and western GOA (Dorn et al. 1999). The projected 2000 spawning stock biomass fell below $B_{40\%}$, therefore the maximum allowable fishing mortality rate for ABC (F_{ABC}) was the adjusted $F_{40\%}$ rate 0.34 (Dorn et al. 1999). This F_{ABC} translated to a yield projection of 111,306 mt in 2000 for the western and central regions. The 2000 Council ABC level was 100,000 mt for the western and central regions, which was equivalent to the recommended stock assessment ABC, and equivalent to the TAC.

Pacific Cod

Stock Description and Life History

Pacific cod is a demersal species that occurs on the continental shelf and upper slope from Santa Monica Bay, California through the GOA, Aleutian Islands, and EBS to Norton Sound (Bakkala 1984). The Bering Sea represents the center of greatest abundance, although Pacific cod are also abundant in the Gulf and Aleutian Islands (OCSEAP 1987). GOA, Bering Sea, and Aleutian Islands cod stocks are genetically indistinguishable (Grant et al. 1987), and tagging studies show that cod migrate seasonally over large areas (Shimada and Kimura 1994).

In the late winter, Pacific cod converge in large spawning masses over relatively small areas. Major aggregations occur between Unalaska and Unimak Islands, southwest of the Pribilof Islands and near the Shumagin group in the western Gulf (Shimada and Kimura 1994). Spawning takes place in the sublittoral-bathyal zone (the area of the continental shelf and slope [40-290 m]) near the bottom. The eggs sink to the bottom and are somewhat adhesive (Hirschberger and Smith 1983).

Pacific cod reach a maximum recorded age of 19. Estimates of natural mortality vary widely and range from 0.29 (Thompson and Shimada 1990) to 0.83-0.99 (Ketchen 1964). For stock assessment purposes, a value of 0.37 is used in both the BSAI (Thompson et al. 1999) and the GOA (Thompson and Dorn 1999). In the BSAI, 50 percent of Pacific cod are estimated to reach maturity by the time they reach 67 cm in length, or about 5 years of age (Thompson et al. 1999).

Trophic Interactions

Pacific cod are omnivorous. Livingston (1991b) characterized the diet of Pacific cod in the BSAI and GOA as follows: In terms of percent occurrence, the most important items were polychaetes, amphipods, and crangonid shrimp; in terms of numbers of individual organisms consumed, the most important items were euphausiids, miscellaneous fishes, and amphipods; and in terms of weight of organisms consumed, the most important items were pollock, fishery offal, and yellowfin sole. Small Pacific cod were found to feed mostly on invertebrates, while large Pacific cod are mainly piscivorus. Predators of Pacific cod include halibut, salmon shark, northern fur seals, Steller sea lions, harbor porpoises, various whale species, and tufted puffin (Westrheim 1996).

Fishery

The Pacific cod fishery is the second largest Alaskan groundfish fishery. In 1999, Pacific cod constituted

12 percent of the groundfish catch in the BSAI and 30 percent of the groundfish catch in the GOA. The fishery for Pacific cod is conducted with bottom trawl, longline, pot, and jig gear. Of these, the fishery conducted with jig gear is by far the smallest. More than 100 vessels participate in each of the three larger fisheries. The age at 50 percent recruitment varies between regions. For trawl, longline, and pot gear, the age at 50 percent recruitment in the EBS is approximately 4, 4, and 5 years, respectively (Thompson and Dorn 1999). For all three gears, the age at 50 percent recruitment in the GOA is approximately 6 years (Thompson et al. 1999). The trawl fishery is typically concentrated during the first few months of the year, whereas fixed-gear fisheries may sometimes run essentially year-round. Bycatch of crab and halibut often causes the Pacific cod fisheries to close prior to reaching the TAC. In the EBS, trawl fishing is concentrated immediately north of Unimak Island, whereas the longline fishery is distributed along the shelf edge to the north and west of the Pribilof Islands. In the GOA, the trawl fishery has centers of activity around the Shumagin Islands and south of Kodiak Island, while the longline fishery is located primarily in the vicinity of the Shumagins. Pacific cod is also taken as bycatch in a number of trawl fisheries. In the EBS, Pacific cod is taken as bycatch in the trawl fisheries for pollock, yellowfin sole, and rock sole. In the Aleutian Islands region, Pacific cod is taken as bycatch in the trawl fishery for Atka mackerel. In the GOA, Pacific cod is taken as bycatch in the trawl fisheries for shallow-water flatfish, arrowtooth flounder, and flathead sole. Since 1998, discarding of Pacific cod has been prohibited except in fisheries where Pacific cod is in “bycatch only” status.

Stock Assessment

Beginning with the 1993 BSAI SAFE report (Thompson and Methot 1993) and the 1994 GOA SAFE report (Thompson and Zenger 1994), Pacific cod have been assessed with a length-based synthesis model (Methot 1990). Although the Pacific cod stocks in the EBS and GOA are modeled separately, the model structures in recent years have been identical (Thompson and Dorn 1999, Thompson et al. 1999). No formal assessment model exists for the Aleutian Islands portion of the BSAI stock. Instead, results from the EBS assessment are inflated proportionally to account for Aleutian Islands fish.

Annual trawl surveys in the EBS and triennial trawl surveys in the Aleutian Islands and GOA are the primary fishery-independent sources of data for Pacific cod stock assessments (Thompson and Dorn 1999, Thompson et al. 1999). For the most recent assessments, fishery size compositions were available, by gear, for the years 1978 through the first part of 1997. The catch history was divided into two portions, determined by the relative importance of the domestic fishery. A “pre-domestic” portion was defined as those years in which the domestic fishery took less than half the catch, and a “domestic” portion was defined as those years in which the domestic fishery took at least half the catch. Within each year (in both portions of the time series), catches were divided according to three time periods: January-May, June-August, and September-December. This particular division, which was suggested by participants in the EBS fishery, is intended to reflect actual intra-annual differences in fleet operation (e.g., fishing operations during the spawning period may be different than at other times of year). Four fishery size composition components were included in the likelihood functions used to estimate model parameters: the period 1 trawl fishery, the periods 2-3 trawl fishery, the longline fishery, and the pot fishery. In addition to the fishery size composition components, likelihood components for the size composition and biomass trend from the bottom trawl surveys were included in the model. All components were weighted equally.

Quantities estimated in the most recent stock assessments include parameters governing the selectivity schedules for each fishery and survey in each portion of the time series, parameters governing the length-at-age relationship, population numbers at age for the initial year in the time series, and recruitments in each year of the time series. Given these quantities, plus parameters governing natural mortality, survey catchability, the maturity schedule, the weight-at-length relationship, and the amount of spread surrounding the length-at-age relationship, the stock assessments reconstruct the time series of numbers at age and the population biomass trends (measured in terms of both total and spawning biomass). The model around which the most recent Pacific cod assessments are structured uses an assumed survey catchability of 1.0 and an assumed natural mortality rate of 0.37. Other outputs of the assessments include projections of biomass and harvest under a variety of reference fishing mortality rates. Based on these projections, the scientists responsible for conducting the assessments recommend a pair of ABC values for the coming year (one value for the BSAI and one for the GOA).

Pacific cod is currently managed under Tier 3 of the Council's ABC and OFL definitions (Amendment 56 to each of the respective FMPs). Management under Tier 3 requires reliable estimates of projected biomass, $B_{40\%}$, $F_{40\%}$ (for ABC), and $F_{35\%}$ (for OFL).

ABC as Recommended in the Most Recent Stock Assessments

Under Tier 3 of Amendment 56 to the BSAI and GOA Groundfish FMPs, the maximum permissible ABC depends on the relationship of projected spawning biomass to $B_{40\%}$. For the BSAI, the base model in the 1999 assessment projected a 2000 spawning biomass of 355,000 mt, about 6 percent below the $B_{40\%}$ estimate of 379,000 mt, leading to a maximum permissible ABC of 206,000 mt (Thompson and Dorn 1999). For the GOA, the base model in the 1999 assessment projected a 2000 spawning biomass of 111,000 mt, about 12 percent above the $B_{40\%}$ estimate of 98,800 mt, leading to a maximum permissible ABC of 86,000 mt (Thompson et al. 1999). To determine whether ABC should be set at the maximum permissible level, the 1999 assessments presented a decision-theoretic analysis of the statistical uncertainty surrounding the respective model's projected $F_{40\%}$ catch level, specifically the uncertainty associated with the assumed values of the natural mortality rate (M=0.37) and survey catchability coefficient (q=1.0). These analyses resulted in a recommended 2000 ABC of 193,000 mt for the BSAI region and 76,400 mt for the GOA region.

Flathead Sole

Flathead sole is distributed from northern California northward throughout Alaska (Wolotira et al. 1993). In the northern part of its range, it overlaps with the related and very similar Bering flounder (Hart 1973). Because it is difficult to separate these two species at sea, they are currently managed as a single stock (Walters and Wilderbuer 1997). Adults are benthic and occupy separate winter spawning and summer feeding distributions. From over-wintering grounds near the continental shelf margin, adults begin a migration onto the mid and outer continental shelf in April or May. The spawning period occurs in the spring, primarily in deeper waters near the margins of the continental shelf (Walters and Wilderbuer 1997). Eggs are large and pelagic. Upon hatching, the larvae are planktonic and usually inhabit shallow areas (Waldron and Vinter 1978). Exact age and size at maturity are unknown, but recruitment to the fishery begins at age 3. The maximum age for flathead sole is approximately 20 years. An estimated natural mortality rate of 0.20 is used for stock assessment (Turnock et al. 1997a, Waldron and Vinter 1978). Flathead sole feed primarily on invertebrates such as amphipods and decapods. In the EBS, other fish species represented 5-25 percent of the diet (Livingston et al. 1993). Flathead sole are taken in bottom trawls both as a directed fishery and in pursuit of other bottom dwelling species.

The following information is available to assess the unit stock condition:

Data Component	Years of Data
Fishery catch	1977 to 1999
Foreign fishery size composition data	1977 to 1989
Domestic fishery size composition data	1990 to 1998
NMFS trawl survey biomass estimates	1982 to 1999
NMFS trawl survey size composition data	1982 to 1999
NMFS trawl survey age composition data	1982, 1985, 1992, 1995

Annual trawl survey biomass results have been the primary data component used to assess stock level since 1982, although all the above information was also input into a length-based stock assessment model (Spencer et al. 1999a). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which, when considered with projected future biomass, are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE report.

Flathead sole are currently managed under Tier 3 of the Council's ABC and OFL definitions (Amendment 44 to the FMP). Management under Tier 3 requires reliable estimates of projected biomass, $B_{40\%}$, $F_{40\%}$ (for ABC) and $F_{35\%}$ (for OFL). Since the projected flathead sole female spawning biomass for 2000 is greater than $B_{40\%}$ (261,300 > 133,800), $F_{40\%}$ (the upper limit on ABC), is recommended as the F_{ABC} harvest reference point for 2000. The 2000 TAC is well below the ABC and the 1999 catch was only 23 percent of the 1999 TAC, as follows: BSAI 2000 ABC = 73,500 mt, BSAI TAC = 52,652 mt, and BSAI 1999 catch = 17,777 mt.

Rock Sole

Rock sole are distributed from southern California northward through Alaska (Wolotira et al. 1993). Two species of rock sole occur in the North Pacific ocean, a northern rock sole and a southern rock sole. These species have an overlapping distribution in the GOA, but the northern species primarily comprise the BSAI populations, where they are managed as a single stock (Wilderbuer and Walters 1997). Adults are benthic and, in the EBS, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Spawning takes place during the late winter-early spring, near the edge of the continental shelf at depths of 125 to 250 m. Eggs are demersal and adhesive (Forrester 1964). The estimated age at 50 percent maturity for female rock sole is 9-10 years at a length of 35 cm (Wilderbuer and Walters 1997). The best estimate for natural mortality is 0.18 for the BSAI (Wilderbuer and Walters 1992) and 0.20 for the GOA (Turnock et al. 1997a). Rock sole are important as the target of a high value bottom trawl roe fishery occurring in February and March, which accounts for the majority of the BSAI catch. Although female rock sole are highly desirable when in spawning condition, large amounts are discarded in other trawl fisheries during the rest of the year. Commercial harvest occurs primarily on the EBS continental shelf and in lesser amounts in the Aleutian Islands region.

Northern and southern rock sole are managed as a single unit in the BSAI. Rock sole are abundant on the EBS shelf and to a lesser extent in the Aleutian Islands. This species represents a "data-rich" case where the following information is available.

Data Component	Years of Data
Trawl fishery catch at age	1980 to 1998
Trawl survey population age composition	1975, 1979 to 1998
Catch weight	1975 to 1999
Trawl survey biomass estimates and standard error.	1982 to 1999
Maturity schedule	1993 to 1994
Mean weight at age	1985 to 1988

The time-series of fishery and survey age compositions allows the use of an age-based stock assessment model as the primary analytical tool (Wilderbuer and Walters 1999). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which, when considered with projected future biomass, are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE report.

Rock sole are currently managed under Tier 3 of the Council's ABC and OFL definitions (Amendment 44 to the FMP). Management under Tier 3 requires reliable estimates of projected biomass, $B_{40\%}$, $F_{40\%}$ (for ABC) and $F_{35\%}$ (for OFL). Since the projected rock sole female spawning biomass for 2000 is greater than $B_{40\%}$ (675,500 > 284,700), $F_{40\%}$ (the upper limit on ABC), is recommended as the F_{ABC} harvest reference point for 2000. ABC and TAC information are as follows: BSAI 2000 ABC = 230,000 mt, BSAI TAC = 134,760 mt, and BSAI 1999 catch = 40,362 mt.

Greenland Turbot

Greenland turbot are distributed from Baja California northward throughout Alaska, although it is rare south of Alaska and is primarily distributed in the eastern BSAI region (Hubbs and Wilimovsky 1964). Juveniles are believed to spend the first three or four years of life on the continental shelf and then move to the continental slope as adults (Alton et al. 1988, Templeman 1973). Greenland turbot are demersal to semi-pelagic. Unlike most flatfish, the migrating eye of Greenland turbot does not move completely to one side, but stops at the top of the head, which presumably results in a greater field of vision and helps to explain this species' tendency to feed off the sea bottom (de Groot 1970). Spawning occurs in winter and may be protracted, starting as early as September and continuing until March (Bulatov 1983). The eggs are benthypelagic (suspended in the water column near the bottom)(D'yakov 1982). Juveniles are absent in the Aleutian Islands region, suggesting that populations in that area originate from elsewhere (Alton et al. 1988). Greenland turbot are a moderately long-lived species, with a maximum recorded age of 21 years (Ianelli and Wilderbuer 1995) and an estimated natural mortality rate of 0.18 (Ianelli et al. 1997). Pelagic fish are the main prey of Greenland turbot, with pollock often a major species in the diet (Livingston 1991b). Greenland turbot also feed on squid, euphausiids and shrimp.

Abundance of juvenile Greenland turbot is estimated in the EBS by the annual trawl survey and in the Aleutian Islands by the triennial trawl survey. Abundance of adults has been estimated by trawl slope surveys conducted cooperatively by the U.S. and Japan. In the Gulf, abundance is estimated by the triennial trawl survey. A lack of deepwater samples, however, creates a high degree of uncertainty for these estimates (Turnock et al. 1997a). The biomass of Greenland turbot in the BSAI increased during the 1970s and is currently estimated to be about half of the unfished level. A lack of recruitment success during recent years has led to extra caution in setting harvest levels. Greenland turbot is a relatively valuable species; however, because of low ABC and TAC amounts, it is primarily a bycatch only fishery. They are caught both in bottom trawls and on longlines.

The resource in the BSAI is managed as a single stock. The following information is available to assess the stock condition of Greenland turbot in the BSAI.

Data Component	Years of Data
Trawl survey size-at-age	1975, 1979 to 1982
Shelf survey size composition and biomass	1979 to 1999
Slope survey size composition and biomass	1979, 1981, 1982, 1985, 1988, 1991
Longline survey size composition and abundance index	1983 to 1993
Total fishery catch data	1960 to 1999
Trawl fishery CPUE index	1978 to 1984
Trawl fishery size compositions	1977 to 1987, 1989 to 1991, 1993 to 1998
Longline catch size composition	1977, 1979 to 1985, 1992 to 1998

The time-series of fishery and survey length compositions allows the use of a length-based stock assessment model (Ianelli et al. 1997). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which, when considered with projected future biomass, are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE report.

Greenland turbot are currently managed under Tier 3 of the Council's ABC and OFL definitions (Amendment 44 to the FMP). Management under Tier 3 requires reliable estimates of projected biomass, $B_{40\%}$, $F_{40\%}$ (for ABC) and $F_{35\%}$ (for OFL). Since the projected Greenland turbot female spawning biomass for 2000 is greater than $B_{40\%}$ (165,000 > 81,300), $F_{40\%}$ is considered the upper limit on ABC. However, the recommended F_{ABC} for 2000 is 25 percent of $F_{40\%}$ due to the lack of recruitment for the past 25 years and the anticipated declining future stock condition. ABC and TAC information are as follows: BSAI 2000 ABC = 9,300 mt, BSAI TAC = 9,300 mt, and BSAI 1999 catch = 5,776 mt.

Yellowfin Sole

Yellowfin sole is distributed from British Columbia to the Chukchi Sea (Hart 1973). In the Bering Sea, it is the most abundant flatfish species and is the target of the largest flatfish fishery in the United States. While also found in the Aleutian Islands and GOA, the stock is of much smaller size in those areas. Adults are benthic and occupy separate winter and spring/summer spawning/feeding grounds. Adults overwinter near the shelf-slope break at approximately 200 m and move into nearshore spawning areas as the shelf ice recedes (Nichol 1997). Spawning is protracted and variable, beginning as early as May and continuing through August, occurring primarily in shallow water at depths less than 30 m (Wilderbuer et al. 1992). Eggs, larvae and juveniles are pelagic and usually are found in shallow areas (Nichol 1994). The estimated age at 50 percent maturity is 10.5 years at a length of approximately 29 cm (Nichol 1994). The natural mortality rate likely falls within the range of 0.12 to 0.16, with a maximum recorded age of 33 years (Wilderbuer 1997). Yellowfin sole feed primarily on benthic invertebrates, with polychaetes, amphipods, decapods and clams dominating the diet in the EBS (Livingston 1993).

Yellowfin sole stocks were over-exploited by foreign fisheries in 1959-1962. Since that time, indices of relative abundance have shown major increases in abundance during the late 1970s. Since 1981, abundance has fluctuated widely but biomass estimates indicate that the yellowfin sole population remains at a high, stable level. Information on yellowfin sole stock conditions in the BSAI comes primarily from the annual EBS trawl survey. Estimates of yellowfin sole biomass derived from these surveys have been more variable than would be expected for a comparatively long-lived and lightly exploited species (Wilderbuer 1997). The reason for this variability is not known. However, Nichol (1997) hypothesized that much of the yellowfin sole resource is found at depths less than 30 m during the summer when bottom trawl surveys are conducted. This could cause the survey to underestimate the abundance of yellowfin sole.

In the Bering Sea, yellowfin sole are considered as one stock for management purposes. The following information is available for stock assessment.

Data Component	Years of Data
Trawl Fishery catch-at-age	1964 to 1998
Trawl survey population age composition	1975, 1979 to 1998
Catch weight	1982 to 1999
Trawl survey biomass estimates and S.E..	1954 to 1999
Maturity schedule	1992 to 1993
Mean weight at age	1979 to 1990

The time-series of fishery and survey age compositions allows the use of an age-based stock assessment model (Wilderbuer 1997). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which, when considered with projected future biomass, are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE report.

Yellowfin sole are currently managed under Tier 3 of the Council’s ABC and OFL definitions (Appendix 1; Amendment 44). Management under Tier 3 requires reliable estimates of projected biomass, $B_{40\%}$, $F_{40\%}$ (for ABC) and $F_{35\%}$ (for OFL). Since the projected yellowfin sole female spawning biomass for 2000 is greater than $B_{40\%}$ (789,300 > 576,600), $F_{40\%}$ (the upper limit on ABC), was recommended as the F_{ABC} harvest reference point for 2000. ABC and TAC information are as follows: BSAI 2000 ABC = 191,000 mt, BSAI TAC = 123,262 mt, and BSAI 1999 catch = 67,392 mt.

Arrowtooth Flounder

Arrowtooth flounder is common from Oregon through the EBS (Allen and Smith 1988). The very similar Kamchatka flounder also occurs in the Bering Sea. Because it is not usually distinguished from arrowtooth flounder in commercial catches, both species are managed as a group. Arrowtooth flounder is a relatively large flatfish that occupies continental shelf waters almost exclusively until age 4, but at older ages occupies both shelf and slope waters, with concentrations at depths between 100 and 200 m (Martin and Clausen 1995). Spawning is protracted and variable and probably occurs from September through March (Zimmermann 1997). For female arrowtooth flounder collected off the Washington coast, the estimated age at 50 percent maturity was 5 years with an average length of 37 cm. Males matured at 4 years and 28 cm (Rickey 1995). Values of 50 percent maturity for the Bering Sea stock are 42.2 cm and 46.9 cm for males and females, respectively (Zimmerman 1997). The maximum reported ages are 16 years in the Bering Sea, 18 years in the Aleutian Islands and 23 years in the GOA, with a natural mortality rate used for assessment purposes of 0.2 (Turnock et al. 1997b, Wilderbuer and Sample 1997). Arrowtooth flounder are important as a large and abundant predator of other groundfish species. Adults are almost exclusively piscivorus and over half their diet can consist of pollock (Livingston 1991b). Currently, arrowtooth flounder have a low perceived commercial value because the flesh softens soon after capture due to protease enzyme activity (Greene and Babbitt 1990). Enzyme inhibitors such as beef plasma have been found to counteract this flesh-softening activity, but suitable markets have not been established to support increased harvests. Thus, they are primarily caught by bottom trawls as bycatch in other high value fisheries. Stocks are lightly exploited and appear to be increasing in both the GOA and the BSAI. Information on arrowtooth flounder stock conditions in the BSAI comes primarily from the annual EBS shelf trawl survey. Limited information is also available from past slope surveys (1981-91) and catch sampling of the commercial fishery.

Information on Bering Sea arrowtooth flounder is available from the following sources:

Data Component	**Years of Data**
Fishery catch	1970 to 1999
Shelf survey biomass and Southeast	1982 to 1999
Slope survey biomass and Southeast	1981, 1982, 1985, 1988, 1991
Shelf survey size composition (by sex)	1979 to 1999
Slope survey size composition (by sex)	1981, 1982, 1985, 1988,1991
Fishery length-frequencies from observers	1978 to 1991

The time-series of fishery and survey size compositions allows the use of an size-based stock assessment model (Wilderbuer and Sample 1997). The outputs include estimates of sex-specific abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which, when considered with projected future biomass, are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE report.

The reference fishing mortality rate and ABC for arrowtooth flounder are determined by the amount of population information available (Appendix 1; Amendment 44). Arrowtooth flounder are managed under Tier 3 of the ABC/OFL definition since equilibrium recruitment could be approximated by the average recruitment from the time-series estimated in the stock assessment, and $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ could be estimated. In the 1999 assessment, projected biomass in 2000 is greater than $B_{40\%}$ (496,000t >194,600 t) so the $F_{40\%}$ fishing mortality rate (the upper limit) was recommended for calculating ABC. The 2000 Council TAC was set equal to the ABC. Increased future harvest is likely constrained by Pacific halibut bycatch limitations. ABC and TAC information are as follows: BSAI 2000 ABC = 131,000 mt, BSAI TAC = 131,000 mt, and BSAI 1999 catch = 10,679.

Information on GOA arrowtooth flounder used for stock assessments is available from the following sources:

Data Component	Years of Data
Fishery catch	1960 to 1999
IPHC trawl survey biomass and S.E.	1961 to 1962
NMFS exploratory research trawl survey biomass and S.E.	1973 to 1976
NMFS triennial trawl survey biomass and S.E.	1984, 1987, 1990, 1993, 1996, 1999
Fishery size compositions	1977 to 1981, 1984 to 1993, 1995 to 1996
NMFS triennial trawl survey size compositions	1984, 1987, 1990, 1993, 1996, 1999
NMFS GOA groundfish surveys length-at-age data	1975, 1977 to 1978, 1980 to 1983
NMFS triennial trawl survey length-at-age data	1984, 1987, 1990, 1993, 1996

Current abundance estimates indicate that arrowtooth flounder have the largest biomass of the groundfish species inhabiting the GOA. The time-series of fishery and survey size compositions allows the use of a size-based stock assessment model (Turnock et al. 1997b). The outputs include estimates of sex-specific abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate ABC. The stock assessment is updated annually and incorporated into the GOA SAFE report.

The reference fishing mortality rate and ABC for arrowtooth flounder are determined by the amount of population information available. Assuming that equilibrium recruitment can be approximated by the average recruitment from the time-series estimated in the stock assessment, $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ are known and because biomass in 2000 is greater than $B_{40\%}$ (1,075,900 > 436,700), $F_{40\%}$ (the upper limit) is the recommended fishing mortality rate to calculate ABC. The 2000 Council TAC of 35,000 mt is well below the ABC of 145,360 mt recommended from the stock assessment. Increased future harvest is likely constrained by Pacific halibut bycatch limitations. ABC and TAC information are as follows: BSAI 2000 ABC = 145,360 mt, BSAI TAC = 35,000 mt, and BSAI 1999 catch = 16,062 mt.

Other Flatfish

In the Bering Sea, eight other flatfish species are managed under the FMPs. Alaska plaice, rex sole, Dover sole, starry flounder, English sole, butter sole, sand sole, and deep sea sole. Adults of all species are benthic and occupy separate winter spawning and summer feeding grounds. Adults overwinter in deeper water and move into nearshore spawning areas in the late winter and spring. Spawning takes place as early as November for Dover sole (Hagerman 1952) but occurs from February through April for most species (Hart 1973). All flatfish eggs are pelagic and sink to the bottom shortly before hatching (Alderdice and Forrester 1968, Hagerman 1952, Orcutt 1950, Zhang 1987), except for butter sole, which has demersal eggs (Levings 1968).

In the Bering Sea, Alaska plaice is the most abundant and commercially important of the other flatfish species. It is a comparatively long-lived species, and has frequently been aged as high as 25 years. For stock assessment purposes, a natural mortality rate of 0.25 is used (Wilderbuer and Walters 1997). Alaska plaice appear to feed primarily on polychaetes, marine worms and other benthic invertebrates (Livingston and DeReynier 1996, Livingston et al. 1993). For the other seven species in the BSAI "other flatfish" management category, little is known of their feeding habits, spawning, growth characteristics or seasonal movements and population age/size structure.

In general, other flatfish are taken as bycatch in bottom trawl fisheries for other groundfish. Alaska plaice are also taken in directed bottom trawl fisheries in the EBS. Because other flatfish are generally not targeted, commercial catch data is of limited use for stock assessment purposes. The principal source of information for evaluating the condition of other flatfish stocks in the BSAI is the annual EBS shelf trawl survey.

A moderate amount of information is available for Alaska plaice in the Bering Sea and is summarized below.

Data Component	Years of Data
Catch number at age	1971 to 1979, 1988, 1995
Total catch weight	1971 to 1999
Age-specific estimates of proportion of mature females	1971 to 1996
Trawl survey biomass estimates and S.E.	1982 to 1999
Survey age composition	1979, 1981, 1982, 1988, 1992 to 1995

The time series of fishery and survey age compositions allows the use of an age-based stock assessment model (Spencer et al. 1999b). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which, when considered with projected future stock abundance, are used to calculate ABC. For the rest of the species of the "other flatfish" management group, annual trawl survey biomass estimates are considered the best information available to determine the stock biomass. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE report. ABC and TAC information are as follows: BSAI 2000 ABC = 117,000 mt, BSAI TAC = 83,813 mt, and BSAI 1999 catch = 15,184 mt.

The other flatfish species complex in the GOA is currently managed as four categories with separate

ABCs: shallow-water flatfish, deep-water flatfish, flathead sole and rex sole. The shallow-water flatfish consists of Alaska plaice, starry flounder, yellowfin sole, English sole, butter sole, northern rock sole, and southern rock sole. Deep-water flatfish are: Dover sole, Greenland turbot, and deepsea sole. The shallow water category catch in 1999 was about 60 percent rock sole (southern and northern combined), 15 percent butter sole, 11 percent starry flounder, 4 percent English sole, 4 percent yellowfin sole, <1 percent Alaska plaice and 5 percent sand sole. The deep water catch is practically all Dover sole (over 99 percent in 1999).

The classification into the shallow-water and deep-water groups was due to significant differences in halibut bycatch rates in directed fisheries targeting on shallow and deep water flatfish species. Flathead sole were assigned a separate ABC due to their overlap in depth distribution of the shallow and deep water groups. In 1993, rex sole was split out of the deep-water management category because of concerns regarding the Pacific ocean perch bycatch in the rex sole target fishery. The information available for each species varies.

Data Component	**Years of Data**
Age composition from surveys-not all species	Various years
Triennial bottom trawl survey biomass and S.E.	1984, 1987, 1990, 1993, 1996, 1999
Total fishery catch weight by management category	Various years
Survey size composition	1984, 1987, 1990, 1993, 1996, 1999

Stock assessment models were not used for any of the species here due to the lack of available information (Turnock et al. 1999). Triennial trawl survey biomass estimates from 1984, 1987, 1990, 1993, 1996 and 1999 are considered the best information available to determine the stock biomass for all of the "other flatfish" species.

The reference fishing mortality rate and ABC for the flatfish management groups are determined by the amount of population information available. Rock sole, for which maturity information from Bering sea rock sole is deemed adequate, are in Tier 4 of the ABC and overfishing definitions, where $F_{ABC} = F_{40\%}$ and $F_{OFL} = F_{30\%}$. ABCs for all flatfish except rock sole, deep-sea sole and Greenland turbot were calculated using $F_{ABC} = 0.75\ M$ and $F_{OFL} = M$ (Tier 5), because maturity information was not available. Natural mortality was assumed to be 0.2 for all flatfish species except Dover sole where natural mortality is 0.1. Greenland turbot and Deep-sea sole are in Tier 6 because no reliable biomass estimates exist, where ABC = 0.75 OFL and the overfishing level (OFL) = the average catch from 1978 to 1995.

The TAC is well below the ABC for shallow-water group and flathead sole. The ABC, TAC, and catch are summarized below. The TAC is essentially the same as the ABC for the deep-water group and rex sole. The flatfish fishery in the GOA mainly targets rock sole, rex sole, and Dover sole. The catch of flatfish is limited by the bycatch of halibut and does not reach the TAC for any species group.

GOA Management Group	**GOA 2000 ABC**	**GOA 2000 TAC**	**GOA 1999 Catch**
Shallow-water	37,860	19,400	2,545
Deep-water	5,300	5,300	2,285

Flathead sole	26,270	9,060	891
Rex sole	9,440	9,440	3,057

Sablefish

Sablefish is found from northern Mexico to the GOA, westward to the Aleutian Islands, and in gullies and deep fjords, generally at depths greater than 200 m. Sablefish observed from a manned submersible were found on or within 1 m of the bottom (Krieger 1997). Several studies have shown sablefish to be highly migratory for at least part of their life cycle (Heifetz and Fujioka 1991, Maloney and Heifetz 1997), and substantial movement between the BSAI and the GOA has been documented (Heifetz and Fujioka 1991). Thus sablefish in Alaskan waters are assessed as a single stock (Sigler et al. 1999). Adults reach maturity at 4 to 5 years and a length of 51 to 54 cm (McFarlane and Beamish 1990). Spawning is pelagic at depths of 300-500 m near the edges of the continental slope (McFarlane and Nagata 1988). Juveniles are pelagic and appear to move into comparatively shallow near-shore areas where they spend the first 1 to 2 years (Rutecki and Varosi 1997). Sablefish are long-lived, with a maximum recorded age in Alaska of 62 years (Sigler et al. 1997). For stock assessments, a natural mortality rate of about 0.1 has been estimated (Sigler et al. 1999). It appears that sablefish are opportunistic feeders. Feeding studies conducted in Oregon and California, found that fish made up 76 percent of the diet (Laidig et al. 1997). Other studies, however, have found a diet dominated by euphausiids (Tanasichuk 1997).

Alaskan sablefish are considered a single stock and assessed in a combined area (BSAI and GOA) with an age-structured model incorporating fishery and survey catch data and age and length compositions. Survey data come from annual sablefish longline surveys in the GOA, and biennial longline surveys in the BSAI. These surveys indicate that the stock size peaked in the mid-1980s because of a series of strong year classes and has declined to lower level since.

The stock assessment includes catch history, fishery description, assessment methods, abundance and exploitation trends, and projected catch and abundance. Sablefish fall into Tier 3 of the ABC/OFL definitions, which requires reliable estimates of biomass, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$. Under the definitions and projected stock conditions in 1999, the overfishing fishing mortality rate was the adjusted $F_{35\%}$ rate which was 0.136 for sablefish and equated to a combined stock yield of 21,400 mt. Projections for 2000 showed that the maximum allowable fishing mortality rate for ABC (F_{ABC}) was the adjusted $F_{40\%}$ rate (0.109) and translated to a combined stock yield of 17,300 mt. The 2000 ABC recommendation was set at the adjusted $F_{40\%}$ rate. The stock assessment authors also constructed an approximate probability figure on the odds of the year 2004 spawning biomass dropping below the projected year 2000 level. They determined that a constant 5-year catch scenario of 17,000 mt was appropriate for minimizing the risks of further stock declines.

Relatively strong yearclasses include the 1990 and 1995 cohorts, and the 1997 appears to be relatively strong although this assessment is based on only a single year of data. Abundance has fallen in recent years because recent recruitment is insufficient to replace strong year classes from the later 1970s which are dying off. The estimated mean age of the recruited portion of the population is 7.3 years. The dominating factor determining the age composition is the magnitude of the recruiting year classes. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of a fished population with a several-decade catch history. How the current age composition of the population compares with the unfished population is unknown.

The directed fishery for sablefish is prosecuted by longlining. Sablefish are caught incidentally in trawl fisheries. A tiny amount of sablefish is caught by pot boats. By gear, the catches in 1998 were longlines (90 percent), trawls (10 percent) and pots (<1 percent). The directed fishery occurs on the upper continental slope and a few deepwater gullies, the areas inhabited by adult sablefish. The average discard from 1994 to 1997 was 3 percent for all longline fisheries and 27 percent for all trawl fisheries.

Larval sablefish feed on a variety of small zooplankton ranging from copepod nauplii to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids). The older demersal juveniles and adults appear to be opportunistic feeders, with food ranging from variety of benthic invertebrates, benthic fishes, as well as squid, mesopelagic fishes, jellyfish, and fishery discards. Gadid fish (mainly pollock) comprise a large part of the sablefish diet. Nearshore residence during their second year provides the opportunity to feed on salmon fry and smolts during the summer months. Young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the southeast troll fishery during the late summer.

Rockfish

At least 32 rockfish species of the genus *Sebastes* and *Sebastolobus* have been reported to occur in the GOA and BSAI (Eschmeyer et al. 1984), and several are of commercial importance. Pacific ocean perch has historically been the most abundant rockfish species in the region and has contributed most to the commercial rockfish catch. Other species such as northern rockfish, rougheye rockfish, shortraker rockfish, shortspine thornyheads, yelloweye rockfish, and dusky rockfish are also important to the overall rockfish catch. The TAC levels for these and all other rockfish species are determined on an annual basis by the Council. Among the main inputs needed for making this determination are the ABC and OFL recommendations from annual stock assessments conducted for each species and/or species assemblage.

Rockfish in the GOA is currently managed as four assemblages: 1) slope rockfish, 2) pelagic shelf rockfish, 3) demersal shelf rockfish, and 4) thornyheads. Separate ABCs, OFLs, and TACs are set for each assemblage except for slope rockfish which is further subdivided into four subgroups with separate ABCs, OFLs, and TACs: 1) Pacific ocean perch, 2) shortraker and rougheye rockfish, 3) northern rockfish, and 4) “other slope rockfish”.

Rockfish in the BSAI are currently managed as two assemblages; 1) Pacific ocean perch complex and 2) other rockfish. The Pacific ocean perch complex includes Pacific ocean perch, rougheye rockfish, shortraker rockfish, sharpchin rockfish, and northern rockfish. For the EBS region, the Pacific ocean perch complex is divided into two subgroups with: 1) Pacific ocean perch, and 2) shortraker, rougheye, sharpchin, and northern rockfish combined. For the Aleutian Islands region, the Pacific ocean perch complex is divided into three subgroups: 1) Pacific ocean perch, 2) shortraker and rougheye rockfish, and 3) sharpchin and northern rockfish. Separate ABC, and TAC, and OFLs are assigned to each subgroup. Other rockfish includes all *Sebastes* and *Sebastolobus* species in the BSAI region other than the Pacific ocean perch complex. Shortspine thornyheads account for more than 90 percent of the estimated biomass of the other rockfish assemblage in the BSAI.

Rockfish are assessed with either an age structured model or trawl survey based model, depending on the management group. Pacific ocean perch are assessed with an age-structured model incorporating fishery and survey catch and age composition data. Most other species of rockfish are assessed based on trawl survey catch data. Survey data are from the NMFS triennial trawl surveys. The stock assessments provide the best available information. For all rockfish management groups, the assessment includes catch history, characterizations of the fishery, assessment methodology, and abundance and exploitation trends. The results of the analyses, which are updated annually, are presented in the GOA and BSAI stock assessment report, which is incorporated into the NPFMC SAFE reports.

Pacific ocean perch

Pacific ocean perch is primarily a demersal species which inhabits the outer continental shelf and slope regions of the North Pacific and Bering Sea, from southern California to Japan (Allen and Smith 1988). As adults, they live on or near the sea floor, generally in areas with smooth bottoms (Krieger 1993), generally at depths ranging from 180 to 420 m. The diet of Pacific ocean perch appears to consist primarily of plankton (Brodeur and Percy 1984); euphausiids are the single most important prey item (Yang 1996).

Though more is known about the life history of Pacific ocean perch than about other rockfish species (Kendall and Lenarz 1986), much uncertainty still exists about its life history. Pacific ocean perch are viviparous, with internal fertilization and the release of live young (Hart 1973). Insemination occurs in the fall, and release of larvae occurs in April or May. Pacific ocean perch larvae are thought to be pelagic and drift with the current. Juveniles seem to inhabit rockier, higher relief areas than adults (Carlson and Straty 1981, Krieger 1993). Pacific ocean perch is a slow growing species that, in the Gulf, reaches maturity at approximately 10 years, or 36 cm in length (Heifetz et al. 1997) and has a maximum life span of 90 years (Chilton and Beamish 1982). The natural mortality rate likely is between 0.02 and 0.08 (Archibald et al. 1981, Chilton and Beamish 1982).

Pacific ocean perch is the most commercially important rockfish in Alaska’s fisheries and is taken almost exclusively with bottom trawls. The species is highly valued and supported large Japanese and Soviet trawl fisheries throughout the 1960s. Apparently, stocks were not productive enough to support the large removals that took place, and they declined throughout the 1960s and 1970s, reaching their lowest levels in the early 1980s. Since that time, stocks have stabilized in the EBS, and increased in the Aleutian Islands and GOA.

A time series of fishery and survey age compositions allows the use of an age-based stock assessment model for POP. The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model uses the ratio of female spawning biomass to that which would exist without fishing to estimate reference fishing mortality rates. The reference fishing mortality rates are used to calculate ABC, and the assessment is updated annually.

In the GOA, Pacific ocean perch fall into Tier 3 of the ABC/OFL definitions, which requires reliable estimates of biomass, $B_{40\%}$, $F_{30\%}$, and $F_{40\%}$. Under the definitions and current stock conditions, the overfishing fishing mortality rate for Pacific ocean perch is the $F_{35\%}$ adjusted rate which is 0.078 for Pacific ocean perch and equates to a yield of 15,385 mt. The maximum allowable fishing mortality rate for ABC (F_{ABC}) defined by Tier 3 is the $F_{40\%}$ adjusted rate which is 0.065 for Pacific ocean perch and translates to a yield of 13,020 mt. The stock assessment fishing mortality rate for ABC is equivalent to the maximum allowable fishing mortality rate. The current Council TAC level is 13,020 mt, equal to the recommended stock assessment ABC.

The current age and size distributions of Pacific ocean perch in the GOA are discussed in Heifetz et al. (1999). Information is available from the 1984, 1987, 1990, 1993, and 1996 surveys. The dominating factor determining the age composition is the magnitude of the recruiting year classes which are highly variable. The first three surveys show a strong 1976 year-class, and the 1980 year-class appears strong in the 1987 survey and average in the 1990 survey. The 1986 year-class appears strong in the 1990 survey, and exceptionally strong in the 1993 and 1996 surveys. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and it is not certain how the current age composition of the population would compare to an unfished population.

In the GOA, the directed fishery for Pacific ocean perch is prosecuted by catcher-processor and catcher bottom trawlers. The percentage of Pacific ocean perch taken by pelagic trawls has increased from 2-8 percent during 1990-1995 to 14-20 percent during 1996-1998. Factory trawlers continue to take nearly all the catch in the eastern and western GOA; however, since 1996, the percentage of Pacific ocean perch in the central GOA taken by shore-based trawlers has ranged from 28 percent to 49 percent. The fishery generally occurs at depths between 150 and 300 m along the outer continental shelf, the upper continental slope and at the mouth of gullies. Important Pacific ocean perch fishery locations include: in the eastern GOA, the gully and slope southwest of Yakutat Bay and off Cape Omaney; in the central GOA, the shelf, slope and gullies off of Kodiak Island south of Portlock Bank and near Albatross Bank; and in the western GOA, the shelf and slope south of Unimak and Umnak Islands.

In the GOA, Pacific ocean perch are caught as bycatch (not necessarily discarded) in other directed fisheries aimed mostly at other species of rockfish. Heifetz and Ackley (1997) analyzed bycatch in rockfish fisheries of the GOA. Bycatch rates of Pacific ocean perch are highest in the pelagic shelf rockfish, “other slope rockfish”, and shortspine thornyhead fisheries. Information on bycatch in non-rockfish fisheries has not been analyzed. Recent discard rates (discards/total catch) of Pacific ocean perch have been about 15 percent (Heifetz et al. 1997). In 1997, about 1,360 mt of Pacific ocean perch were discarded compared to a total catch of 9,500 mt.

The diets of commercially important groundfish species in the GOA during the summer of 1990 were analyzed by Yang (1993). About 98 percent of the total stomach content weight of Pacific ocean perch in the study was made up of invertebrates and 2 percent of fish. Euphausiids (mainly *Thysanoessa inermis*) were the most important prey item. Euphausiids comprised 87 percent by weight of the total stomach contents. Calanoid copepods, amphipods, arrow worms, and shrimp were frequently eaten by POP. Documented predators of Pacific ocean perch include Pacific halibut and sablefish, and it likely that Pacific cod and arrowtooth flounder also prey on POP. Pelagic juveniles are consumed by salmon, and benthic juveniles are eaten by lingcod and other demersal fish.

In the BSAI, Pacific ocean perch are assessed with an age-structured model incorporating fishery and survey catch data and age compositions. Survey data are from the NMFS triennial trawl groundfish surveys and the fishery data comes from the observer program. The stock assessment is based on the best available information. It includes catch history, characterizations of the fishery, assessment methodology, abundance and exploitation trends, and projected catch and abundance trends for a range of fishing mortalities and recruitment assumptions (Ito et al. 1999). The assessments for the other species in the Pacific ocean perch complex and for the "other rockfish" management category are based on substantially less information (Ito and Spencer 1999, Ito et al. 1999).

The current spawning biomass for Pacific ocean perch in the Aleutian Islands is about 2,500 mt below its long-term average under an $F_{40\%}$ (=0.072) harvest strategy. Our current estimate of spawning biomass for this stock is about 97,800 mt, whereas, the long-term equilibrium spawning biomass is about 100,300 mt. Based on the guidelines established under Tier 3, the adjusted F_{ABC} was calculated as 0.0702, which equates to an ABC estimate of approximately 12,300 mt. The total Aleutian Islands recommended ABC was then apportioned among Aleutian Islands subareas based on survey distribution, as follows: western = 5,670 mt, central = 3,510 mt, and eastern = 3,120 mt. This was done to better distribute fishing effort over a wider area, thereby reducing the chance for localized depletion. The OFL was determined using an adjusted $F_{35\%}$ rate of 0.0826 which translates to an OFL of 14,400 mt.

For the EBS stock of POP, the estimate of current spawning biomass is also below its long-term average. The current estimate of spawning biomass for this stock is about 24,900 mt and its long-term equilibrium spawning biomass is 26,200 mt. The same adjustment procedure used for the Aleutian Islands $F_{40\%}$ rate was also applied to the EBS $F_{40\%}$ estimate. This procedure produced an F_{ABC} of 0.0544 and an ABC estimate for the EBS of approximately 2,600 mt. The overfishing mortality level (FOFL) was given as an adjusted $F_{35\%}$ and was 0.0653, which translates to an OFL of about 3,100 mt.

Shortraker and Rougheye Rockfish

Shortraker and rougheye rockfish inhabit the outer continental shelf of the north Pacific from the EBS as far south as southern California (Kramer and O'Connell 1988). Adults of both species are semi-demersal and are usually found in deeper waters (from 50 to 800 m) and over rougher bottoms (Krieger and Ito 1999) than POP. Little is known about the biology and life history of these species, but they appear to be long-lived, with late maturation and slow growth. Shortraker rockfish have been estimated to reach ages in excess of 120 years and rougheye rockfish in excess of 140 years. Natural mortality rates have been estimated by Heifetz and Clausen (1991) at 0.025 for rougheye rockfish and 0.030 for shortraker rockfish. Like other members of the genus *Sebastes*, they are viviparous (bear live young) and birth occurs in the early spring through summer (McDermott 1994). Food habit studies conducted by Yang (1993) indicate that the diet of rougheye rockfish is dominated by shrimp. The diet of shortraker rockfish is not well known, based on a small number of samples, the diet appears to be dominated by squid. Because shortraker rockfish have large mouths and short gill rakers, it is possible that they are potential predators of other fish species (Yang 1993). Though shortraker and rougheye rockfish are highly valued, amounts available to the commercial fisheries are limited by relatively small TAC and ABC amounts that are fully needed to support bycatch needs in other groundfish fisheries. As a result, the directed fishery for these species typically is closed at the beginning of the fishing year.

The primary methods of harvest for shortraker and rougheye rockfishes are bottom trawl and longline gears. The bulk of the commercial harvest usually occurs at depths between 200 and 500 m along the upper continental slope. Both species are associated with a variety of habitats from soft to rocky habitats, although boulders and sloping terrain appear also to be desirable habitat. Age at recruitment is uncertain, but is probably on the order of 20+ years for both species. Length at 50 percent sexual maturity is about 45 cm for shortraker rockfish and about 44 cm for rougheye rockfish (McDermott 1994).

A sufficient time series of fishery and survey age compositions is not available to construct an age-based stock assessment model for shortraker and rougheye rockfish. Thus assessment is based mostly on exploitable biomass estimates provided by trawl surveys. Specifically, exploitable biomass for the GOA stocks is estimated as the unweighted average of the three most recent surveys (1993, 1996, and 1999), excluding the 1-100 m depth stratum (which contains largely unexploitable juvenile fish). Life history information allows estimates of reference fishing mortality rates which are used to calculate ABC. The stock assessment is updated annually.

In the GOA, shortraker rockfish falls into Tier 5, and rougheye rockfish falls into Tier 4 of the ABC/OFL definitions. Under these definitions, the overfishing fishing mortality rate for shortraker rockfish is the

$F=M$ rate of 0.03. The maximum allowable fishing mortality rate for ABC (F_{ABC}) defined by Tier 5 for shortraker rockfish is the $F=0.75M$ rate which is 0.023. The maximum allowable fishing mortality rate for ABC (F_{ABC}) for rougheye rockfish defined by Tier 4 is $F_{40\%}$ which is 0.032. The stock assessment F_{ABC} for rougheye set equal to the natural mortality M of 0.025, which is lower than the maximum allowable fishing mortality rate for ABC. This results in the recommended ABC of 1,730 mt for shortraker and rougheye rockfish, and this level was adopted as the ABC and TAC by the Council. Because the shortraker and rougheye rockfish ABC and TAC are set more conservatively than the maximum prescribed under the definitions, less of a risk of the F_{ABC} rate being an overly aggressive harvest rate for shortraker and rougheye rockfish exists. This affords more protection to the stocks given the variability and uncertainty associated with the abundance.

For the Aleutian Islands shortraker and rougheye rockfish stocks, the assessment is also based on catch and survey data. The biomass estimates from U.S. domestic Aleutian Islands bottom trawl surveys (1991, 1994, 1997) are averaged to obtain the best estimate of biomass for the species in this subcomplex; earlier U.S.-Japan cooperative surveys were excluded because of differences in survey gear. The 2000 biomass estimates of rougheye and shortraker rockfish were 12,762 mt and 28,713 mt, respectively. In 1996, the Council's Science and Statistical Committee determined that reliable estimates of the natural mortality rate existed for the species in this subcomplex, and that shortraker and rougheye rockfish in the Aleutian Islands therefore qualified for management under Tier 5. The accepted estimates of M is 0.025 for rougheye rockfish and 0.030 for shortraker rockfish. The Plan Team recommends setting F_{ABC} at the maximum value allowable under Tier 5, which is 75 percent of M. This produced F_{ABC} of 0.019 for rougheye rockfish and 0.023 for shortraker rockfish. Multiplying these rates by the biomass estimates and summing across species gives a 2000 ABC of 885 mt. The Plan Team's OFL was determined from the Tier 5 formula, where setting $F_{OFL}=M$ for each species gives a combined OFL of 1,180 mt.

In recent years a directed fishery for shortraker and rougheye rockfish has not been allowed, because TACs are small. Shortraker and rougheye rockfishes are often caught as bycatch and retained in the sablefish and halibut longline fisheries and fisheries targeting other species of rockfish. Heifetz and Ackley (1997) analyzed bycatch (not necessarily discarded) in rockfish fisheries of the GOA. Bycatch rates of shortraker and rougheye rockfish are highest in the shortspine thornyhead and Pacific ocean perch fisheries. An analysis of bycatch rates in non-rockfish fisheries has not been conducted. Discard rates (discards/total catch) of shortraker and rougheye rockfish in the GOA during 1995 to 1999 have ranged from 22 percent to 32 percent (Heifetz et al. 1999). In 1999, about 397 mt of shortraker and rougheye rockfish were discarded compared to a total catch of 1,310 mt.

Northern Rockfish

Northern rockfish inhabit the outer continental shelf from the EBS, throughout the Aleutian Islands and the GOA (Kramer and O'Connell 1988). This species is semi-demersal and is usually found in comparatively shallower waters of the outer continental slope (from 50 to 600 m). Little is known about the biology and life history of northern rockfish. However, they appear to be long lived, with late maturation and slow growth. Heifetz and Clausen (1991) estimated the natural mortality rate for northern rockfish to be 0.060. Like other members of the genus Sebastes, they bear live young, and birth occurs in the early spring through summer (McDermott 1994). Food habit studies conducted by Yang (1993) indicate that the diet of northern rockfish is dominated by euphausiids. Although northern rockfish are lower in value than Pacific ocean perch, they still support a valuable directed trawl fishery, especially in the GOA.

In the GOA, northern rockfish falls into Tier 4 of the ABC/OFL definitions. The exploitable biomass is estimated as the weighted mean from the three most recent surveys; this produces an estimate of 85,357 mt for northern rockfish. The maximum allowable fishing mortality rate for ABC (F_{ABC}) defined by Tier 4 is the $F_{40\%}$ rate of 0.075. The stock assessment F_{ABC} for rougheye set equal to the natural mortality M of 0.06, which is lower than the maximum allowable fishing mortality rate for ABC. This results in the stock assessment ABC of 5,120 mt for northern rockfish. The current Council ABC and TAC levels are 4,990 mt. Because the northern rockfish ABC and TAC are more conservative than the maximum prescribed under the definitions, less risk exists of the F_{ABC} rate being an overly aggressive harvest rate for this species. This affords more protection to the stocks given the variability and uncertainty associated with the abundance.

Age-structured information exists for GOA northern rockfish, and has led to the development of an age-structured population model (Heifetz et al 1999). It is expected that this model will be used for future assessments. The current age and size distributions of Pacific ocean perch in the GOA are discussed in Heifetz et al. (1999). Information is available from the 1984, 1987, 1990, 1993, and 1996 surveys. The dominating factor determining the age composition is the magnitude of the recruiting year classes which are highly variable. Most surveys (except the 1993 survey) indicate that 1968-1971 and 1975-1977 were periods of strong year-classes. The 1993 and 1996 surveys indicate that the 1984 and 1985 year-classes may be stronger than average. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and it is not certain how the current age composition of the population would compare to an unfished population.

The directed fishery for northern rockfish is prosecuted by catcher-processor and catcher bottom trawlers. As with the Pacific ocean perch fishery, a higher percentage of the catch in the central GOA is being taken by shore-based trawlers, ranging from 32 percent to 53 percent from 1996 to 1999. The patterns of the fishery generally reflect the distribution of the species. The fishery is concentrated at discrete, relatively shallow offshore banks of the outer continental shelf at depths between 75 and 125 m. Important northern rockfish fishery locations include Portlock Bank and Albatross Bank south of Kodiak Island, Shumagin Bank south of the Shumagin Islands, and Davidson Bank south of Unimak Island.

Heifetz and Ackley (1997) analyzed bycatch (not necessarily discarded) in rockfish fisheries of the GOA. Bycatch rates of northern rockfish are highest in the pelagic shelf rockfish, “other slope rockfish”, and Pacific ocean perch fisheries. Information on bycatch of northern rockfish in non-rockfish fisheries has not been analyzed. Discard rates (discards/total catch) of the GOA northern rockfish from 1995 to 1999 have ranged from 13 percent to 28 percent (Heifetz et al. 1999). In 1999, about 597 mt of northern rockfish were discarded compared to a total catch of 5297 mt.

Northern rockfish are generally planktivorous (feed on plankton) with euphausiids being the predominant prey item (Yang 1993). Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities. Predators of northern rockfish are not well documented but likely include larger fish such as Pacific halibut that are known to prey on other rockfish species.

In the Aleutian Islands, northern rockfish are managed together with sharpchin rockfish. Because sharpchin rockfish are found only rarely in the Aleutian Islands, northern rockfish are, for all practical purposes, the only species in this subcomplex. As with the shortraker and rougheye stocks, the biomass estimates from U.S. domestic Aleutian Islands bottom trawl surveys (1991, 1994, 1997) are averaged to obtain the best estimate of biomass for the species in this subcomplex. This procedure produced a biomass estimate of 114,501 mt. Northern rockfish in the Aleutian Islands are managed under Tier 5 of

Amendment 44. The accepted estimate of M for northern rockfish in the Aleutian Islands is 0.06. ABC was based on maximum allowable F_{ABC} under Tier 5, which is 75 percent of M, or 0.045. Multiplying this rate by the best estimate of biomass gave a 2000 ABC of 5,153 mt. The Plan Team's OFL was determined from the Tier 5 formula, where setting $F_{OFL}=M$ gives a 2000 OFL of 6870 mt.

Pelagic Shelf Rockfish

In the GOA, pelagic shelf rockfish consist of dusky rockfish, yellowtail rockfish, and widow rockfish. Black rockfish were formerly in this group, but were removed in April, 1998, from both the pelagic shelf group and the GOA groundfish FMP. Dusky rockfish is by far the most important species in the group, both in terms of abundance and commercial value. This complex is assessed with a trawl survey-based model, with survey data coming from the NMFS GOA triennial trawl surveys. The stock assessments provide the best available information for pelagic shelf rockfish, and include discussions of catch history, characterizations of the fishery, assessment methodology, and abundance and exploitation trends. The results of the analyses, which are updated annually, are presented in the GOA pelagic shelf rockfish stock assessment which is incorporated into the GOA SAFE report.

Pelagic shelf rockfish fall into Tier 4 of the current ABC/OFL definitions, which requires estimates of biomass, $F_{35\%}$, and $F_{40\%}$. Biomass estimates are produced from averaging the three most recent triennial surveys (1993, 1996, and 1999), and the current exploitable biomass is 66,443 mt. Estimates of $F_{35\%}$ and $F_{40\%}$ are derived using life history parameters for dusky rockfish. According to the definitions for Tier 4, the maximum allowable fishing mortality rate for ABC (F_{ABC}) is the $F_{40\%}$ rate, which is 0.11 for pelagic shelf rockfish and translates to a Gulfwide yield of 7,309 mt. The actual stock assessment F_{ABC} for pelagic shelf rockfish, however, is set to a more conservative value, $F=M$, in which F_{ABC} equals the natural mortality of dusky rockfish, 0.090. Hence, the corresponding yield is 5,980 mt, which is the recommended ABC value in the stock assessment for 2000. The Council has adopted this level for both the ABC and TAC for 2000. The corresponding OFL fishing mortality rate is $F_{35\%} = 0.136$, which results in an OFL yield of 9036 mt. Because the northern rockfish ABC and TAC are more conservative than the maximum prescribed under the definitions, less risk exists of the F_{ABC} rate being an overly aggressive harvest rate for this species. This affords more protection to the stocks given the variability and uncertainty associated with the abundance.

Age and size distributions of dusky rockfish are based on results of the five triennial trawl surveys from 1984 to 1996, and are discussed in Clausen and Heifetz (1999). Age results are only available from the 1987, 1990, and 1993 surveys, and these show that substantial recruitment of dusky rockfish appears to be a relatively infrequent event. Strong year classes are only seen for 1976 to 1977, 1979 to 1980, and 1986. The size compositions from each of the five surveys indicate that recruitment of small fish to the survey occurred only in 1993, corresponding to the 1986 year class. The effects of fishing on the age and size compositions are unknown, as no age or size data are available from either the fishery, or the unfished population prior to the beginning of the fishery.

Dusky rockfish are caught almost exclusively with bottom trawls. Factory trawlers dominated the directed fishery from 1988 to 1995. Since 1996, the percentage of the catch taken by shore-based trawlers in the central GOA has ranged from 18 percent to 45 percent. Catches are concentrated at a number of relatively shallow, offshore banks of the outer continental shelf, especially the "W" grounds west of Yakutat, and Portlock Bank. Other fishing grounds include Albatross Bank, the "Snakehead" south of Kodiak Island, and Shumagin Bank. Highest catch per unit effort is generally taken at depths of 10-150 m (Reuter 1998).

Dusky rockfish often co-occur with northern rockfish, and they are caught as bycatch in the northern rockfish and "other slope rockfish" fisheries (Heifetz and Ackley 1997). To a lesser extent, they are also taken as bycatch in the Pacific ocean perch fishery. Overall discard rates (discards/total catch) of dusky rockfish in recent years have been quite low, generally 10 percent or less (Clausen and Heifetz 1999).

Trophic interactions of dusky rockfish are not well known. Food habits information is available from just one study with a relatively small sample size for dusky rockfish (Yang 1993). This study indicated that adult dusky rockfish consume primarily euphausiids, followed by larvaceans, cephalopods, and pandalid shrimp. Predators of dusky rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

Demersal Shelf Rockfish

Demersal shelf rockfish include seven species of nearshore, bottom-dwelling rockfish: canary rockfish, China rockfish, copper rockfish, quillback rockfish, rosethorn rockfish, tiger rockfish, and yelloweye rockfish. Demersal shelf rockfish are managed by the Council as a distinct assemblage only off Southeast Alaska Outside (SEO) east of 140°W, an area which is further divided into four management units along the outer coast: the South SEO (SSEO), central SEO (CSEO), North SEO (NSEO), and East Yakatat (EYKT). Yelloweye rockfish comprise 90 percent of the catch and will be the focus of this section.

Yelloweye rockfish occur on the continental shelf from northern Baja California to the EBS, commonly in depths less than 200 m (Kramer and O'Connell 1988). They are long-lived, slow growing, and late maturing. Yelloweye have been estimated to reach 118 years and their natural mortality rate is estimated at 0.20 (O'Connell and Funk 1987). They are viviparous (live bearing) with parturition (birth) occurring primarily in late spring through mid-summer (O'Connell 1987). Yelloweye inhabit areas of rugged, rocky relief and adults appear to prefer complex bottoms with the presence of "refuge spaces" (O'Connell and Carlile 1993). Demersal shelf rockfish are highly valued and a directed longline fishery is held for these species. However, yelloweye are the primary bycatch in the halibut fishery and therefore a large portion of the TAC and ABC are set aside for bycatch. In 1998, 31 percent of the total Demersal shelf rockfish landings occurred as bycatch in the halibut fishery (O'Connell et al. 1999).

Traditional abundance estimation methods (e.g., area-swept trawl surveys, mark recapture) are not considered useful for these fishes given their distribution, life history, and physiology. However, ADF&G is continuing research to develop and improve a stock assessment approach for them. As part of that research a manned submersible, R/V Delta, is used to conduct line transects (Buckland et al. 1993, Burnham et al. 1980). Density estimates are limited to adult yelloweye, because it is the principal species targeted and caught in the fishery, and therefore ABC/TAC recommendations for the entire assemblage are keyed to adult yelloweye abundance. Total yelloweye rockfish biomass is estimated for each management subdistrict as the product of density, mean weight of adult yelloweye, and areal estimates of Demersal shelf rockfish habitat (O'Connell and Carlile 1993). For estimating variability in yelloweye biomass, log-based confidence limits are used because the distribution of density tends to be positively skewed and density is assumed to be log-normal (Buckland et al. 1993). Estimation of both line length for the transects and total area of rocky habitat are difficult and result in some uncertainty in the biomass estimates. Density estimates were made in the EYKT and SSEO areas in 1999. The density in the SSEO area increased 38 percent from the previous density estimate made in 1994, although some of this change may be due to increased sample size and a change in survey techniques. In contrast, the density in the EYKT area decreased 44 percent from the previous estimate in 1997. During the 1997 survey, the area estimate of rock habitat in the EYKT management area was reduced by 60 percent compared to past assessments, resulting in a reduction in the biomass estimate for this area. The sum of the lower 90 percent confidence limits of biomass, by area, is the reference number for setting ABC because of the continued uncertainty in yelloweye biomass estimation. This resulted in a biomass estimate of 15,100 mt for 2000.

Demersal shelf rockfish falls into Tier 4 of the ABC/OFL definitions. Under these definitions, the OFL mortality rate is $F_{35\%}$=0.028 (420 mt), and the maximum allowable fishing mortality rate for ABC is the $F_{40\%}$=0.025. However, a more conservative approach has been taken for setting ABC and TAC. By applying F=M=0.02 to yelloweye rockfish biomass and adjusting for the 10 percent of other Demersal shelf rockfish species, the recommended 2000 ABC is 340 mt. Continued conservatism in managing this fishery is warranted given the life history of the species and the uncertainty of the biomass estimates.

The age and size distributions of yelloweye rockfish are discussed in O'Connell et al. (1999) and O'Connell and Funk (1987). Estimated length and age at 50 percent maturity for yelloweye collected in CSEO in 1988 are 45 cm and 21 years for females and 50 cm and 23 years for males. Age of first recruitment into the fishery is between 13 and 18 years. The most recent age data is from the 1998 commercial catch samples. In the CSEO, the area with the longest catch history, the 1997 distribution shows a strong mode at 28 years of age, with some younger modes. The older ages have declined in frequency over time and the average age continues to decline and remains the lowest of all areas. In the SSEO ,the 1997 age data shows pronounced modes at 16 and 20 years, with the older ages contributing less. In EYKT, the 1998 age distribution is multimodal, the largest mode at 29-30 years, and smaller modes at 33 and 40 years. Unlike other areas, no sign of recruitment is seen here. The effects of fishing on the age and size compositions are unknown, as no age or size data are available from either the fishery, or the unfished population prior to the beginning of the fishery.

The directed fishery for Demersal shelf rockfish is prosecuted by longliners. Yelloweye rockfish occur in areas of rugged, rocky bottom, commonly between 100 and 200 m. The lava fields off Cape Edgecumbe in CSEO and the offshore Fairweather Ground in EYKT are the most important fishing areas. A small amount of Demersal shelf rockfish are taken as bycatch in jig and troll fisheries. Trawling is prohibited in the eastern GOA. Yelloweye rockfish is the dominant bycatch species in the halibut longline fishery. The majority of the longline vessels in the eastern GOA are unobserved so it is difficult to get an accurate accounting of discards at sea. For the past several years we have estimated unreported mortality of Demersal shelf rockfish during the halibut fishery based on International Pacific Halibut Commission (IPHC) interview data. The 1993 interview data indicates a total mortality of Demersal shelf rockfish of 13 percent of the June halibut landings (by weight) and 18 percent of the September halibut landings. Unreported mortality data has been more difficult to collect under the halibut IFQ fishery and appears to be less reliable than previous data. The allowable bycatch limit of Demersal shelf rockfish during halibut fishing is 10 percent of the halibut weight. The total bycatch of Demersal shelf rockfish during the 1999 halibut fishery in the eastern Gulf is estimated to be 184 mt, much of which is unreported. Catch statistics do not accurately reflect true mortality of Demersal shelf rockfish.

Yelloweye are a large, predatory fish that usually feeds close to the bottom. Food habit studies indicate that the diet of yelloweye rockfish is dominated by fish remains, which comprised 95 percent, by volume, of the stomachs analyzed. Herring, sandlance and Puget Sound rockfish were particularly dominant. Shrimp are also an important prey item (Rosenthal et al. 1988).

Thornyheads

Thornyheads in Alaskan waters are comprised of two species, the shortspine thornyhead and the longspine thornyhead. Only the shortspine thornyhead is of commercial importance. It is a demersal species found in deep water from 93 to 1,460 m from the Bering Sea to Baja California (Ianelli and Gaichas 1999). Little is known about thornyhead life history. Like other rockfish, they are long lived and slow growing. The maximum recorded age is probably in excess of 50 years, and females do not become sexually mature until an average age of 12 to 13 at a length of about 21 cm. Thornyheads spawn large masses of buoyant eggs during the late winter and early spring (Pearcy 1962). Juveniles are pelagic for the first year. Yang (1993, 1996) showed that shrimp were the top prey item for shortspine thornyheads in the GOA; while cottids were the most important prey item in the Aleutian Islands region. Until recently, thornyheads were not targeted by the commercial fishery. However, they are now among the most valuable rockfish species and are harvested by trawl and longline gear. Most of the domestic harvest is exported to Japan. Thornyheads are taken with some frequency in the longline fishery for sablefish, and cod and are often part of the bycatch of trawlers concentrating on pollock and other rockfish species.

In the GOA ,shortspine thornyheads are assessed with an age-structured model incorporating data from two fisheries (longline and trawl) and two types of survey data. Bottom trawl surveys have been conducted every three years in the GOA during June through August and provide a limited time-series of abundance since 1977. Longline surveys occur annually and extend into the deeper waters (300 – 800 m) of shortspine thornyhead habitat. Both surveys provide estimates of the size distributions of their respective catches. These are used in the stock assessment model in place of age compositions because extensive age-determinations on this species are currently impractical, given the difficulties in interpretation of their otoliths. Biologically, the biggest area of uncertainty for this species is in their longevity and natural mortality rate. Currently, NMFS scientists believe they are slow-growing and long-lived fish that are relatively sedentary on the ocean floor. Survey and fishery catch rates indicate that they are relatively evenly distributed within their habitat and do not tend to form dense aggregations like many other groundfish species. This distribution pattern is important in interpreting the survey results because the assumptions implied in "area-swept" methods for the bottom trawl gear are likely to be satisfied. Fishery data include estimates of the total catch and size distribution information by gear type. The estimated biomass for 2000 is 23,084 mt, and the recommended ABC is 2,360 mt. The Council has adopted this value for both the 2000 TAC and OFL harvest levels.

In the EBS and Aleutian Islands, thornyheads are managed as part of the "other rockfish" management assemblage. Shortspine thornyheads are the primary species in the "other rockfish" management assemblage. The assessment is based on the most recent catch and survey data. Traditionally, the biomass estimates (split according to management area) from all bottom trawl surveys (EBS shelf/slope and Aleutian Islands) are averaged over all years to obtain the best estimates of biomass for the species in this complex. In 1999, this procedure produced a biomass estimate of 7,030 mt in the EBS, and a biomass estimate of 13,000 mt in the Aleutian Islands. The great majority of this biomass is comprised of thornyhead rockfish. In 1996, the SSC determined that a reliable estimate of the natural mortality rate existed for the species in this subcomplex, and that "other rockfish" in the EBS and Aleutian Islands therefore qualified for management under Tier 5 (Appendix 1; Amendment 44). The accepted estimate of M for these species in both areas is 0.07. F_{ABC} was set at the maximum value allowable under Tier 5, which is 75 percent of M, or 0.053. Multiplying this rate by the best estimate of complex-wide biomass gives an ABC of 369 mt in the EBS and 685 mt in the Aleutian Islands. The Plan Team's OFLs were determined from the Tier 5 formula, where setting F_{OFL}=M gives an OFL of 492 mt in the EBS and 913 mt in the Aleutian Islands.

Other Rockfish Species

Numerous other rockfish species of the genus *Sebastes* have been reported in the GOA and BSAI (Eschmeyer et al. 1984), and several are of commercial importance. Most are demersal or semi-demersal with different species occupying different depth strata (Kramer and O'Connell 1988). All are viviparous (Hart 1973). Life history attributes of most of these rockfish are poorly known or virtually unknown. Because they are long lived and slow growing, natural mortality rates are probably low (less than 0.10). The diet of species for which dietary information exists seems to consist primarily of planktonic invertebrates (Yang 1993, 1996). Other rockfish species are taken both in directed fisheries and as bycatch in trawl and longline fisheries.

In the GOA, although the "other slope rockfish" management group comprises 17 species, six species alone make up 95 percent of the catch and estimated abundance. These six species are sharpchin, redstripe, harlequin, yellowstripe, silvergrey, and redbanded rockfish. Sharpchin rockfish falls into Tier 4, and the remaining species fall into Tier 5 of the ABC/OFL definitions. The overfishing fishing mortality rate for the other species is the F=M rate of 0.10 for redstripe rockfish, 0.04 for silvergrey rockfish, and 0.06 for all the other species (except sharpchin rockfish). The F_{ABC} for sharpchin rockfish is F=M=0.05, which is less that the maximum allowable rate of $F_{40\%}$ = 0.055. For the other species the maximum allowable fishing mortality rate for ABC is the F=0.75M rate which is 0.075 for redstripe rockfish, 0.030 for silvergrey rockfish, and 0.045 for the remaining species. These rates result in the recommended stock assessment ABC of 4,900 mt for "other slope rockfish". The current Council ABC and TAC levels are equivalent to this value. Because the ABC and TAC for sharpchin rockfish component of the "other slope rockfish" are more conservative than the maximum prescribed under the definitions, less risk exists of the F_{ABC} rate and TAC being an overly aggressive harvest rate for "other slope rockfish." This affords more protection to the stocks, given the variability and uncertainty associated with the abundance.

Heifetz and Ackley (1997) analyzed bycatch (not necessarily discarded) in rockfish fisheries of the GOA. Bycatch rates of "other slope rockfish" are highest in the pelagic shelf rockfish and Pacific ocean perch fisheries. Information on bycatch of "other slope rockfish" in non-rockfish fisheries has not been analyzed. Discard rates (discards/total catch) of "other slope rockfish" from 1995 to 1999 have ranged from 52 percent to 76 percent (Heifetz et al. 1999). In 1999, about 544 mt of "other slope rockfish" were discarded compared to a total catch of 789 mt. High discard rates are seen because many species of "other slope rockfish" are small in size and of low economic value, and fishermen have little incentive to retain these fish.

Prey of "other slope rockfish" is not documented for the GOA. Predators of "other slope rockfish" are also not well documented, but likely include larger fish such as Pacific halibut that are known to prey on other rockfish species.

Atka Mackerel

BSAI

Atka mackerel are distributed from the east coast of the Kamchatka Peninsula, throughout the Aleutian Islands and the EBS, and eastward through the GOA to southeast Alaska (Wolotira et al. 1993). Their current center of abundance is in the Aleutian Islands, with marginal distributions extending into the southern Bering Sea and into the western GOA (Lowe and Fritz, 1999a). Atka mackerel are one of the most abundant groundfish species in the Aleutian Islands where they are the target of a directed trawl fishery (Lowe and Fritz 1999a). Adults are semi-pelagic and spend most of the year over the continental shelf in depths generally less than 200 m. Adults migrate annually to shallow coastal waters during spawning, forming dense aggregations near the bottom (Morris 1981, Musienko 1970). In Russian waters, spawning peaks in mid-June (Zolotov 1993) and in Alaskan waters in July through October (McDermott and Lowe 1997). Females deposit adhesive eggs in nests or rocky crevices. The nests are guarded by males until hatching occurs (Zolotov 1993). The first *in situ* observations of spawning habitat in Seguam Pass were recently (August, 1999) documented (pers. comm. Robert Lauth, AFSC). Genetic studies indicate that Atka mackerel form a single stock in Alaskan waters (Lowe et al. 1998). However, growth rates can vary extensively among different areas (Kimura and Ronholt 1988, Lowe et al. 1998, Lowe and Fritz 1999a). Age and size at 50 percent maturity has been estimated at 3.6 years and 33 to 38 cm, respectively (McDermott and Lowe 1997). Atka mackerel are a relatively short-lived groundfish species. A maximum age of 15 years has been noted, however most of the population is probably less than 10 years old. Natural mortality estimates vary extensively, and estimates have ranged from 0.12 to 0.74 as determined by various methods (Lowe and Fritz 1999a). For stock assessment purposes, a value of 0.3 is used (Lowe and Fritz 1999a).

Atka mackerel are an important component in the diet of other commercial groundfish, mainly arrowtooth flounder, Pacific halibut, and Pacific cod; seabirds, mainly tufted puffins; and marine mammals, mainly northern fur seals and Steller sea lions (Byrd et al. 1992, Fritz et al. 1995, Livingston et al. 1993, Yang 1996). Atka mackerel are also components in the diets of the following marine mammals and seabirds: harbor seals, Dall's porpoise, thick-billed murre, and horned puffins (Yang 1996). The diets of commercially important groundfish species in the Aleutian Islands during the summer of 1991 were analyzed by Yang (1996). More than 90 percent of the total stomach contents weight of Atka mackerel in the study was made up of invertebrates, with less than 10 percent made up of fish. Euphausiids were the most important prey item, followed by calanoid copepods. Euphausiids comprised 55 percent by weight of the total stomach contents, and copepods comprised 17 percent of the total stomach contents weight. Larvaceans and hyperiid amphipods had high frequencies of occurrence (81 percent and 68 percent, respectively), but comprised less than 8 percent of the total stomach contents weight. Squid was another item in the diet of Atka mackerel; it had a frequency of occurrence of 31 percent, but only comprised 8 percent of the total stomach contents weight. Atka mackerel are known to eat their own eggs. Yang (1996) found that Atka mackerel eggs comprised 3 percent of the total stomach contents weight and occurred in 9 percent of the Atka mackerel stomachs analyzed. Walleye pollock were the second most important prey fish of Atka mackerel, comprising about 2 percent of the total stomach contents weight. Myctophids, bathylagids, zoarcids, cottids, stichaeids, and pleuronectids were minor components of the Atka mackerel diet; each category comprised less than 1 percent of the total stomach contents.

Atka mackerel are a difficult species to survey because they do not have a swim bladder, and therefore are poor targets for hydroacoustic surveys. They prefer rough and rocky bottoms that are difficult to sample with the current survey gear, and their schooling behavior and patchy distribution result in survey estimates with large variances. Complicating the difficulty in surveying Atka mackerel is the low probability of encountering schools in the GOA where the abundance is lower and their distribution is patchier relative to the BSAI. Because of this, it has not been possible to estimate trends in population for the species in the GOA. The stock assessment in the Aleutian Islands is based on the triennial trawl survey as well as total catch and catch at age data from the commercial fishery.

BSAI Atka mackerel are assessed with an age-structured model incorporating fishery and survey catch data and age compositions. Survey data are from the NMFS Aleutian Islands triennial trawl groundfish surveys. Fishery catch statistics (including discards) are estimated by the NMFS Regional Office. These estimates are based on the best blend of observer reported catch and weekly production reports. The stock assessment includes catch history, characterizations of the fishery, key life history parameters, survey and model estimated abundance trends, historical exploitation rates, reference fishing mortality rates, projected catch and abundance trends for a range of fishing mortalities and recruitment assumptions, and a recommended harvest rate and catch for the upcoming year. The results of the analyses, which are updated annually, are presented in the BSAI Atka mackerel stock assessment which is incorporated into the BSAI SAFE report.

In 1999, Atka mackerel fell into Tier 3a of the ABC/OFL definitions, which requires reliable estimates of biomass, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$. Under the definitions and current stock conditions, the overfishing fishing mortality rate is the $F_{35\%}$ rate which was estimated to be 0.42 for Atka mackerel and equated to a yield of 119,300 mt (Lowe and Fritz 1999a). The maximum allowable fishing mortality rate for ABC (F_{ABC}) is the $F_{40\%}$ rate which was estimated to be 0.35 for Atka mackerel in 1999, which translated to a yield of 102,700 mt (Lowe and Fritz 1999a). In 1999, the stock assessment ABC recommendation for the 2000 Atka mackerel fishery was below the maximum rate prescribed under Tier 3a, to provide a more risk-averse harvest rate and to accommodate uncertainty. The stock assessment F_{ABC} is 0.23 which translated to a yield of 70,800 mt. A recommendation lower than $F_{40\%}$ was recommended in the 1999 stock assessment because: 1) stock size as estimated by the age-structured analysis has declined by approximately 60 percent since 1991; and 2) the 1997 Aleutian trawl survey biomass estimate was about 50 percent lower than the 1991 and 1994 survey estimates.

The 1998 age and size distributions of BSAI Atka mackerel are discussed in Lowe and Fritz (1999a). The age composition is dominated by a recent strong 1992 year class (6-year- olds), and there is still evidence of the strong 1988 year class (10-year- olds) in the population. The estimated mean age of the 1998 fishery age composition is six years. The current fishery tends to select fish ages 3 to 12 years old (Lowe and Fritz 1999a). It is not known how the age composition of the population would look in an unfished population.

The directed fishery for Atka mackerel is prosecuted by catcher-processor bottom trawlers. The patterns of the fishery generally reflect the behavior of the species in that the fishery is highly localized, occurring in the same few locations each year, generally occurs at depths between 100 and 200 m (Lowe and Fritz 1999a). Important Atka mackerel fishery locations include Seguam Bank, Tanaga Pass, north of the Delarof Islands, Petrel Bank, south of Amchitka Island, east and west of Kiska Island, and on the seamounts and reefs near Buldir Island.

Since 1979, the Atka mackerel fishery has occurred largely within areas designated as Steller sea lion critical habitat. While total removals from critical habitat may be small in relation to estimates of total Atka mackerel biomass in the Aleutian Islands region, fishery harvest rates in localized areas may have been high enough to affect prey availability of Steller sea lions (Lowe and Fritz 1997). The localized pattern of fishing for Atka mackerel apparently does not affect fishing success from one year to the next, since local populations in the Aleutian Islands appear to be replenished by immigration and recruitment. However, this pattern could create temporary reductions in the size and density of localized Atka mackerel populations, which could affect Steller sea lion foraging success during the time the fishery is operating and for a period of unknown duration after the fishery is closed.

To address the possibility that the fishery creates localized depletions of Atka mackerel and adversely modifies Steller sea lion critical habitat by disproportionately removing prey, the Council, in June 1998, passed a fishery management regulatory amendment which proposed a four-year timetable to temporally and spatially disperse and reduce the level of Atka mackerel fishing within Steller sea lion critical habitat in the BSAI. The temporal dispersion is accomplished by dividing the BSAI Atka mackerel TAC into two equal seasonal allowances. The first allowance is made available for directed fishing from January 1 to April 15 (A season), and the second seasonal allowance is made available from September 1 to November 1 (B season). The spatial dispersion is accomplished through maximum catch percentages of each seasonal allowance that can be caught within Steller sea lion critical habitat (CH) as specified for the central and western Aleutian Islands. No critical habitat closures are established for the eastern subarea, but the 20 nm trawl exclusion zones around the Seguam and Agligadak rookeries that have been in place only for the pollock A-season, are in effect year-round. The regulations implementing these management changes became effective January 22, 1999. The four-year timetable for spatial dispersion of the Atka mackerel fishery outside of critical habitat is:

Aleutian Island District

	Area 541		Area 542		Area 543	
Year(s)	*Inside CH*	*Outside CH*	*Inside CH*	*Outside CH*	*Inside CH*	*Outside CH*
1999			80%	20%	65%	35%
2000			67%	33%	57%	43%
2001			54%	46%	49%	51%
2002			40%	60%	40%	60%

Relative to 1998, the biggest shift in the distribution of fishing effort was observed in area 542 where effort shifted to Petral Bank in 1999.

Atka mackerel are not commonly caught as bycatch in other directed fisheries. The largest amounts of discards of Atka mackerel, which are likely undersize fish, occur in the directed Atka mackerel trawl fisheries. Recent discard rates (discards/retained catch) of Atka mackerel in the directed fishery have been below 10 percent (Lowe and Fritz 1999a). Atka mackerel are also caught as bycatch in the trawl Pacific cod and rockfish (primarily Pacific ocean perch, sharpchin and northern rockfish) fisheries. It is difficult to discern the level of natural bycatch of Atka mackerel in the rockfish fisheries, as vessels may actually be targeting Atka mackerel in particular hauls, but overall they are designated as targeting rockfish on a particular trip. In 1998, 4,597 mt of Atka mackerel were discarded in the directed fishery as compared to 1,072 mt discarded in all other fisheries.

GOA

No reliable estimate exists of current Atka mackerel biomass in the GOA. Atka mackerel have not been commonly caught in each of the GOA triennial trawl surveys. It has been determined that the general GOA groundfish bottom trawl survey does not assess the Gulf portion of the Atka mackerel stock well, and the resulting biomass estimates have little value as absolute estimates of abundance or as indices of trend (Lowe and Fritz 1999b). Because of this lack of fundamental abundance information GOA Atka mackerel are not assessed with a model and the assessment does not utilize abundance estimates from the trawl survey. The stock assessment for GOA Atka mackerel consists of descriptions of catch history, length and age distributions from the fishery during 1990 to 1994, and length and age distributions from the trawl surveys (1990, 1993, and 1996). This information is presented in the GOA Atka mackerel stock assessment, which is incorporated into the GOA SAFE report.

GOA Atka mackerel fall into Tier 6 of the ABC/OFL definitions, which defines the overfishing level as the average catch from 1978 to 1995, and that ABC cannot exceed 75 percent of the OFL. The average annual catch from 1978-95 is 6,200 mt; thus ABC cannot exceed 4,700 mt. The current ABC recommendation from the stock assessment is below the maximum prescribed under Tier 6, to provide a very risk-averse harvest rate given the uncertainty about GOA Atka mackerel. The 1999 stock assessment for the 2000 fishery, recommended an ABC of 600 mt, with the intention of precluding a directed fishery, but providing for bycatch needs in other trawl fisheries. An ABC lower than the maximum prescribed under Tier 6 was recommended because: 1) When past ABCs were lower than 4,700 mt (approximately 3,000 mt in 1994), it was shown that the fishery might have created localized depletions of Atka mackerel even at those catch levels [appendix in (Lowe and Fritz 1996)]. This analysis indicated that the fishery was very efficient in removing fish from local areas and at rates which far surpassed the target harvest rate. 2) Analyses of local fishery catch per unit effort indicated that the Atka mackerel populations may have declined significantly between 1992 and 1994 (appendix in Lowe and Fritz 1996), reflecting the trend of the Aleutian Islands Atka mackerel population during that period, which has continued to decline since 1994 (Lowe and Fritz 1999b). 3) The GOA Atka mackerel population appears to be particularly vulnerable to fishing pressure because of sporadic movement of fish eastward from the Aleutian Islands.

Age and size distributions of GOA Atka mackerel are discussed in Lowe and Fritz (1999b). The most recent size and age distributions are from the 1996 and 1993 trawl surveys, respectively. Male and female size distributions had mean lengths of 45 and 47 cm, respectively. A mode of fish from 45 to 47 cm represented the 1988 year class. It appears as though little recent recruitment has occurred in the GOA population. Currently, no directed fishery for GOA Atka mackerel occurs. Atka mackerel are caught as bycatch, and the selectivity of Atka mackerel by the other fisheries is unknown. As such, Atka mackerel in the GOA are currently managed as a bycatch fishery. They are caught as bycatch in the pollock, Pacific cod, Pacific ocean perch, and northern rockfish fisheries. The low level of TAC likely precludes directed targeting of Atka mackerel on a haul by haul basis, and the catches of Atka mackerel in other directed fisheries may represent true bycatch of Atka mackerel.

The diets of commercially important groundfish species in the GOA during the summer of 1990 were analyzed by Yang (1993). Atka mackerel were not sampled as a predator species. However, it is probably a reasonable assumption that the major prey items of GOA Atka mackerel would likely be euphausiids and copepods as was found in Aleutian Islands Atka mackerel (Yang 1996). The abundance of Atka mackerel in the GOA is much lower compared to the Aleutian Islands. Atka mackerel only showed up as a minor component in the diet of arrowtooth flounder in the GOA (Yang 1993).

Squid and Other Species

Squid are found throughout the Pacific Ocean. They are not currently the target of groundfish fisheries in the GOA or BSAI, though they are taken as bycatch in trawl fisheries for pollock and rockfish. The red (magistrate) armhook squid is probably the best known species found in Alaskan waters. It is abundant over continental slopes throughout the North Pacific from Oregon to southern Japan (Nesis 1987). It is the basis of fisheries in both Russian and Japanese waters. Little is known about the reproductive biology of squid. Fertilization is internal and juveniles have no larval stage. Eggs of inshore species are often enveloped in a gelatinous matrix attached to substrate, while the eggs of offshore species are extruded as drifting masses. The red armhook squid appears to spawn in the spring and to live as long as 4 years, though most die after spawning at one year to 16 months old (Arkhipkin et al. 1996). Perez (1990) estimated that squids comprise over 80 percent of the diet of some whales. Seabirds and some salmon species are also known to feed heavily on squid at certain times of the year.

In the BSAI FMP squid are grouped in a "Squid and Other Species" group made up of squids, which are considered separately; and sculpins, skates, sharks, and octopi, which comprise the true "other species" category. Because insufficient data exists to manage each of the other species groups separately, they are considered collectively. Neither squid nor any of the species in the "other species" category are currently targeted by the groundfish fisheries in the BSAI and GOA. As such, they are only caught as bycatch by fisheries targeting groundfish. Beginning in 1999, smelts were removed from the "other species" category and have been placed, along with a wide variety of other fish and crustaceans including krill, deep-sea smelts, and lantern fishes, in the forage fish category. This action was accomplished through Amendments 36 and 39 to the BSAI and GOA groundfish FMPs. These amendments place specific catch percentage limits for forage fish on all groundfish fishery participants to prevent the development of directed forage fish fisheries. The following table presents estimated catches (mt) of other species, squid, forage fish and miscellaneous fish by groundfish fisheries in the BSAI and GOA in 1999 by target species fishery and gear using observer and NMFS blend data.

Target Groundfish Species	**Gear**	**Other Species**						**Forage Fish**	**Miscellaneous Fish**
		Skates	**Sharks**	**Sculpins**	**Octopus**	**Total**	**Squid**		
BSAI									
Atka mackerel	Trawl	96	0	285	0	382	5	-	75
Pacific cod	Trawl	831	8	954	23	1,817	2	2	132
Pacific cod	Pot	0	-	649	260	909	0	-	10
Pacific cod	Longline	9,625	105	1,139	21	10,890	0	0	113
Pacific cod	ALL	10,456	113	2,742	304	13,615	2	2	255
Flatfish	Trawl	11,750	179	9,101	11	21,041	60	20	2,589
Flatfish	Longline	5		0		5		-	42
Flatfish	ALL	11,755	179	9,101	11	21,045	60	20	2,630
Rockfish	Trawl	53	3	21	0	77	5	0	55
Rockfish	Longline	9	1	0	0	11	-	-	223
Rockfish	ALL	62	4	21	0	88	5	0	278
Pollock	Pelagic trawl	314	104	40	0	458	403	38	209
Pollock	Bottom trawl	42	2	18	1	62	4	1	10
Pollock	ALL	355	105	58	1	520	406	39	219
Rock sole	Trawl	207	0	152	12	371		0	69
Sablefish	Pot	0			0	0		-	0

	Target Groundfish Species	Gear	Other Species					Squid	Forage Fish	Miscellaneous Fish
			Skates	Sharks	Sculpins	Octopus	Total			
1	Sablefish	Longline	105	21	0	0	126	-	-	4,730
2	Sablefish	ALL	105	21	0	0	126	-	-	4,730
3	Turbot	Trawl	11		3	0	15	4	0	12
4	Turbot	Pot	1	-	-	0	1	0	-	0
5	Turbot	Longline	273	203	2	0	479	-	-	3,840
6	Turbot	ALL	285	203	6	0	494	4	0	3,852
7	Yellowfin Sole	Trawl	566	1	935	2	1,503		2	328
8	ALL	Trawl	13,827	295	11,492	48	25,662	478	63	3,469
9		Pot	1	-	649	260	909	0	-	10
10		Longline	10,017	330	1,141	22	11,509	0	0	8,947
11	ALL	ALL	23,844	625	13,282	329	38,080	478	63	12,426

12 (continued)

Target Groundfish Species	Gear	Other Species						Forage Fish	Miscellaneous Fish
		Skates	Sharks	Sculpins	Octopus	Total	Squid		
GOA									
Pacific cod	Trawl	216	10	98	3	238	0	15	24
Pacific cod	Pot	0	1	111	115	118	-	45	13
Pacific cod	Longline	333	230	129	5	675	-	1	5
Pacific cod	ALL	549	241	338	123	1,032	0	61	42
Flatfish	Trawl	470	46	58	9	490	7	9	350
Flatfish	Longline	0	-	-	-	-	-	-	4
Flatfish	ALL	470	46	58	9	490	7	9	353
Rockfish	Trawl	46	5	26	0	17	6	101	123
Rockfish	Longline	27	58	0	-	-	-	10	6
Rockfish	ALL	73	63	26	0	17	6	111	129
Pollock	Bottom Trawl	20	63	0	0	83	2	2	107
Pollock	Pelagic trawl	2	131	3	0	118	18	23	120
Pollock	ALL	22	194	4	0	201	20	25	227
Sablefish	Trawl	0	-	0	0	-	0	0	1
Sablefish	Longline	200	126	0	0	19	1	2	9,338
Sablefish	ALL	201	126	0	0	19	1	2	9,339
ALL	Trawl	754	255	185	13	946	33	151	724
ALL	Pot	0	1	111	115	118	-	45	13
ALL	Longline	1,030	460	187	15	1,184	8	22	9,703
ALL	ALL	1,784	716	484	143	2,248	41	218	10,440

Note: Forage fish are myctophids, osmerids, bathylagids, sandfish, sand lance, gunnels, and pricklebacks. Miscellaneous fish are mostly grenadiers, but also include greenlings, poachers, lumpsuckers, ronquils, gastropods, fish waste, snipe eels, eelpouts, hagfish, pomfrets, and snailfish. "-": < 0.01 mt; "0": > 0.01 and <0.5 mt of estimated catch.

Assessment data are not available for squid from AFSC surveys because of their mainly pelagic distribution over deep water. Information on the distribution, abundance, and biology of squid stocks in the EBS and Aleutian Islands region is generally lacking. Red armhook squid predominates in commercial catches in the EBS and GOA, and *Onychoteuthis boreali japonicus* is the principal species encountered in the Aleutian Islands region.

Forty-one species of sculpins were identified in the EBS and 22 species in the Aleutian Islands region (Bakkala 1993, Bakkala et al. 1985, Ronholt et al. 1985). During these same surveys, 15 species of skates were identified but inadequate taxonomic keys for this family may have resulted in more species being identified than actually exist. Species that have been consistently identified during surveys are the Alaska skate, big skate, longnose skate, starry skate, and Aleutian skate. Biomass estimates of sculpins and skates from demersal trawl surveys serve as valuable indices of their relative abundance.

While biomass estimates have been made for sharks and octopi, the AFSC bottom trawl surveys are not designed to adequately sample the realms they inhabit. Sharks are rarely taken during demersal trawl surveys in the Bering Sea; however, spiny dogfish is the species usually caught, and the Pacific sleeper shark has been taken on occasion. Two species of octopus have been recorded, with *Octopus dofleini*, the principal species, and *Opisthoteuthis california* appearing only intermittently.

Many species in the squid and other species assemblage are important as prey for marine mammals and birds as well as commercial groundfish species. Squid and octopus are consumed primarily by marine mammals, such as Steller sea lions ((Lowry et al. 1982), northern fur seals (Perez and Bigg 1986), harbor seals (Lowry et al. 1982, Pitcher 1980b), sperm whales (Kawakami 1980), Dall's porpoise (Crawford 1981), and Pacific white-sided dolphins (Morris et al. 1983), and beaked whales (Loughlin and Perez 1985)). Sculpins have also been found in the diet of harbor seals (Lowry et al. 1982).

EBS and GOA Biomass Estimates for Squid and Other Species

Data from AFSC surveys provide the only abundance estimates for the various groups and species comprising the "other species" category. Biomass estimates for the EBS are from a standard survey area of the continental shelf. The 1979, 1981, 1982, 1985, 1988 and 1991 data include estimates from continental slope waters (200-1,000 m in 1979, 1981, 1982, and 1985; 200-800 m in 1988 and 1991), but data from other years do not. Slope estimates were usually 5 percent or less of the shelf estimates, except for grenadiers. Stations as deep as 900 m were sampled in the 1980, 1983 and 1986 Aleutian Islands bottom trawl surveys, while surveys in 1991 and 1994 obtained samples only to a depth of 500 m.

Since the survey biomass estimates for species other than squid vary substantially from year to year due to different distributions of the component species, it is probably more reliable to estimate current biomass by averaging estimates of recent surveys. The average biomass of other species from the last three EBS surveys (1997-99) is 561,600 mt; adding the estimate from the 1997 Aleutian Islands survey (48,800 mt) yields a total BSAI “other species” biomass estimate of 610,400 mt.

Biomass estimates from AFSC surveys illustrate that sculpins were the major component of this group until 1986, after which the biomass of skates exceeded that of sculpins. The abundance of skates increased between 1985 and 1990 (when a high of 583,800 mt survey biomass was observed), but has since declined to about 370,000 mt in 1999. The abundance of sculpins remained relatively stable through 1998, but declined to the lowest biomass estimate since 1975 in 1999.

Trends in the biomass of GOA "other species” (sharks, skates, sculpins, smelts, octopi, and squids) were investigated using the NMFS triennial trawl survey data from 1984 through 1999. Any discussion of biomass trends should be viewed with the following caveats in mind: 1) Survey efficiency may have increased for a variety of reasons between 1984 and 1990, but should be stable after 1990 (Robin Harrison, personal communication). 2) Surveys in 1984, 1987, and 1999 included deeper strata than the 1990 - 1996 surveys. Therefore, the biomass estimates for deeper-dwelling components of the other species category are not comparable across all years.

The average biomass within the other species category using all six(6) survey biomass estimates is

160,000 tons. The most recent estimate of other species biomass (1999) is 213,000 tons. Skates represent 30-40 percent of the other species biomass from all surveys and are the most common group in each year except 1984, when sculpin biomass was highest within the category. Total biomass for the other species category has increased between 1984 and 1999. This is the result of apparent increases in skate, shark, and smelt biomass, some of which may be difficult to resolve from changes in survey efficiency. Sculpin biomass appears relatively stable over this period.

Individual species biomass trends were evaluated for the more common and easily identified shark and sculpin species encountered by the triennial trawl survey. In general, the increasing biomass trend for the shark species group is as result of increases in spiny dogfish and sleeper shark biomass between 1990 and 1999. Salmon shark biomass has been stable to decreasing, according to this survey, but salmon sharks are unlikely to be well sampled by a bottom trawl (as evidenced by the high uncertainty in the biomass estimates). It should be noted that both salmon shark and Pacific sleeper shark biomass estimates may be based on a very small number of individual tows in a given survey. No salmon sharks were encountered in the 1999 survey, despite reports of their increased abundance in other areas of the GOA.

Individual sculpin species display divergent biomass trends between 1984 – 1999. While the biomass of bigmouth sculpins has decreased over the period of the survey, great sculpin biomass has remained relatively stable, and yellow Irish lord biomass has increased. The biomass of yellow Irish lords appears to have increased over time despite general stability in the number of hauls where they occurred, whereas bigmouth sculpins were encountered in fewer hauls each year. Uncertainty in these estimates varies between years.

In addition to sharks and sculpins, we examined available biomass estimates for grenadiers, which are not included in the other species category. The species most commonly encountered in the triennial trawl surveys was the giant grenadier. The Pacific grenadier was present, but with much lower estimated biomass in all years. Survey coverage of deeper strata is particularly important to grenadier biomass estimates; therefore we consider the 1990–1996 survey estimates to be of little use for detecting trends in grenadier abundance

Current Stock Assessment and OFL/ABC/TAC Determinations

No reliable biomass estimates for squid exist, and no stock assessment per se. Sobolevsky (1996) cites an estimate of four million tons for the entire Bering Sea made by squid biologists at TINRO (Shuntov et al. 1993), and an estimate of 2.3 million tons for the western and central Bering Sea (Radchenko 1992), but admits that squid stock abundance estimates have received little attention. AFSC bottom trawl surveys almost certainly underestimate squid abundance. Squid catches and ABCs are almost certainly a very small percentage of the total squid biomass in the EBS and GOA. BSAI squid ABC and OFL are set using criteria in Tier 6 as described in Amendment 44 to the BSAI FMP given the lack of data on their population dynamics and biomass. OFL is set equal to the average annual catch from 1978 to 1995 (2,624 mt), while ABC is capped at no greater than 75 percent of OFL (1,970 mt). As currently defined, BSAI squid ABC and OFL values would remain constant in the future, unless different methodologies were employed to assess squid abundance (e.g., analysis of fishery CPUE data). This methodology change could occur under any of the alternatives considered. The BSAI squid TAC has been set equal to the stock-assessment-recommended ABC by the Council.

Reliable biomass estimates exist for two (skates and sculpins) of the groups that comprise the bulk of the biomass and fishery catches in the other species category. Survey biomass estimates for sharks, smelts, and octopi, while not reliable, represent the best data available on the abundance of these species. A single estimate of M for this diverse assemblage, while not known, is conservatively estimated at 0.2. OFL for the other species assemblage is set using the criteria in Tier 5 as described in Amendment 44, where $F_{OFL}=M$, and OFL=M x (total other species survey biomass). Using Tier 5 criteria, ABC is capped at 75 percent of OFL. However, rather than use this method, the other species ABC has been calculated as the average annual catch since 1978 to avoid potentially 5-fold increases in other species catches that could occur if it were set at 75 percent of OFL. In 1998 (for the 1999 fishery), the Council began a 10-step increase toward full $F=M$ exploitation strategy for "other species" complex by implementing the first 10 percent of the difference between that strategy and average catch since 1978. For the 2000 fishery, the Council stopped the step-wise increase and kept the ABC at a level approximately 10 percent higher than the stock assessment author's recommendation. BSAI area other species TAC has been set equal to the other species ABC by the Council. A 2000 ABC for the BSAI other species category set using this process (31,360 mt) represents an exploitation rate of about 5 percent of the best estimate of current biomass (610,400 mt). This estimate was obtained by averaging the three most recent EBS bottom trawl survey estimates of other species biomass (from 1997 to 1999: 561,600 mt), and adding the most recent Aleutian Islands bottom trawl estimate (from 1997: 48,800 mt).

The annual TAC for other species in the GOA (which includes squid) is set equal to 5 percent of the sum of all GOA groundfish TACs. Catches of other species in the GOA have ranged between 1,570 and 6,867 mt from 1990 to 1999.

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APPENDIX 3 STELLER SEA LION CASE STUDY

Annual estimates of prey availability for the entire BSAI and GOA

The current estimate of groundfish biomass in 1999 in the BSAI/GOA is approximately 21.8 million tons. The estimated annual consumption of forage by 43,000 Steller sea lions is 399,700 tons (based on the approach reported in Winship 2000). The current estimate of the ratio of biomass consumed by Steller sea lions to biomass of groundfish is approximately 1:54. The estimated equilibrium theoretical unfished stock size for 17 groundfish stocks combined was likely to be no more than 37.6 million tons (NMFS 2000), although it must be recognized that this figure represents an estimate of a hypothetical condition (i.e., the amount of groundfish biomass in the action area at this time had there been no commercial fishery ever prosecuted in this area). The estimated historical abundance of Steller sea lions (prior to their recent decline) is approximately 184,000 animals (Loughlin et al. 1984). The 1999 estimate of abundance for Steller sea lions from Winship (2000) is about 43,000 animals or roughly 23% of its historical carrying capacity, where annual consumption by sea lions in 1999 was estimated at 399,700 tons. Therefore, by analogy, 200,000 animals would be expected to eat approximately 1.71 million tons of forage annually. While crude, the estimated ratio of biomass consumed by 184,000 Steller sea lions to biomass of groundfish in an unfished environment is approximately 1:21. To interpret this estimate, it must be assumed that Steller sea lions only eat groundfish, which of course is a conservative assumption. With this assumption, it could be argued that a healthy population of Steller sea lions requires no more than 22 times as much forage as it is capable of consuming in a single year.

Another approach to estimating what the multiplier in going from prey consumed to prey available should be for a healthy marine mammal population was reported by Fowler (1999). The information reported in Fowler (1999) was extracted from Perez and McAlister (1993). Perez and McAlister reported that 32,000 Steller sea lions would consume 140,700 tons of forage. Extrapolating to the consumption of 184,000 Steller sea lions leads to a consumption estimate of 809,600 tons of forage. If it is again assumed that the unfished, equilibrium biomass of groundfish is 37.6 million tons, then the multiplier of groundfish forage available to Steller sea lions forage consumed is 46.

At present it is not possible to evaluate the relative merits of the two multipliers. Therefore, lacking alternatives, two approaches are proposed regarding the inference as to whether the current multiplier of forage available to forage consumption for a species listed under the ESA is indicative of a population that has adequate access to forage. One would be to use the average value of the two multipliers. In this case, that would be a multiplier of 34 (i.e., (22+46)/2). The other approach would be to use the more conservative estimate, as the ESA requires NMFS to err on the side of the animal when interpreting available data. The current ratio of biomass consumed by SSL to biomass available is 1:54 or a multiplier of 55. In either case, the current multiplier is greater than either of the two threshold values. This analysis, given uncertainties as discussed above, is therefore consistent with the conclusion that at the global or Action Area scale of the BSAI and GOA, Steller sea lions have adequate forage available to them to recover to optimal population levels.

Monthly estimates of prey availability for critical habitat

Average monthly estimates of biomass of pollock, Atka mackerel, and Pacific cod in critical habitat are reported in NMFS (2000). Alaska Fisheries Science Center. Biological Opinion Questions and Answers, unpublished report). In addition, monthly consumption estimates of a population of 43,000 Steller sea lions are reported in Table based on the methods reported in Winship (2000). The monthly estimates of biomass range from a low of 2.1 million tons in June to a high of 6.4 million tons in February (Table 2). Steller sea lion consumption estimates range from a low of 25,664 tons in June to a high of 35,787 tons in March. The average percent of biomass consumed was 0.88% percent or a ratio of 1:113 biomass consumed to biomass available. The lowest percentage of the twelve month period was in 0.52% in February, while the highest percentage was 1.48%. The corresponding multipliers for these percent consumption rates are 192 and 68.

A worst-case estimate of the percent of biomass of pollock, Atka mackerel, and Pacific cod in critical habitat, which was based on the upper 95% confidence interval for consumption and the lower 95% confidence interval for biomass available, ranges from a low of 1.27% to a high of 3.12% (i.e., multipliers of forage consumed to forage available of 79 and 32). The average percent consumption using these data was 2.01% or a ratio of 1:49 biomass consumed to biomass available (i.e., multiplier of 50).

It should be emphasized that these estimates of percent biomass consumed are likely to be positively biased (i.e., over-estimated) because the diet of Steller sea lions includes species other than the three considered in this analysis and because the foraging area of Steller sea lions in the western population is not limited to critical habitat. It should be noted that the associated estimates of precision of Steller sea lion consumption are likely negatively biased because the variance associated with the abundance estimate, age structure, and energetic needs have not been included in the analysis (as estimates for these statistics are not available). Further, in interpreting the results of these data it is necessary to assume that forage is adequately available to Steller sea lions throughout critical habitat. The information needed to test this assumption are not available. Therefore, the degree to which heterogeneity in the distribution of biomass confounds the interpretation of forage availability in critical habitat for Steller sea lions and the effects of commercial fishing on forage availability for SSL cannot be assessed at this time.

The best available data indicate that the current multiplier varies monthly between 68 and 191, where the multiplier is never less than 46. Further, using the conservative data on forage consumed to forage available, the estimated multipliers range over the 12 month period between 32 and 79. In this case, only one of the monthly multipliers is less than the threshold of a multiplier of 34, while four of the monthly multipliers are less than the more conservative threshold of 46. As noted in NMFS (2000), there is considerable uncertainty in trying to estimate monthly estimates of Steller sea lion consumption and biomass of pollock, Pacific cod, and Atka mackerel and in estimating the fraction of the total biomass of these three prey species that occur in Critical Habitat for Steller sea lions. However, given uncertainty consistent with previous analyses, the available data on monthly consumption requirements relative to the total biomass of three important prey species in critical habitat are consistent with the conclusion that forage availability (without consideration regarding species composition or spatial distribution) is adequate to support the recovery of Steller sea lions to optimal population levels.

Table 1. Summary of Steller sea lion consumption estimates by month (based on Winship 2000). The population size assumed in this analysis was 43,127 animals post-pupping.

Month	Biomass (tons)	Month	Biomass (tons)
Jan	35,093	July	32,275
Feb	33,407	Aug	32,990
Mar	35,787	Sept	33,057
Apr	34,125	Oct	34,497
May	34,127	Nov	33,775
Jun	25,664	Dec	34,872

Table 2. Summary of biomass estimates of pollock, Pacific cod, and Atka mackerel in Critical Habitat (see NMFS 2000)

Month	Biomass (tons)	% Consumed	Month	Biomass (tons)	% Consumed
Jan	**6,012,615**	0.58	July	**2,183,687**	1.48
Feb	**6,383,644**	0.52	Aug	**2,538,000**	1.30
Mar	**6,397,301**	0.56	Sept	**3,083,889**	1.07
Apr	**5,961,198**	0.57	Oct	**3,750,186**	0.92
May	**3,851,215**	0.89	Nov	**4,456,918**	0.76
Jun	**2,056,445**	1.25	Dec	**5,100,096**	0.68

The analyses that we have conducted in this biological opinion suggests that competition as the result of an overall prey removal as allowed by the FMP does not adversely modify critical habitat. Rather, this analysis raises the following issues:

1. The abundance of any species in a particular space at a particular time is finite. Therefore, an activity that can remove hundreds of pounds in a single tow and thousands of tons of fish per day must, for short periods of time (hours to days), reduce the biomass of the targeted fish remaining in the immediate area. By extension, it is reasonable to assume that, as fishing effort increases or is concentrated in a particular area in a specific period of time, the extent and duration of those reductions would increase.

2. The likelihood of locally depleting a fish resource increases when that resource is patchily distributed. An assumption in our analyses suggested that the degree to which heterogeneity in the distribution of biomass occurs could confound the interpretation of forage availability in critical habitat for Steller sea lions. However, fish species are not

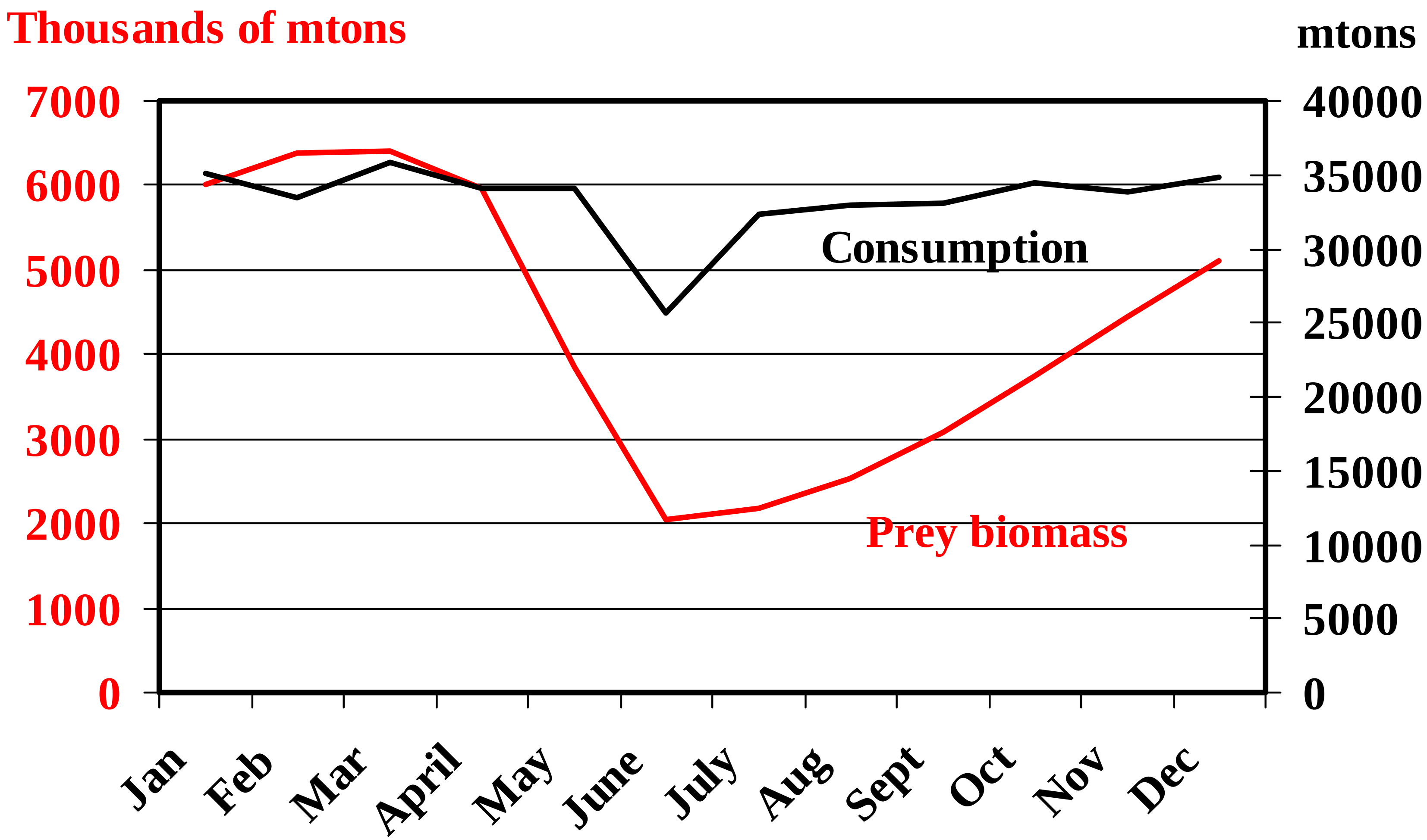
always homogeneously distributed throughout the water column. Instead, there are specific areas that have larger numbers of fish and other areas that have limited numbers of fish (Bakun 1996). Pollock and Atka mackerel are schooling fish that are patchily distributed, within a school their biomass is very high while outside of a school their densities are low. Fishing effort that targets schools of pollock or mackerel, and removes a significant percentage of a school, is likely to reduce the biomass remaining in the immediate area for at least a short period of time in a particular space.

This assumption is partially supported by the behavior of the fishing fleet itself. Fishing vessels use electronic equipment on their vessels to locate large aggregations of pollock. When vessels locate aggregations of pollock, they deploy their nets and continue to fish that school until the density of the aggregation declines to the point at which continued harvest becomes unprofitable.

3. If these reductions in schools of pollock or mackerel occur within the foraging areas of the endangered western population of Steller sea lions, the reduced availability of prey is likely to reduce the foraging effectiveness of sea lions, even if there is sufficient prey overall as indicated by the previous analyses. We have stated in previous opinions that the effects of these reductions become more significant the longer they last and the reductions are likely to be most significant to adult female and juvenile Steller sea lions during the winter months when these animals have their highest energetic demands. Based on the available biomass during the critical winter months, it is apparent that pollock availability is highest during the periods of the greatest energetic demands.

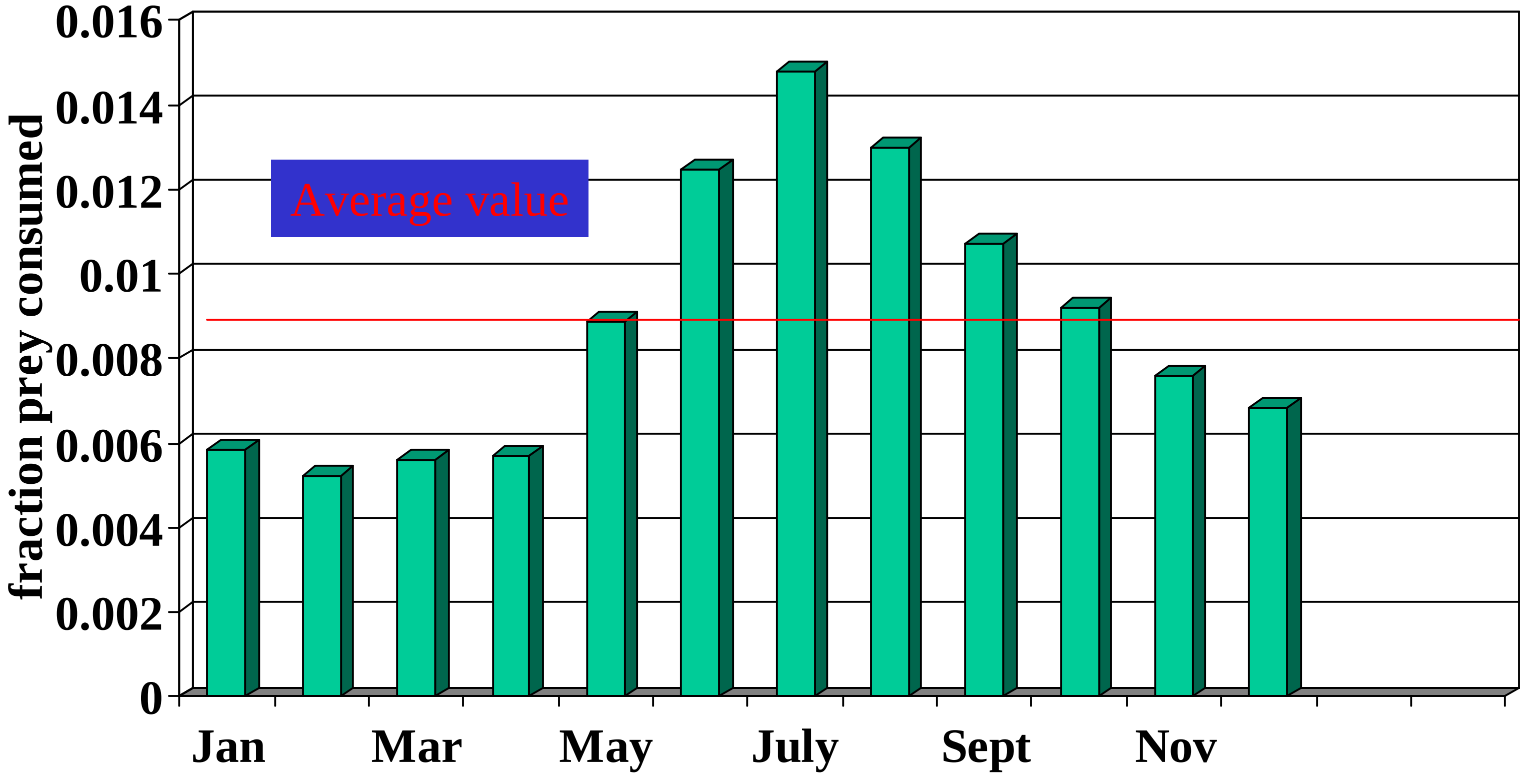
Based on the available information, it is reasonable to expect the groundfish fisheries do compete with non-human consumers in the marine ecosystem in the BSAI and GOA. However, this competition occurs as a result of the temporal and spatial behavior of the fishing fleet, and removals by this fleet on a local level, not as a result of a decrease in total prey availability due to the reduction of total fish biomass. Our current review is consistent with previous biological opinions that suggest that the harvesting ability of the fishing fleet and of individual vessels may deplete the groundfish biomass on small, spatial and temporal scales that would be expected to reduce the availability of groundfish to other, non-human consumers.

Steller Sea Lion Consumption versus Prey Availability in Critical Habitat



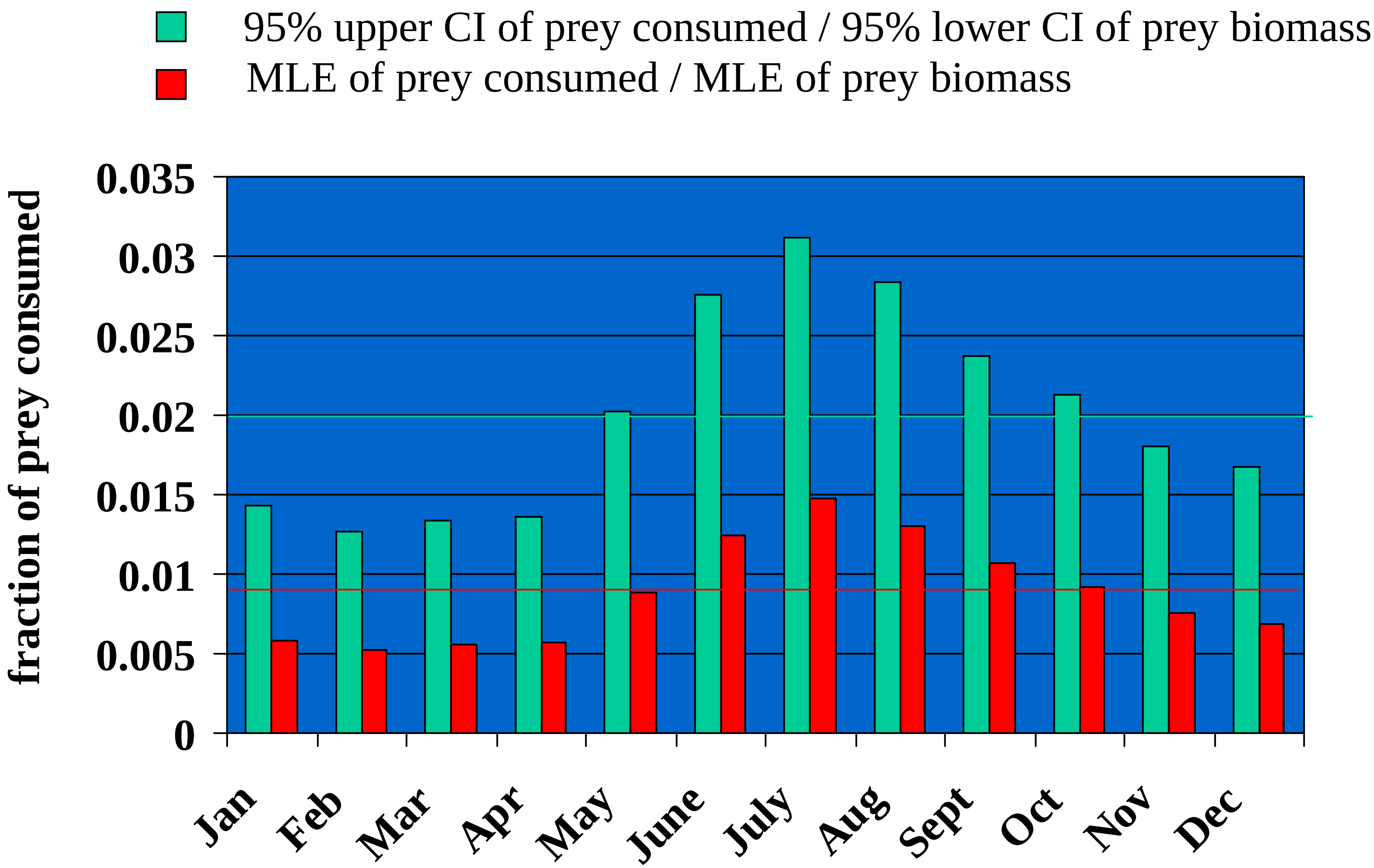
**Biomass estimates of prey are for pollock, Pacific cod and Atka mackerel*

Fraction of Prey Consumed by Steller Sea Lions in Critical Habitat



**Biomass estimates of prey are for pollock, Pacific cod and Atka mackerel*

Steller Sea Lion: Fraction of prey Consumed



**Biomass estimates of prey are for pollock, Pacific cod and Atka mackerel*

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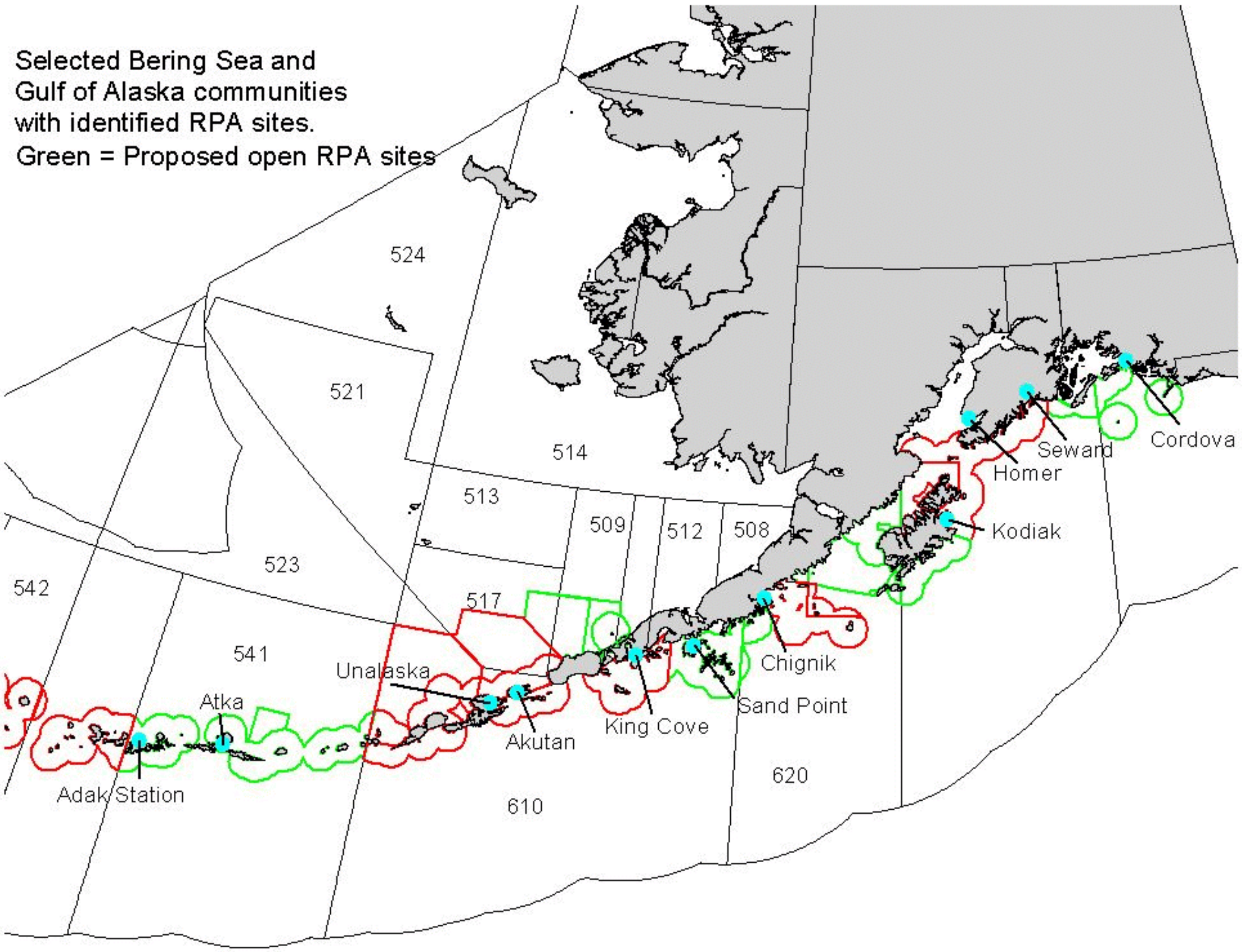
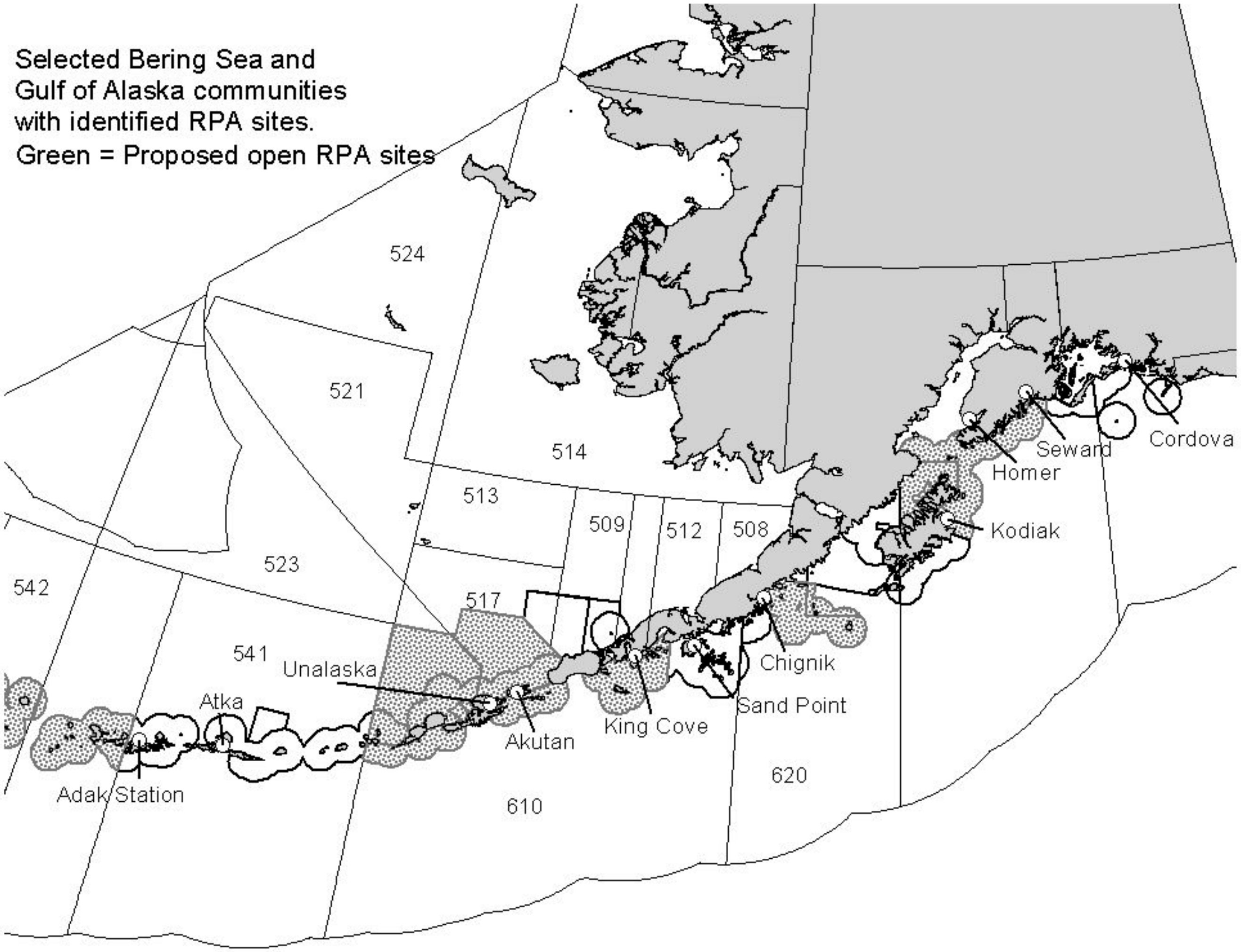
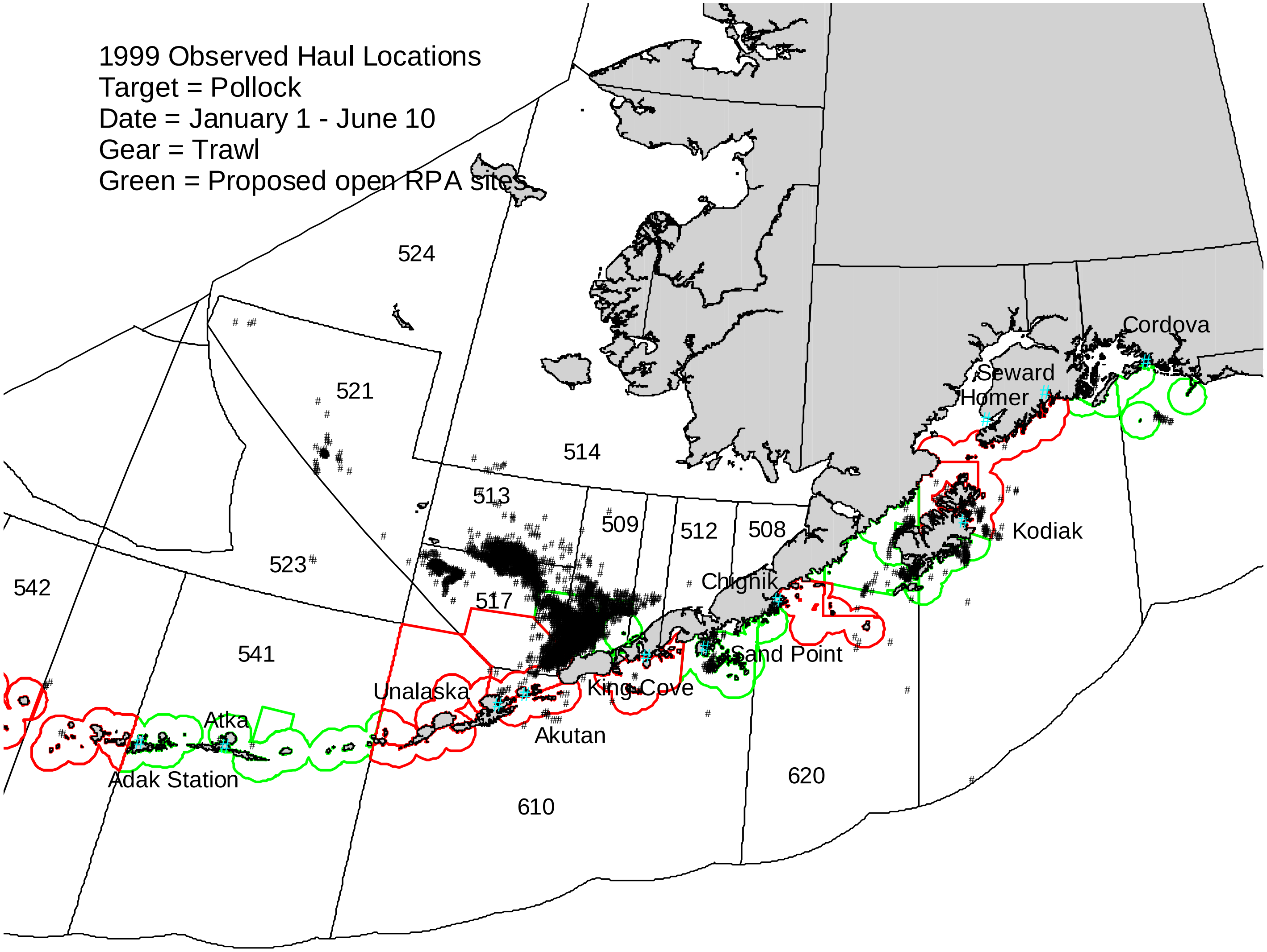
APPENDIX 4 MAPS OF FISHING EFFORT AND CLOSURE AREAS





Black and white version of the previous figure.


1999 Observed Haul Locations
Target = Pollock
Date = January 1 - June 10
Gear = Trawl
Green = Proposed open RPA sites
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513
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512
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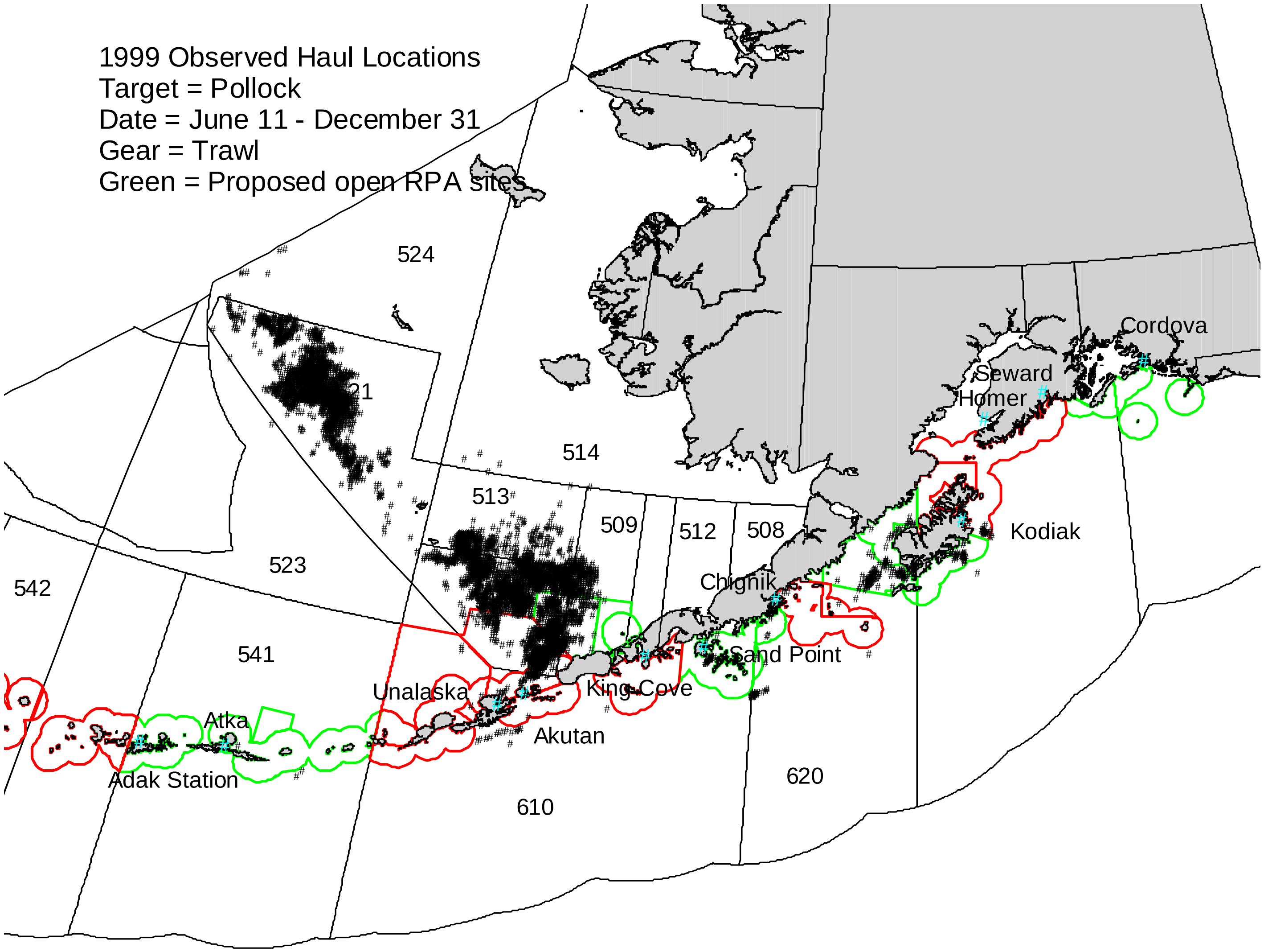
523
517
542
541
Cordova
Seward
Homer
Kodiak
Chignik
Sand Point
King Cove
Unalaska
Akutan
Atka
Adak Station
610
620


1999 Observed Haul Locations
Target = Pollock
Date = June 11 - December 31
Gear = Trawl
Green = Proposed open RPA sites
524
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523
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Akutan
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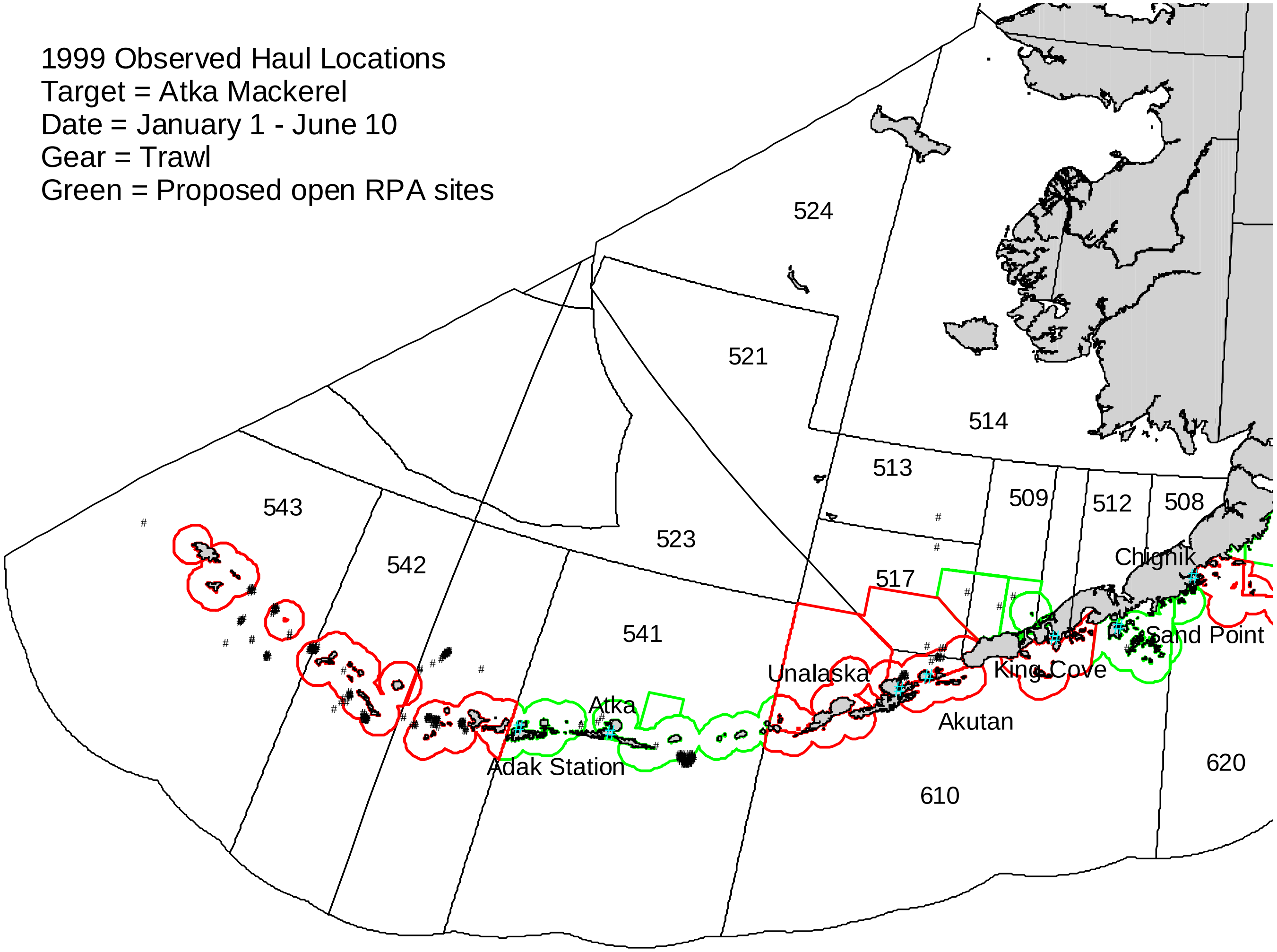
1999 Observed Haul Locations
Target = Atka Mackerel
Date = January 1 - June 10
Gear = Trawl
Green = Proposed open RPA sites
524
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512
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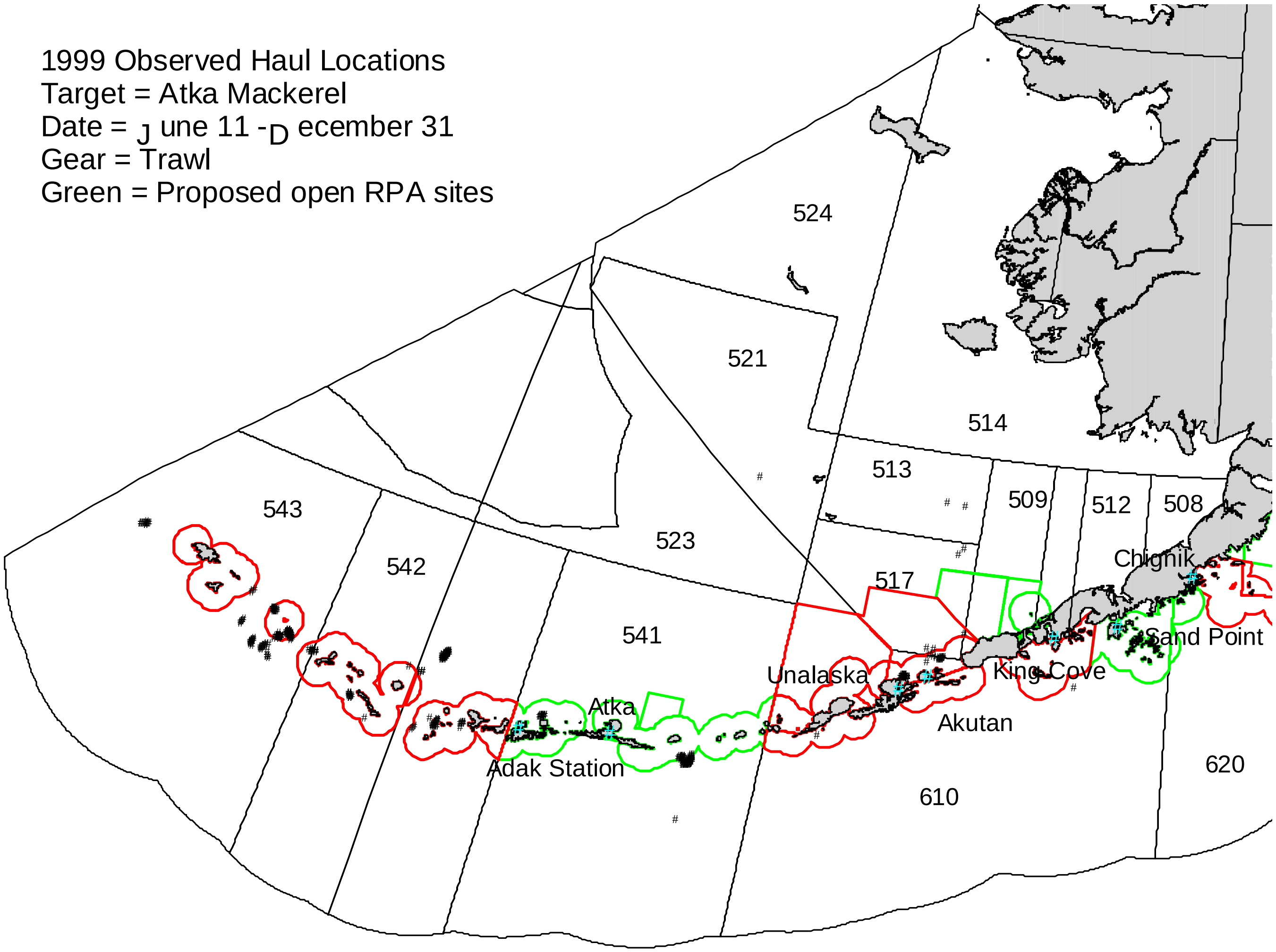
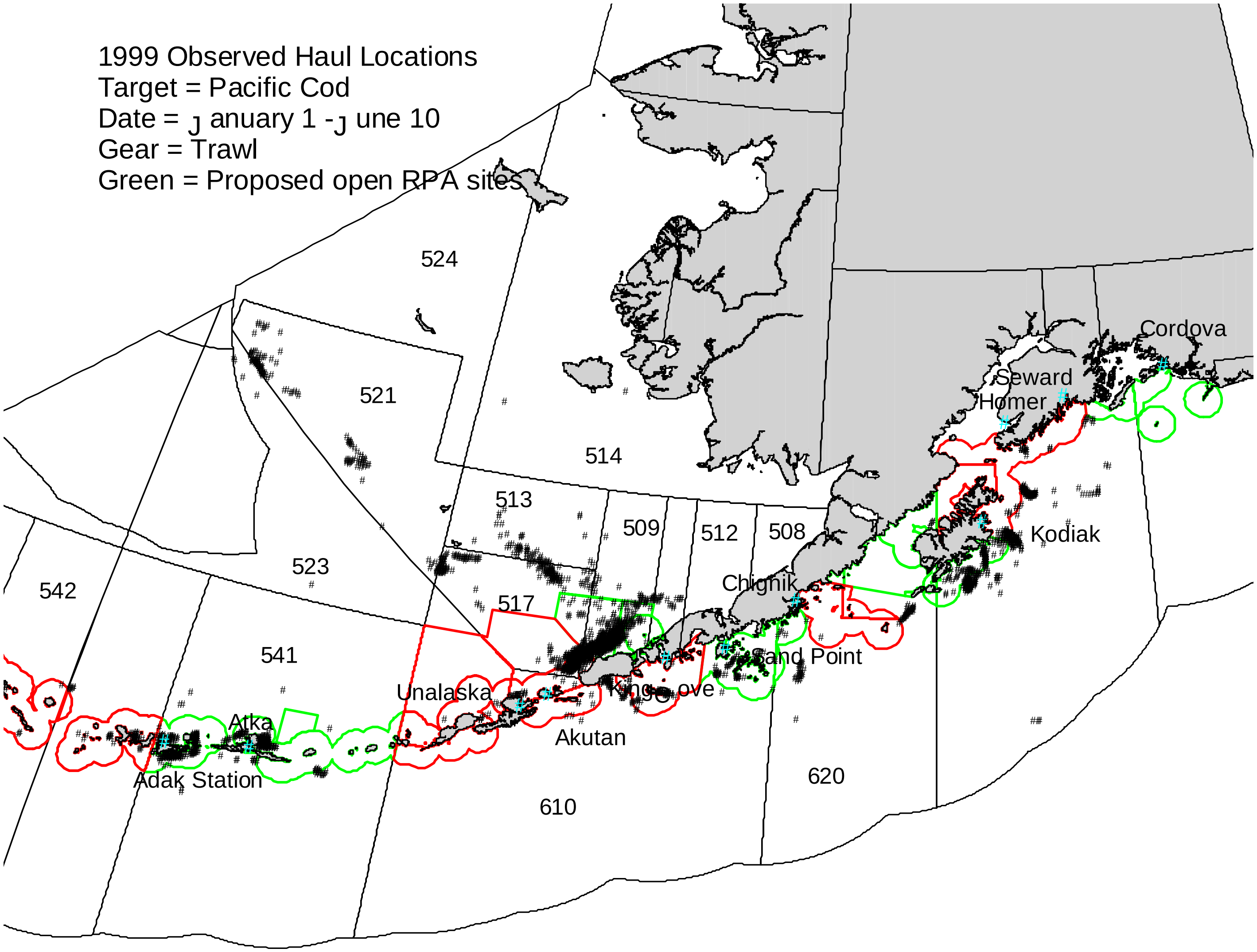
542
523
517
541
Chignik
Sand Point
King Cove
Unalaska
Akutan
Atka
Adak Station
610
620

1999 Observed Haul Locations
Target = Atka Mackerel
Date = June 11 - December 31
Gear = Trawl
Green = Proposed open RPA sites





1999 Observed Haul Locations
Target = Pacific Cod
Date = January 1 - June 10
Gear = Trawl
Green = Proposed open RPA sites
524
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Unalaska
Akutan
Atka
Adak Station
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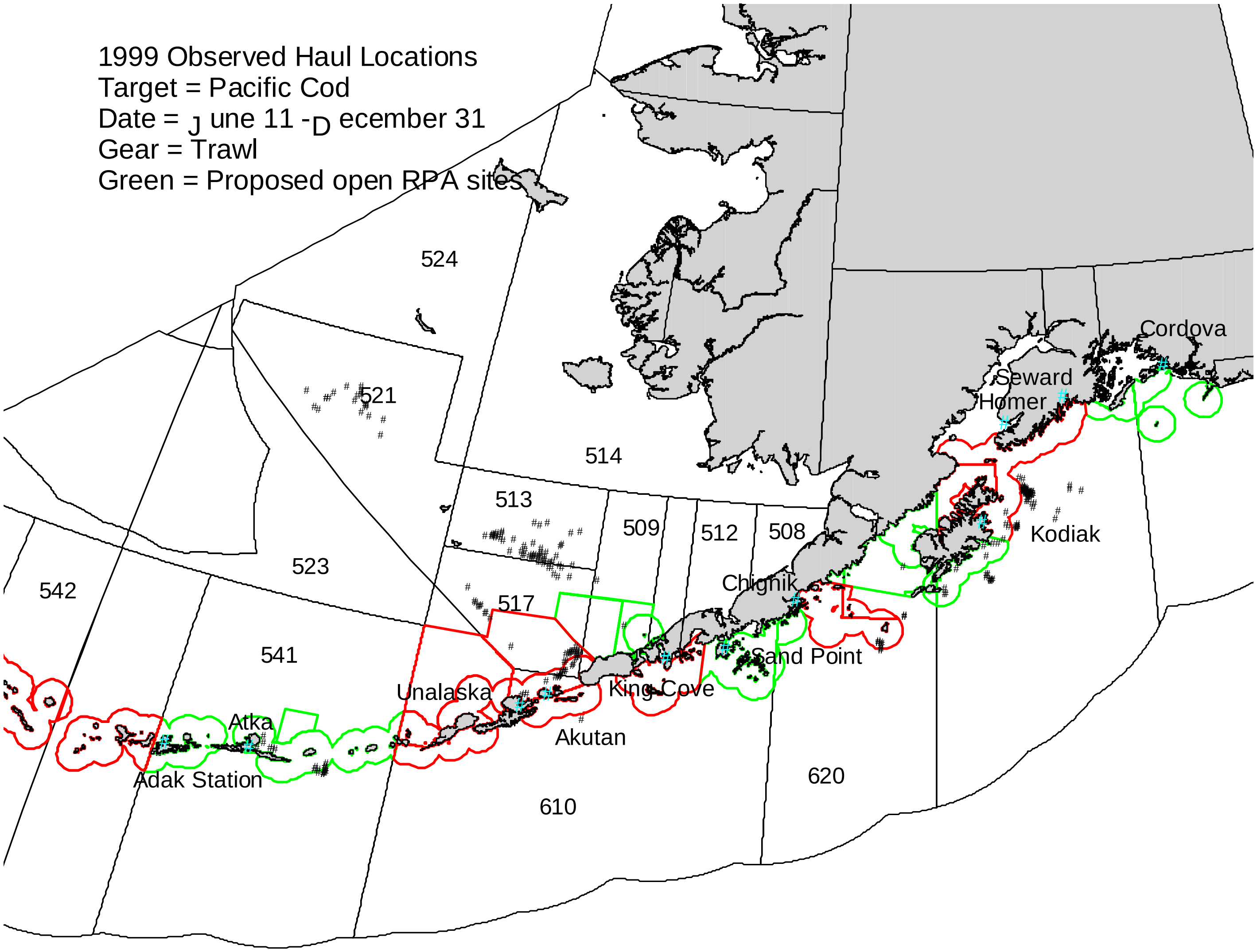
1999 Observed Haul Locations
Target = Pacific Cod
Date = June 11 - December 31
Gear = Trawl
Green = Proposed open RPA sites
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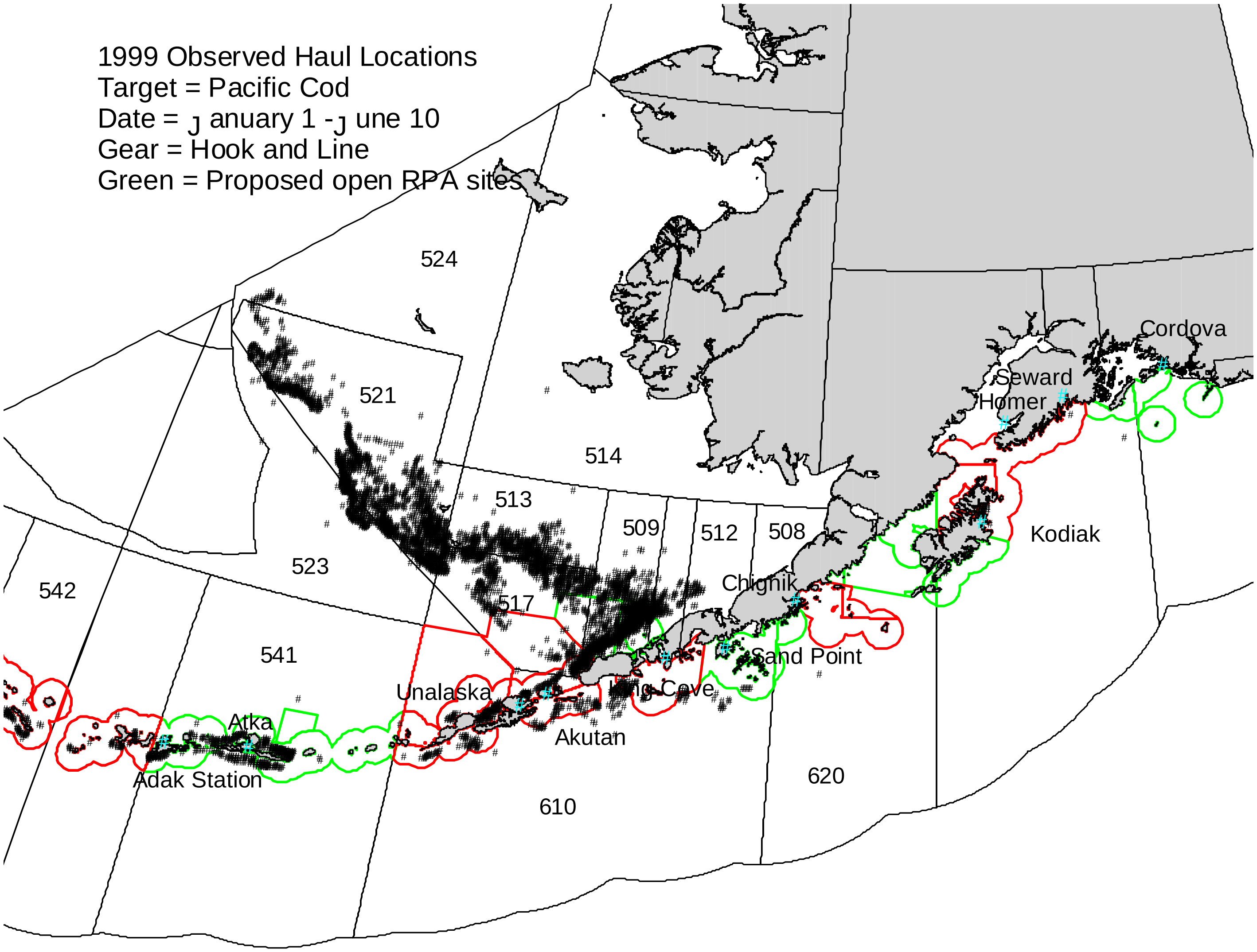
1999 Observed Haul Locations
Target = Pacific Cod
Date = January 1 - June 10
Gear = Hook and Line
Green = Proposed open RPA sites
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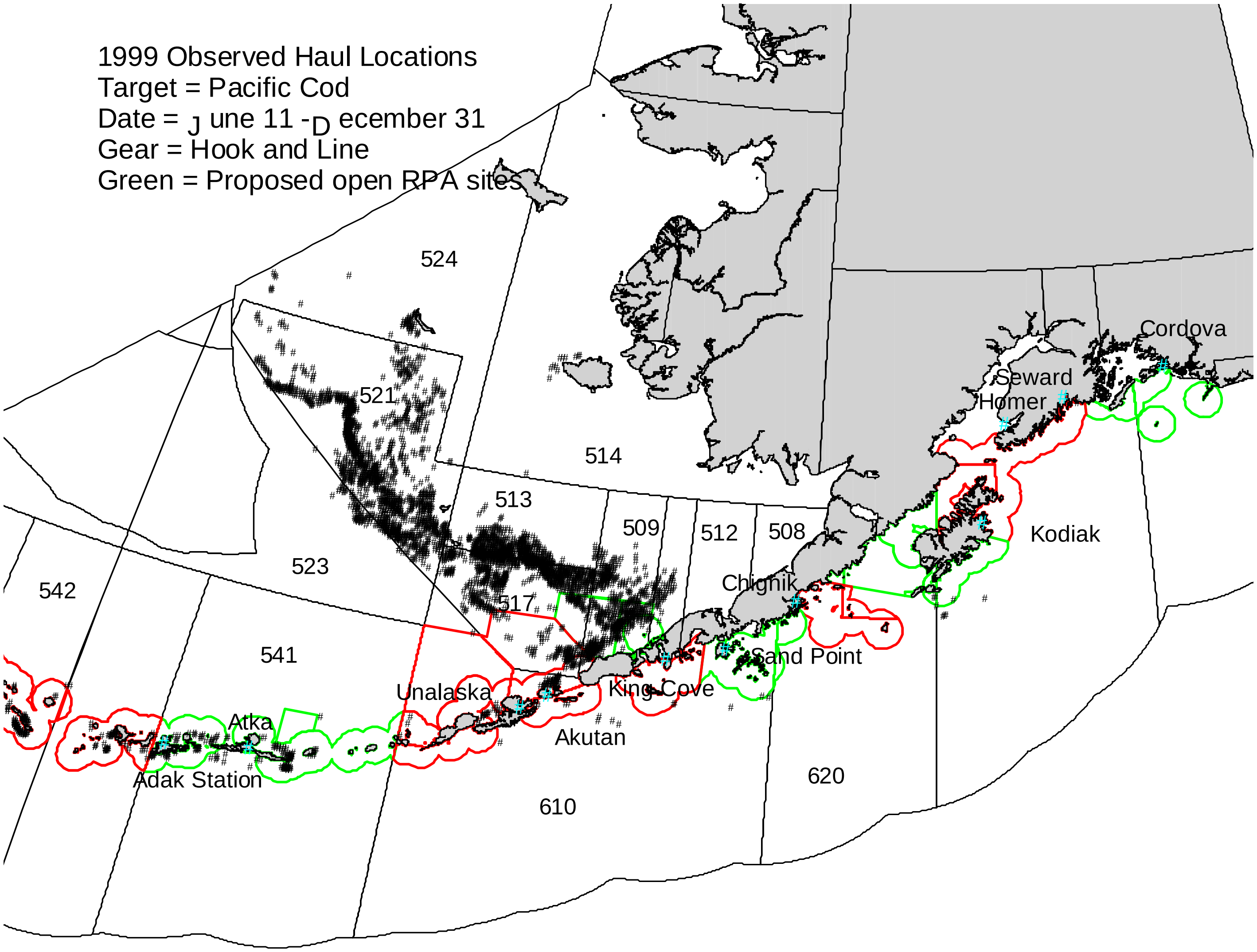
1999 Observed Haul Locations
Target = Pacific Cod
Date = June 11 - December 31
Gear = Hook and Line
Green = Proposed open RPA sites
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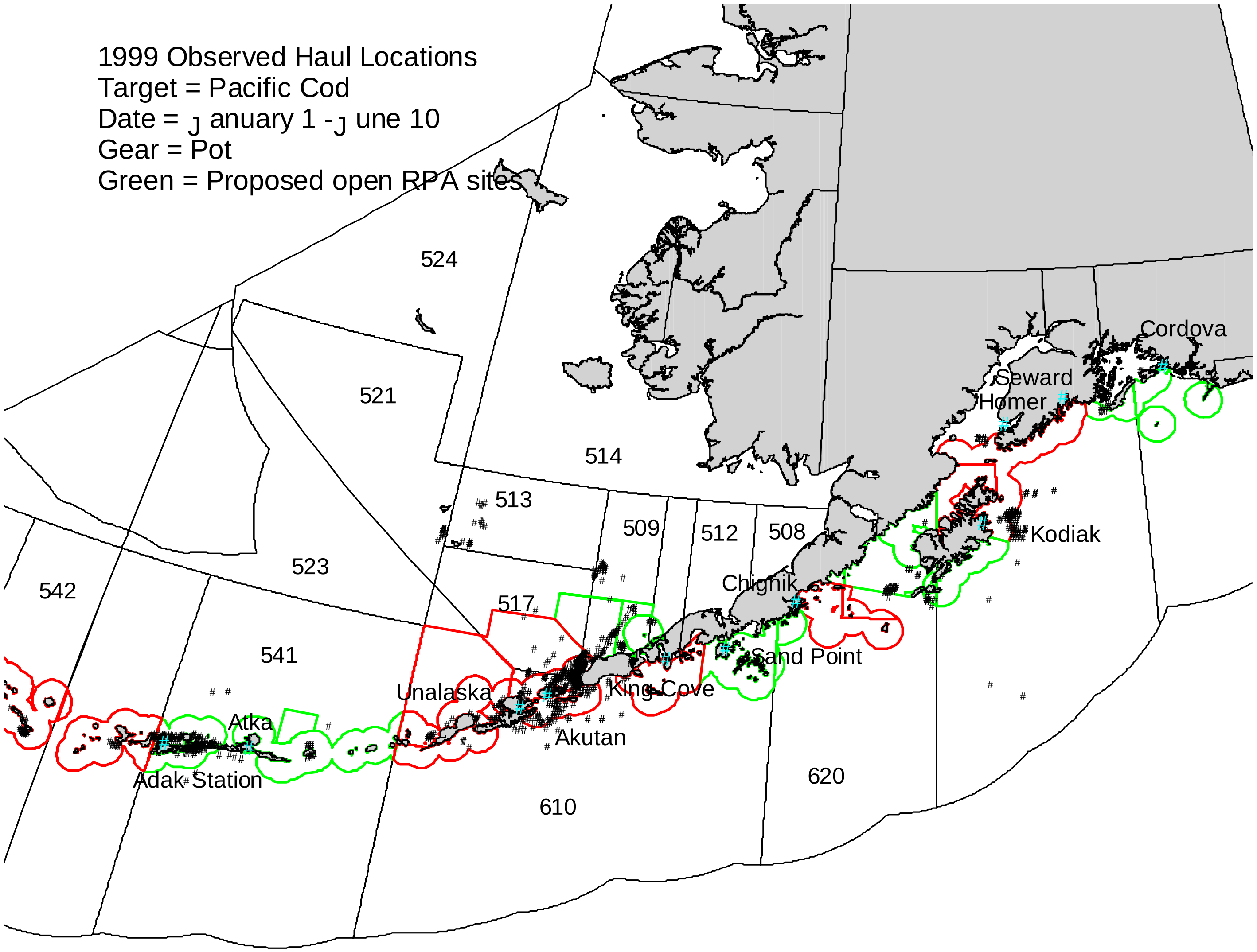
1999 Observed Haul Locations
Target = Pacific Cod
Date = January 1 - June 10
Gear = Pot
Green = Proposed open RPA sites
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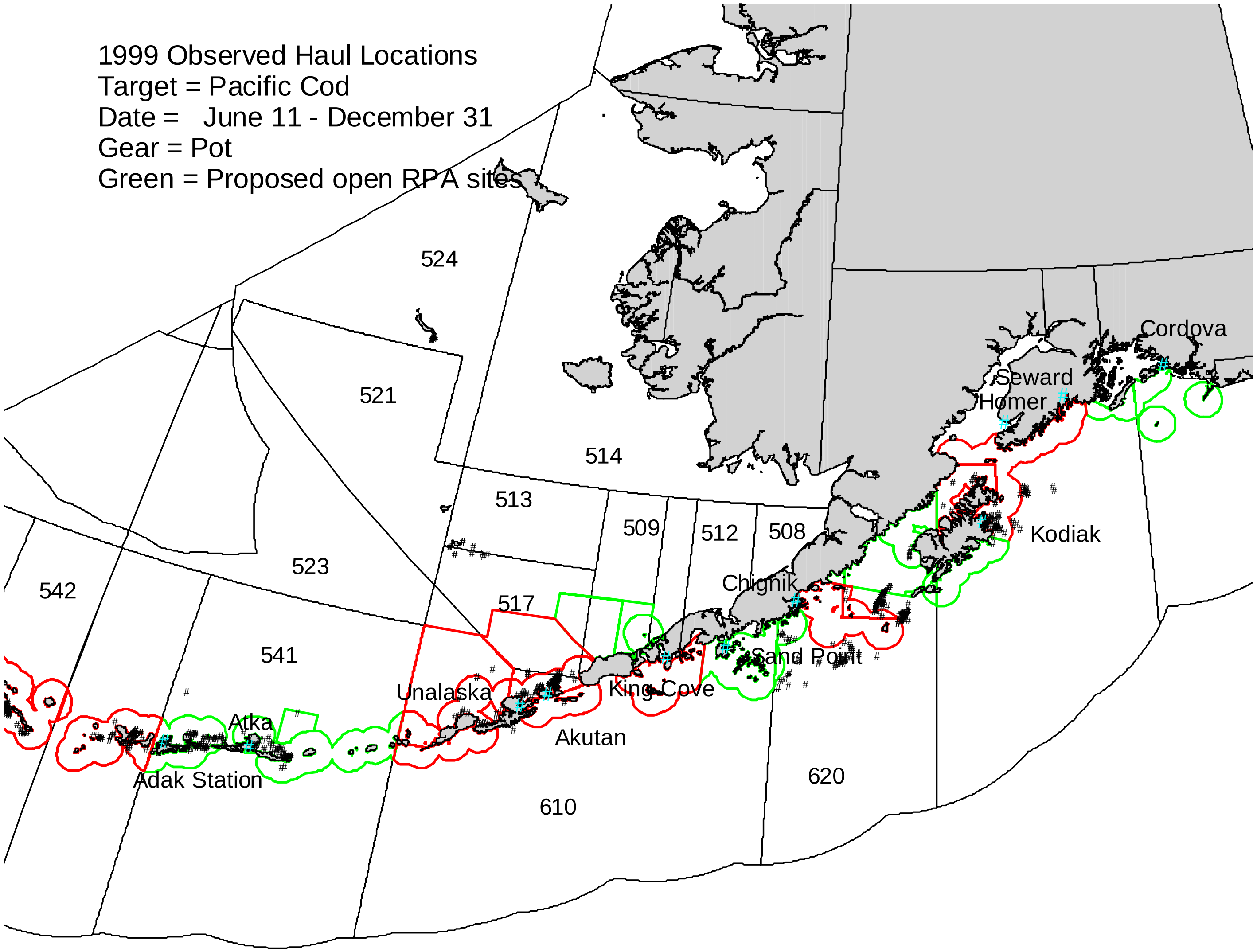
1999 Observed Haul Locations
Target = Pacific Cod
Date = June 11 - December 31
Gear = Pot
Green = Proposed open RPA sites
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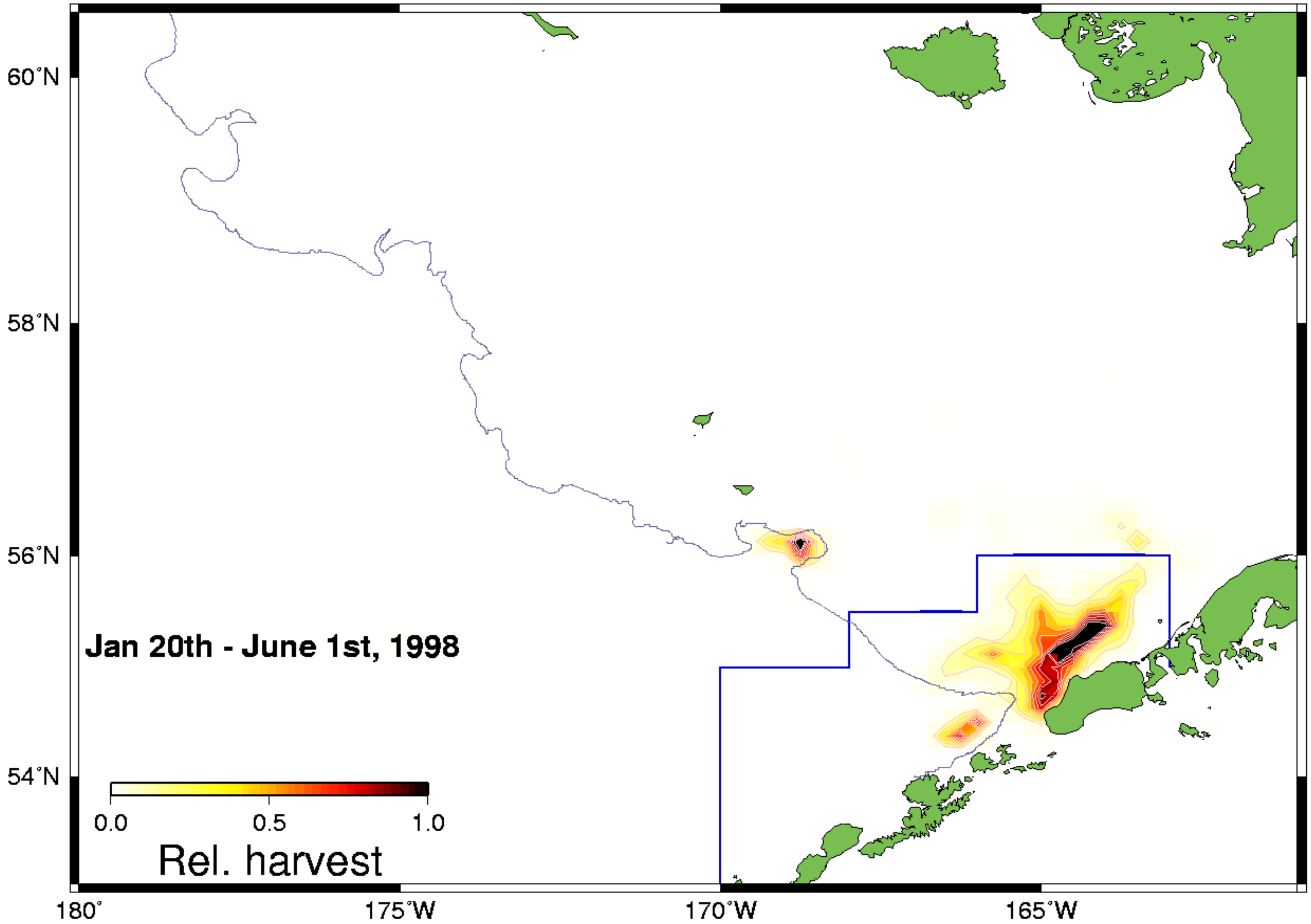
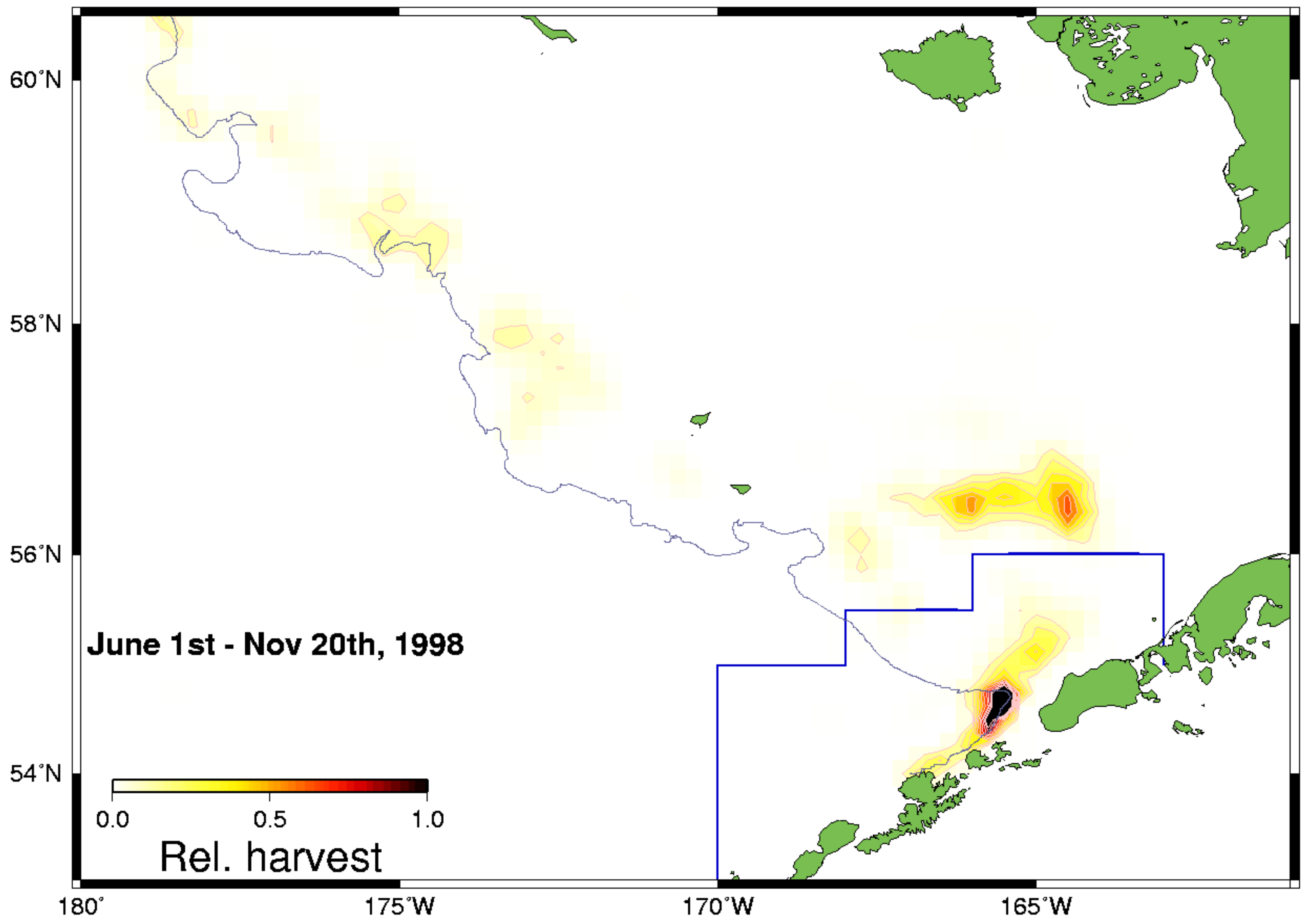
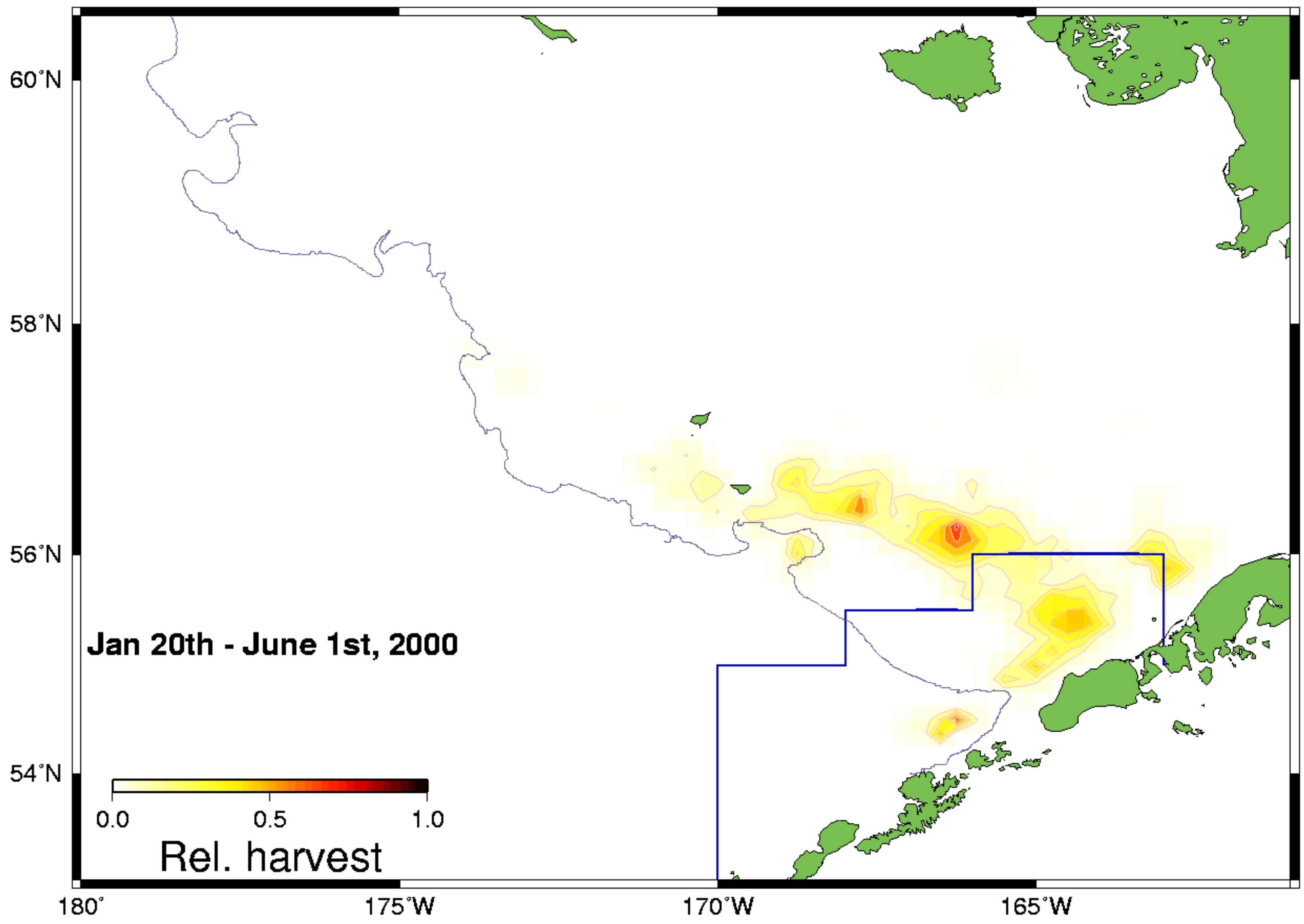


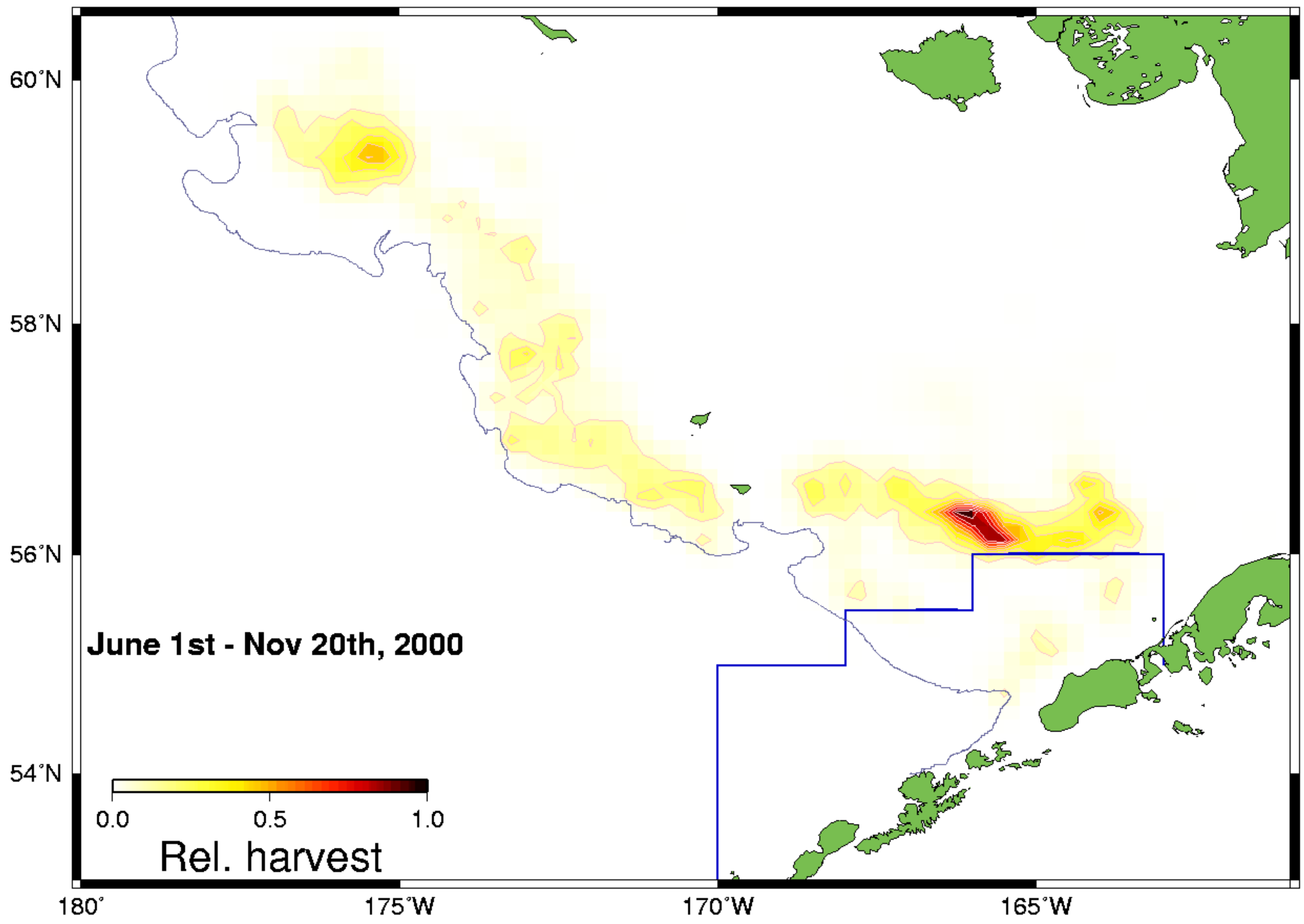
Relative harvest of pollock in the eastern Bering Sea, January 20th - June 1st, 1998.



Relative harvest of pollock in the eastern Bering Sea, June 1st - November 20th, 1998.



Relative harvest of pollock in the eastern Bering Sea, January 20th - June 1st, 2000.



Relative harvest of pollock in the eastern Bering Sea, June 1st - November 20th, 2000.

Table . . Consultation history on BSAI Groundfish Fishery Management Plan and GOA Groundfish Fishery Management Plans as they pertain to Steller sea lions and other protected species.

Region	Year	Date	Consultation	ACTION	CONCLUSION
BSAI					
	1999	23-Dec	Formal	2000 TAC and AFA	No jeopardy
	1998	22-Dec	Formal	1999 TAC	No jeopardy
	1998	3-Dec	Formal	1999 pollock, Atka mackerel fisheries	Jeopardy and adverse modification by pollock fishery
	1998	26-Feb	Informal	1998 TAC	Reinitiation not triggered
	1997	17-Jan	Informal	1997 TAC	No adverse affects not already considered, reinitiation not necessary
	1996	26-Jan	Formal	1996 TAC and BSAI FMP	No jeopardy
	1995	26-Sep	Informal	Effect of I/O (38/40) on SSL	No adverse affects not already considered, reinitiation not necessary
	1995	25-A g	Informal	Amendments 38/40, other species	No adverse affects not already considered, reinitiation not necessary
	1995	3-Feb	Informal	1995 TAC	No adverse affects not already considered, reinitiation not necessary
	1994	2-Feb	Informal	1994 TAC	No adverse affects not already considered, reinitiation not necessary
	1993	28-Apr	Formal	Delay of pollock "B" season	No jeopardy
	1993	20-Jan	Informal	1993 TAC	No adverse affects not already considered, reinitiation not necessary
	1992	9-Oct	Informal	Amendments 20/25	No adverse affects not already considered, reinitiation not necessary
	1992	11-Jun	Informal	IFQ fishery	No adverse affects likely, therefore f rther cons ltation not required
	1992	4-Mar	Formal	Amendment 18 inshore/offshore	No jeopardy
	1992	21-Jan	Formal	1992 TAC	No jeopardy
	1991	22-Oct	Informal	Amendments 17/22 & 20/25	No adverse affects not already considered, reinitiation not necessary
	1991	19-Apr	Formal	BSAI FMP	No jeopardy
	1990	30-Oct	Formal	Bering Sea snail fishery	No jeopardy
	1990	24-Oct	Formal	BSAI crab FMP	No jeopardy
	1989	5-Jul	Formal	Iss e of MMPA exemptions	No jeopardy
	1979	14-Dec	Formal	BSAI FMP	No jeopardy (only whales listed under ESA at this time)

Table . cont.

Region	Year	Date	Consultation	ACTION	CONCLUSION
GOA					
	1999	23-Dec	Formal	2000 TAC and AFA	No jeopardy
	1998	22-Dec	Formal	1999 TAC	No jeopardy
	1998	3-Dec	Formal	1999 pollock fishery	Jeopardy and adverse modification
	1998	2-Mar	Formal	1998 TAC	No jeopardy
	1997	10-Sep	Informal	Amendment 46	Action will not adversely affect listed species
	1997	17-Jan	Informal	1997 TACs	No adverse affects not already considered, reinitiation not necessary
	1996	26-Jan	Formal	1996 TAC and GOA FMP	No jeopardy
	1995	26-Sep	Informal	Effect of I/O (38/40) on SSL	No adverse affects not already considered, reinitiation not necessary
	1995	25-A g	Informal	Amendments 38/40, other species	No adverse affects not already considered, reinitiation not necessary
	1995	3-Feb	Informal	1995 TAC	No adverse affects not already considered, reinitiation not necessary
	1994	31-Jan	Informal	1994 TAC	No adverse affects not already considered, reinitiation not necessary
	1993	6-J l	Informal	Amendment 31	No adverse affects not already considered, reinitiation not necessary
	1993	16-Feb	Informal	Season 2nd quarter delay	No adverse affects not already considered, reinitiation not necessary
	1993	27-Jan	Informal	1993 TAC	No adverse affects not already considered, reinitiation not necessary
	1993	6-Jan	Informal	EFP	Action will not adversely affect listed species
	1992	11-Jun	Informal	IFQ fishery	No adverse affects likely, therefore f rther cons ltation not required
	1992	4-Mar	Informal	Season 2nd quarter delay	Action will not adversely affect listed species
	1991	23-Dec	Informal	1992 TAC	No adverse affects not already considered, reinitiation not necessary
	1991	12-Nov	Informal	Amendment 23	No adverse affects not already considered, reinitiation not necessary
	1991	22-Oct	Informal	Amendments 17/22 & 20/25	No adverse affects not already considered, reinitiation not necessary
	1991	20-Sep	Formal	4th quarter pollock fishery	No jeopardy
	1991	5-J n	Formal	1991 pollock TAC	No jeopardy
	1991	19-Apr	Formal	GOA FMP	No jeopardy

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
1	The amendment included the following measures: 1. Established a m lti-year, m lti-species optim m yield for BSAI gro ndfish complex (1.4 million to 2.0 million mt); 2. Established a framework procedure for the determination and apportionment of amo nts of groundfish specified for total allowable catch (TAC), domestic annual harvest (DAH), reserves, and total allowable level of foreign fishing (TALFF); 3. Allowed year-ro nd domestic trawling and longlining in the Winter Halib t Savings Area and Bristol Bay Pot Sanctuary; 4. Modified seasonal foreign trawl restrictions in the Petrel Bank area to be based on crab opening dates; 5. Updated appendices and annexes to the FMP; added Annex I (description of SAFE document); and 6. Eliminated “Misty Moon” gro nds so th of the Pribilofs from the winter halib t savings area.
1a	Amendment 1a established foreign chinook salmon PSC limits as follows: During any fishing year, that portion of fishing Area 1 lying between 55º N and 57ºN latitude and 165º W and 170º W longitude and all of fishing Area 2 may be closed for the remainder of the periods January 1 through March 31, and October 1 through December 31 to trawl vessels of any nation. This closure will occur when vessels of a nation have intercepted that nation’s portion of the PSC of chinook salmon. A nation’s initial portion of the chinook salmon PSC for a fishing year was determined by m ltiplying 55,250 (the total PSC for chinook salmon) by the ratio of that nation’s initial gro ndfish allocation to the total initial TALFF pl s reserves for gro ndfish.
2	The amendment changed the specifications for yellowfin sole, other flatfish, and Pacific cod as follows: Yellowfin sole: DAH increased from 2,050 mt to 26,200 mt. JVP increased from 850 mt to 25,000 mt. TALFF decreased by 24,150 mt. Other flatfish: DAH increased from 1,300 mt to 4,200 mt. JVP increased from 100 mt to 3,000 mt. TALFF decreased by 2,900 mt. Pacific cod: MSY decreased from 58,700 mt to 55,000 mt. EY increased from 58,700 to 160,000 mt. ABC increased from 58,700 mt to 160,000 mt. OY increased from 58,700 mt to 78,700 mt. Reserve increased from 2,935 mt to 3,935 mt. DAP increased from 7,000 mt to 26,000 mt. DAH increased from 24,265 mt to 43,265 mt.
3	Amendment 3 red ced bycatch of prohibited species in foreign gro ndfish fisheries. Essentially, total PSC allocations for (cont.) foreign nations were based on bycatch rates m ltiplied by the nations TALFF allocation. Bycatch rate reductions to be met by 1986 from status quo base years (1977-80) were as follows: halibut, 50%; king and Tanner crab 25%; salmon 75%. The target level of salmon bycatch

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	was 17,473 fish. If bycatch apportionments for any PSC species were met or exceeded, that nation's fleet was prohibited from fishing in the entire BSAI area, unless exempted by the NMFS Regional Director.
4	Amendment 4 allowed foreign trawling outside 3 miles north of the Aleutians between 170°30 W and 170°W and so th of the Aleutians between 170°W and 172°W, and allowed foreign longlining outside 3 miles west of 170°W longitude. Amendment 4 also changed the specifications for yellowfin sole, other flatfish, and Pacific cod as follows: Pollock: DAH increased from 19,550 mt to 74,500 mt, JVP increased from 9,050 mt to 64,000 mt. TALFF decreased from 930,450 mt to 875,500 mt. Yellowfin sole: DAH increased from 26,200 mt to 31,200 mt, JVP increased from 25,000 mt to 30,000 mt. TALFF decreased from 84,950 mt to 79,950 mt. Other flatfish: DAH increased from 4,200 mt to 11,200 mt, JVP increased from 3,000 mt to 10,000 mt. TALFF decreased from 53,750 mt to 46,750 mt. Atka mackerel: DAH increased from 100 mt to 14,500 mt, JVP increased from 100 mt to 14,500 mt TALFF decreased from 23,460 mt to 9,060 mt. Other species: DAH increased from 2,000 mt to 7,800 mt, JVP increased from 200 mt to 6,000 mt. TALFF decreased from 68,537 mt to 65,648 mt. ABC corrected to be 79,714 mt, OY to 77,314 mt, and reserves to 3,566 mt. Other rockfish: DAP set at 1,100 mt for BSAI area combined. POP: DAP set at 550 mt for Bering Sea and 550 mt for Ale tians. JVP set at 830 mt for Bering Sea and 830 mt for Ale tians. Sablefish: JVP set at 200 mt for Bering Sea and 200 mt for Ale tians. MSY set at 11,600 mt for Bering Sea and 1,900 mt for Aleutians. Pacific cod: EY and ABC increased from 160,000 mt to 168,000 mt, OY increased from 78,700 mt to 120,000 mt. Reserve increased from 3,935 mt to 6,000 mt, TALFF increased from 31,500 mt to 70,735 mt.
5	The amendment was withdrawn when it was s perceded by implementation of Amendment 3.
6	Amendment 6 would have established a fishery development zone (FDZ). The proposed FDZ was located north and west of Unimak Pass and was bounded by the following coordinates: 55º16' N Latitude, 166º10' W Longit de; (cont.) 54º00' N Latitude, 166º10' W Longit de; 54º35' N Latitude, 164º55'42" W Longit de; The FDZ wo ld have been reserved for use by domestic fishing vessels – including those delivering to shore-based processors, U.S.

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	catcher/processors, and foreign processing vessels involved in U.S. joint venture operations. All foreign harvest operations would have been excluded year-round from the FDZ.
7	Amendment 7 allowed the foreign longline fleet to fish in the shallow waters of the WHSA so as to allow them to catch their allocation of Pacific cod. However, the depth restriction would be reimposed if the foreign longline fleet in the entire BSAI caught 105 metric tons of halibut as bycatch during the 12 month period of June 1 through May 31. Thus, if the incidental catch of Pacific halibut by foreign longline vessels in the BSAI reached 105 mt between June 1 and November 30, the WHSA wo ld be closed to foreign longlining landward of the 500 meter depth contour for the 6-month period December 1 through May 31. If the incidental catch limit of 105 mt was reached from December 1 though May 31, the restriction would be reimposed for whatever remained of that 6-month period.
8	Amendments 3 and 8 reduced bycatch of prohibited species in foreign groundfish fisheries. Amendment 3 set a goal of total salmon bycatch of 17,473 fish by 1986, which was a 75% reduction from the 1981 salmon PSC of 69,893 and a 78% reduction from the average salmon bycatch of 80,000 fish for the years 1977-80. Amendment 8 implemented a salmon PSC limit of 38,441 fish for 1984 and 27,957 fish for 1985. The 1986 limit remained at the 17,473 fish PSC envisioned in Amendment 3.
9	Three parts of Amendment 9 were approved: (7) incorporate catcher/processor and mothership vessel reporting requirements to provide NMFS with more timely catch information necessary for adequate in-season management (weekly processor report with check-in/check-o t reporting). A reporting system for catch held aboard for 14 days or more by the expanding domestic fleet was established. Permit holders m st identify vessels as: (a) harvesting/processing, (b) mothership processing; (c) harvesting only; or (d) s pport only. (8) incorporate the NMFS habitat protection policy into the FMP in response to NMFS' Habitat Conservation Policy which advocates consideration of habitat concerns in developing or amending FMPs; and (9) incorporate a definition of directed fishing. One action associated with habitat consideration in the FMP, to prohibit the discard of fishing gear and marine debris, was reserved ntil the req ired analysis was prepared. A measure to red ce bycatch of f lly tilized species by closing an area within 20 miles of the Aleutian Islands to foreign trawling was disapproved.
10	The final reg lations contained the following fo r parts: (cont.) 1) Closed the area north of the Alaska Penins la, so th of 58° N. latitude, west of 160° W longitude, and east of 162° W longitude to all trawling year-ro nd and established the following PSC limits and bycatch limitation zones: Applicable to all domestic vessels in directed fisheries for yellowfin sole and other flatfish in the specified zone: a) 80,000 C. bairdi in bycatch limitation Zone 1 b) 135,000 red king crab in Zone 1 c) 326,000 C. bairdi in Zone 2; Applicable to foreign directed fishing for yellowfin sole and other flatfish: 64,000 *C. bai di* in Zones 1 and 2 combined;

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	Applicable to domestic vessels in directed fisheries for yellowfin sole and other flatfish and delivering to foreign processing vessels (i.e. joint vent res): 828,000 halibut in the entire BSAI. 2) Req ired written weekly catch reports from all catcher/processors and motherships regardless of when the catch is landed (BSAI Amendment 9 implemented the same requirement for catcher/processors holding their catch for more than 2 weeks); 3) Provided authority to the Secretary to make inseason changes to gear reg lations, season, and harvest quotas; and 4) Provided the Secretary with inseason authority to reapportion s rplus groundfish within the domestic allowable harvest.
11	The reg lations implemented the following three provisions: 1) Established an apportionment of the pollock TAC allocated to joint venture operations of 40% in the first season (Jan ary 1-April 15) and 60% in the second season (April 16-December 31). The meas re was effective only in 1988 and 1989; 2) Revised the definition of acceptable biological catch (ABC) to conform with that used by the Pacific Co ncil and includes definitions for “threshold” and “overfishing;” 3) Revised the definition of prohibited species to specifically name the species to be prohibited in the catches of foreign and domestic fishermen. Steelhead and Pacific salmon were added to the prohibited species list of halibut, herring, and king and Tanner crab for domestic and foreign fisheries; all salmonids are prohibited for foreign fishermen. The final rule for Amendment 11 also clarified that the definition of directed fishing (20% or more of the harvest) applied to domestic fisheries as well as foreign fisheries. This was inadvertently omitted from the proposed and final rule for BSAI Amendment 10.
11a	The reg lations implemented the following provisions to the BSAI FMP: 1) A gmented the current catcher/processor and mothership reporting requirements with at-sea transfer information, specifically, a Cargo Transfer/Off-Loading Log and Product Transfer Report; 2) Revised the definition of prohibited species to include Pacific salmonids, Pacific herring, Pacific halib t, king crab, Tanner crab, and steelhead trout. Respecified the other three categories: (cont.) a) Target species–pollock, Pacific cod, flounders, rockfish, and sablefish b) Other species–Atka mackerel, sq id, sc lpins, sharks, skates, eulachon, smelts, capelin, and octopus c) Non-specified species–those species taken incidentally in the groundfish fisheries but are not managed by the FMP. No catch records are required; 3) Required the public comment period for proposed annual specifications and prohibited species catch limits to be 30 days following the date of filing of the notice for p blic inspection with the Office of the Federal Register.
12	Amendment 12 required: (1) All vessels receiving groundfish harvested in the EEZ to hold a federal permit and comply with federal reporting requirements;

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	(2) established PSC limit framework for gro ndfish species in the joint venture and foreign fisheries; (3) established rock sole as a target species separate from the "other flatfish" category; (4) removed the J ly 1 deadline for resource assessment document.
12a	The PSC limits set in reg lation nder Amendment 12a are listed at right.
13	Amendment 13 to the groundfish FMPs authorized a comprehensive domestic fishery observer program. The 1990 and 1991 Observer Plans req ired specific levels of observer coverage which varied with size of fishing vessel and q antity of fish processed. The Observer Plans req ired that owners and operators of vessels and shoreside processing facilities participating in the gro ndfish fishery arrange for and pay for the cost of placing observers aboard their vessels and at their shoreside processing facilities beginning in Jan ary 1990. Each vessel or processor required to have observer coverage is responsible for the cost of obtaining the required observers from a certified contractor. Amendment 13 also: (1) allocated sablefish: 50/50 percent to fixed and trawl gear in the BS and 75/25 percent to fixed and trawl gear in the AI; (2) closed waters seaward of 3 miles o t to 12 miles surro nding the Walrus Islands (Ro nd Island and the Twins) and Cape Peirce from April 1 through September 30 to groundfish fishing; (3) deleted fishing season dates from the FMPs b t retained them in reg lation; (4) clarified authority to recommend TACs for additional or fewer target species within the "target species" category.
14	The amendment implemented rules that reg lated the practice of stripping roe (eggs) from female pollock and discarding female and male pollock carcasses without f rther processing, and seasonally allocated the TAC of pollock. Season opening dates were established as follows for the GOA: Jan ary 1, April, J ly, and October, and for the BSAI: Jan ary 1 and J ne 1. To get at the issue of roe stripping, product recovery rate standards were established, which if exceeded would constitute a violation. The recovery rate (cont.) standard established was 10 percent of the total round-weight equivalent of pollock and other pollock products onboard a vessel at any time during a fishing trip. To extrapolate round weight equivalents, the rule established product recovery rates as follows: fillet (18%), s rimi (15%), mince (17%), meal (17%), and head & g t (50%).
15	The IFQ Program was approved for the Pacific halibut and sablefish fixed gear fisheries in the Federal waters of the BSAI and GOA, and these fisheries have been managed under the program since 1995. The reg lations outline several key provisions of the program: initial allocation of quota shares; vessel categories; transfer provisions; use and ownership provisions; the annual process for allocating quota shares (QS); and the establishment of Comm nity Development Quotas. The reg lations state that legal landings of halib t or sablefish harvested with fixed gear had to occur at any time during 1988-1990 to qualify for an initial allocation of quota share. Generally, if a vessel owner or lessee is q alified, their initial q ota share wo ld be based on their highest total landing of halib t for any 5 years of the 7-year base period 1984-1990. For sablefish, the initial quota share wo ld be based on the highest total landing of sablefish for any 5 years of the 6-year base period 1985-1990. Each person eligible to receive quota share wo ld have it assigned to one of four vessel

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	categories: "A"-freezer vessels of any length; "B"- catcher vessels greater than 60'; "C"- catcher vessels less than or equal to 60' for sablefish, or between 35'-60' for halib t; "D"- catcher vessels less than or eq al to 35' for halib t. Initial q ota share wo ld be assigned to the vessel category that a person's most recent fixed gear landings of groundfish or halibut were caught by that vessel. Vario s restrictions on transfer and ownership are designed to maintain the owner/operator characteristics of the fleet, and to prevent consolidation of QS in the hands of a few participants.
16	The Amendment contained 8 approved management meas res as follows: 1. Modified PSC limits and bycatch limitation zones for halibut, bairdi crab, and red king crab in the BSAI; 2. Apportioned PSC limits into bycatch allowances for trawl fishery categories; 3. Allowed separate apportionment of halibut PSC to hook and line and pot gear in the GOA; 4. Allowed seasonal allocation of halibut and crab PSC; 5. Established proced res for interim TAC specifications 6. Established fishing gear restrictions (definition of pelagic trawl, biodegradable panels & halibut excluders on pot gear); 7. Modified authorization language that allows demersal shelf rockfish in SE Alaska to be managed by the State; and 8. Established definitions of overfishing. Later revisions to the amendment included addition of a vessel incentive program, which wo ld issue civil penalties (fines) to vessels that exceeded seasonal fixed bycatch rate standards for halibut and crab taken in specified target fisheries.
16a	Amendment 16a established prohibited species bycatch limits for Pacific herring taken as bycatch in trawl fisheries. The annual PSC limit was set at 1% of the annual biomass of eastern Bering Sea herring, and is apportioned among trawl fishery categories. Attainment of any apportionment triggers clos re of herring savings areas to that fishery. The Herring Savings Areas are described as (cont.) follows: (1) Summer Herring Savings Area 1 means the part of the Bering Sea s barea that is south of 57° N. latitude and between 162° and 164° W longitude from 12:00 noon Alaska Local Time (ALT) June 15 through 12:00 noon ALT July 1 of a fishing year. (2) Summer Herring Savings Area 2 means the part of the Bering Sea subarea that is south of 56°30' N. latitude and between 164° and 167° W. longit de from 12:00 noon ALT July 1 through 12:00 noon ALT August 15 of a fishing year. (3) Winter Herring Savings Area means that part of the Bering Sea subarea that is between 58° and 60° N. latitudes and between 172° and 175° W. longitudes from 12:00 noon ALT September 1 through 12:00 noon ALT March 1 of the succeeding fishing year. The Regional Director may prom lgate an inseason clos re of an area (for up to 60 days) to reduce prohibited species bycatch rates. A

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	n mber of factors m st be considered when implementing any ‘hot spot’ clos re. Also, Amendment 16a allows the Regional Director, in cons ltation with the Co ncil, to limit the amo nt of pollock that may be taken with trawls other than pelagic trawls. The Co ncil's recommendations are to be available to the public for comment under the annual TAC specification process.
17	Amendment 17 prohibits all vessels federally permitted to fish for gro ndfish from entering the walrus ha lo t closure areas from April 1 through September 30. These areas include the EEZ within 12 miles of islands named Round Island and The Twins, and around Cape Peirce. Amendment 17 allows the NMFS Regional Director, after cons lting with the Director of the Alaska Fishery Science Center and with the Co ncil, to authorize for limited experimental p rposes, the target or incidental harvest of gro ndfish that wo ld otherwise be prohibited. The amendment also combined statistical area 68 with statistical area 65, established the Bogoslof Area, and requires pot gear to be identified as s ch when groundfish fishing.
18	The alternative adopted and approved defined the inshore and offshore components of the fisheries. BSAI Amendment 18 was only partially approved, allocating 35% of the 1992 non-roe pollock season TAC to the inshore component, and the remaining 65% to the offshore component. The portion that was not approved wo ld have further allocated pollock through 1995: (the inshore allocation would have increased to 40% in 1993 and 45% in both 1994 and 1995). A NMFS economic review indicating a large net loss to the Nation as a result of this action provided the rationale for disapproval by the Secretary of Commerce. (Analysis of adjoining GOA Amendment 23 indicated a net benefit; therefore, that amendment was approved in f ll. The GOA inshore component was allocated 90% of the Pacific cod TAC and 100% of the pollock TAC for each fishing year.) While catcher/processors from the offshore component wo ld not be able to conduct directed pollock fishing in the GOA, they would be allowed appropriate bycatch amounts. Amendment 18 also established the CVOA south of 56° N. latitude and between 163° and 168° W. longitudes and the Comm nity Development Quota program. As a res lt of the CDQ program, 7.5 percent of the BSAI pollock TAC was reserved for CDQ (cont.) fisheries (a nonspecific reserve) at the beginning of the year, and that amount would be reduced as allocations are made to comm nity development projects.
19	Amendments 19/24 established three FMP amendment management meas res. These are as follows: 1) For 1992, reduce the Pacific halibut prohibited species catch (PSC) limit established for BSAI trawl gear from 5,333 metric tons (mt) to 5,033 mt, but retain the primary halib t PSC limit at 4,400 mt; 2) For 1992, establish a 750 mt Pacific halibut bycatch mortality limit for BSAI fixed gear; and 3) Establish FMP authority to develop and implement regulatory amendments that allow for time/area clos res to reduce prohibited species bycatch rates (revised “hotspot authority”). In addition to the above FMP amendments, the following amendments to current reg lations were adopted: (1) Revise BSAI fishery definitions for p rposes of monitoring fishery specific bycatch allowances and assigning vessels to fisheries for purposes of the vessel incentive program; (2) Revise the management of BSAI trawl fishery categories for PSC accounting; (3) Expand the vessel incentive program to address halib t bycatch rates in all trawl fisheries; (4) Delay the season opening date of the BSAI and GOA groundfish trawl fisheries to Jan ary 20 of each fishing year to reduce salmon

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	and halibut bycatch rates; (5) Further delay the season opening date of the GOA trawl rockfish fishery to the Monday closest to J ly 1 to reduce halibut and chinook salmon bycatch rates; and (6) Change directed fishing standards to f rther limit halibut bycatch associated with bottom trawl fisheries.
20	Reg lations authorized by Amendment 20 implemented the following meas res: 5) Areas are closed year-round to fishing by vessels sing trawl gear within 10 na tical miles of key Steller sea lion rookeries located in the GOA and BSAI management areas. 6) Areas are closed within 20 nm of five sea lion rookeries to directed pollock fisheries during the "A" season. These rookeries are Sea Lion Rocks, Akun Island, Akutan Island, Seguam Island, and Agligadak Island 7) In the GOA, the specified total allowable catch for pollock in the combined western/central area is f rther divided among three pollock management districts: Area 61 (170º-159º W. longitudes), Area 62 (159º-154º W. longitudes), and Area 63 (154º-147º W. longitudes). The Shelikof Strait district was eliminated. To prevent excessive accum lation of unharvested portions in any q arterly allowance of the pollock TAC, a limit of 150 percent of the initial quarterly allowance in each pollock management district was established.
21	Amendment 21 implemented the following meas res: 1. Establish halib t bycatch limits in terms of halib t mortality rather than halib t bycatch; 2. Establish halib t bycatch mortality limits for trawl and non trawl fisheries in reg lations rather than in the FMP to allow (cont.) for changes in bycatch mortality limits through a regulatory amendment process rather than an FMP amendment; and 3. Establish FMP authority to annually apportion the non-trawl halibut bycatch mortality limit among fisheries and seasons as bycatch allowances. This authority wo ld be similar to FMP provisions for annual specification of bycatch allowances of prohibited species catch limits among trawl fisheries. Consistent with this amendment, reg lations established a 3,775 mt halibut bycatch mortality limit for trawl gear fisheries and a 900 mt halib t bycatch mortality limit for non-trawl fisheries.
21a	All trawling is prohibited at all times in the EEZ within the area bo nded by a straight line connecting the following pairs of coordinates in the following order: (57° 57.0', 168° 30.0') (56° 55.2', 168° 30.0') (56° 48.0', 169° 2.4') (56° 34.2', 169° 2.4') (56° 30.0', 169° 25.2') (56° 30.0', 169° 44.1')

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	(56° 55.8', 170° 21.6') (57° 13.8', 171° 0.0') (57° 57.0', 171° 0.0') (57° 57.0', 168° 30.0')
21b	Amendment 21b established meas res to control the amount of chinook salmon taken as bycatch in BSAI trawl fisheries. Specifically, the alternative adopted would close three areas in the BSAI to all trawling when 48,000 chinook salmon were taken as bycatch. The chinook salmon savings areas are shown in the adjacent fig re. A closure will remain in effect from the time the trigger is reached until April 16, when the areas would reopen to trawling for the remainder of the year.
22	Amendment 22 allows the Secretary to prom lgate reg lations establishing areas where specific types of fishing gear may be tested, to be available for use when the fishing grounds are closed to that gear type. Specific gear test areas contained in reg lations that implement the FMP were allowed by reg latory amendment. These gear test areas would be established in order to provide fishermen the opportunity to ens re that their gear is in proper working order prior to a directed fishery opening. The test areas m st conform to the following conditions: (1) Depth and bottom type m st be suitable for testing the particular gear type. (cont.) (2) Must be outside State waters. (3) Must be in areas not normally closed to fishing with that gear type. (4) Must be in areas that are not us ally fished heavily by that gear type. (5) Must not be within a designated Steller sea lion protection area at any time of the year. The rule implementing this amendment established three trawl test areas: Dutch Harbor (54 º40' to 55º 00' N; 166º 00' to 167º 00' W), Sand Point (54 º35' to 54º 50' N; 160º 30' to 161º 00' W), and Kodiak (57 º23' to 57º 37'N; 151º 25' to 152º 02'W). The reg lation f rther required that the trawl cod end m st be left unzipped so as not to retain fish, that groundfish may not be onboard, and that the time sed to test gear would not contribute to observer coverage requirements.
23	After several proposed moratoriums, the final rule required a moratorium permit for vessels within specific vessel categories that harvest gro ndfish and BSAI crab reso rces off Alaska. Generally, a vessel q alified for a moratorium permit if it made a legal landing of any moratorium species during the qualifying period of Jan ary 1, 1988 through February 9, 1992. In addition, a vessel that made a legal landing during the qualifying period, in either a groundfish or crab fishery, but not both, can cross over as a new vessel in the fishery in which it did not made a legal landing in the q alifying period provided: 1) it uses the same gear type in the new fishery as it sed to q alify for the moratorium in the other fishery; or 2) it made a legal landing in the crossover fishery d ring the q alifying period and it ses only the same gear type it used in that period.
24	Amendment 24 was proposed to authorize the explicit allocation of BSAI Pacific cod among vessels sing trawl, hook-and-line or pot

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	gear, and jig gear through 1996. The alternative adopted and approved allocated the BSAI Pacific cod TAC to the jig gear (2%), hook-and-line or pot gear (44%) and trawl gear (54%) fleets. The action also authorized the seasonal apportionment of the Pacific cod TAC for hook-and-line and pot gear, creating three fo r-month seasons. In addition, the reg lation allowed for the reallocation of Pacific cod from the trawl sector to the longline and pot sectors, and vice versa, if NMFS determines that one gear gro p or the other will not be able to harvest its f ll allocation.
25	The alternative adopted and approved eliminated the primary PSC limit, but did not affect the overall halibut bycatch mortality limit (3,775 mt) for the BSAI trawl fisheries. The action also implemented reg latory amendments which 1) prohibited discards of salmon taken as bycatch in the BSAI gro ndfish trawl fisheries until a NMFS-certified observer determines the n mber of salmon and collects any necessary data; and 2) established the authority to release to the public vessel-specific observer data on bycatch of prohibited species in the BSAI and GOA groundfish fisheries.
26	The Salmon Donation Program authorizes the distribution of Pacific Salmon taken as bycatch in the groundfish trawl fisheries in the groundfish fisheries off Alaska to economically disadvantaged individuals through NMFS a thorized distributor selected by the Regional Director in accordance with federal reg lations implemented under the FMP.
27	The Magnuson-Stevens Act a thorized the Council and the Secretary to establish a North Pacific Fisheries Research Plan which: (1) req ires that observers be stationed on fishing vessels and at fish processing facilities, and (2) establishes a system of fees to pay for the cost of implementing the research plan. The Research Plan, as adopted under this amendment, contained four objectives and elements that included observer employment and contracts, observer d ties, data collection and transmission, annual determination of coverage levels by fishery, in-season changes to coverage levels, establishment of an observer oversight committee, coordination between the NMFS groundfish and ADF&G shellfish observer programs, a fee assessment (up to 2% of ex-vessel value of harvested fish), and details on fee collection and contingency plans in case of f nding shortfalls.
28	Under Amendment 28, the Aleutian Islands region was split into three management districts at 177º W longit de and 177º E longitude. The eastern, central, and western AI districts are shown in the adjacent fig re and are denoted as statistical areas 541, 542, and 543.
29	The amendment was never adopted and the vessel incentive portion was never implemented. NMFS expressed reservations about obtaining statistically valid estimates of salmon bycatch amo nts for use in enforcing a vessel incentive program. Additionally, there were concerns raised abo t establishing a ha l by ha l vessel incentive program because the possibility of a vessel randomly encountering large n mbers of salmon in a single ha l, as well as vessels that deliver unsorted cod ends to shoreside operations. In both cases, violators wo ld be nable to take action to avoid a violation. Notwithstanding these issues, it was felt that significant staff reso rces would need to be shifted to monitor salmon bycatch, enforce, and prosecute salmon bycatch violators. Given the difficulties presented in establishing a reg latory sol tion to individ al vessel bycatch acco nting, amendment development was put on hold while industry representatives developed their own voluntary program named the Salmon Foundation. Participants

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	assessed themselves a $20 fee per chinook and raised a total of $120,000 in 1994. The purpose of the Foundation was to use income generated from salmon bycatch assessment payments to develop a salmon bycatch avoidance program for the BSAI trawl fisheries and to f nd research on stock origin of salmon taken as bycatch. After the Council adopted the time area clos res in April 1995, the ind stry stopped the bycatch assessment fees, so the research monies were spent and the Foundation dissolved.
30	The alternative adopted and approved raised the sablefish Comm nity Development Quota allocation limit for qualified applicants from 12% to 33% in order to allow total allocation of the sablefish CDQ reserve; removed the inadvertent inclusion of the CDQ program in the FMP for the GOA; and expanded the types of evidence that may be used to verify vessel leases for the halibut and sablefish individual fishing quota program. It was emphasized that this action did not change the amount of sablefish available for harvest by persons participating in the Pacific halib t and sablefish IFQ program.
31	The Modified Block Proposal provided that initial allocations of QS that represent less than 20,000 lb of IFQ in the implementation year will be iss ed as a block, 2) QS that represents 20,000 lb or more of IFQ in the implementation year will be " nblocked", and 3) QS in a block cannot be separated and m st be transferred as a block. Fishermen can own p to two blocks of halibut and two blocks of (cont.) sablefish QS in each area, but persons holding any amount of nblocked QS are limited to one block of QS per area. A sweep- p provision allowed fishermen to combine small amo nts into fishable amo nts: halib t blocks can be combined to a sum of less than 1,000 lbs and sablefish blocks can be combined until the s m reaches 3,000 lbs. The amendment also clarified that blocked and unblocked quota share wo ld be transferable s bject to the approval of the NMFS Regional Director. Because the Modified Block Proposal created the potential that some QS wo ld become non-transferable because the size wo ld exceed the quota share use limits established in prior reg lations (50 CFR 676.22 (e)(f)); the alternative also allowed for the transfer of a quota share block exceeding the use limits by providing that one block could be divided into two blocks.
32	The amendment exempted some CDQ compensation QS from the block provision and allowed for a one year period of relief (one-time transfer) from the restriction against transferring CDQ compensation QS across vessel length categories. Reg lations state that if a person is iss ed CDQ compensation QS for an area where the person already has reg lar QS, then their CDQ compensation QS is combined with their existing QS and is either "blocked" or " nblocked" depending on the sum total of their QS (this makes m ch of the CDQ compensation QS unidentifiable after iss ance). If a person is iss ed CDQ compensation QS for an area in which the person doesn't have other QS, the QS is left unblocked. The exemption does not include Category "A" vessels (vessels of any length authorized to process IFQ species).
33	The alternative adopted and approved authorized the processing of fish other than IFQ halibut or IFQ sablefish on board the harvesting vessel by persons authorized to harvest IFQ sablefish based on an annual allocation of IFQ assigned to vessel categories B or C. This authorization is not extended to persons authorized to harvest IFQ halib t, d e to the fact that halib t is characteristically prosecuted by local vessels that do not have onboard processing capabilities. Several modifications were also made to the reg lations implementing the IFQ program in order to accommodate the new provision. In addition, while non-IFQ species could be frozen onboard, the freezing of IFQ sablefish caught with catcher vessel q ota share on a freezer vessel would continue to be prohibited.

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
34	The Co ncil adopted Amendment 34 to the FMP at its June 1997 meeting in response to concerns about the fast-paced nature of the Atka mackerel trawl fishery and the res lting preemption of the small-scale jig gear fishery. The Council's action would allocate up to 2 percent of the Atka mackerel TAC specified for the Eastern AI/BS to vessels sing jig gear. The Council also voted to specify the jig gear allocation annually d ring the groundfish specifications process based on recent and anticipated harvests. This action was taken in consideration of the small amount of Atka mackerel annually harvested in recent years and to respond to trawl industry concerns about allocating more Atka mackerel to the jig gear fleet than could be harvested. Amendment 34 allowed for a ramp p provision, s ch that 1-percent of the Eastern AI/BS Atka mackerel TAC wo ld be allocated to vessels sing jig gear to begin the program. Once the jig gear fleet proved it could harvest that amount of TAC, the allocation could be increased to 2%.
35	Amendment 35 established meas res to control the amount of ch m salmon taken as bycatch in BSAI trawl fisheries. Specifically, the alternative adopted would close an area in the BSAI to all trawling from August 1 though August 31 (the time of year when (cont.) bycatch is highest). In addition, the area wo ld remain closed or re-close after September 1, upon the attainment of a bycatch limit of 42,000 "other" salmon taken within the catcher vessel operational area (CVOA), through October 14. The chum salmon savings areas is the area bo nded by a straight line connecting the following pairs of coordinates in the order listed: 56°00'N., 167°00'W.; 56°00'N., 165°00'W.; 55°30'N., 165°00'W.; 55°30'N., 164°00'W.; 55°00'N., 164°00'W.; 55°00'N., 167°00'W.; 56°00'N., 167°00'W.
36	Amendment 36 defined a forage fish species category and authorized that the management of this species category be specified in reg lations in a manner that prevents the development of a commercial directed fishery for forage fish which are a critical food so rce for many marine mammal, seabird and fish species. Forage fish species are not included in a target species category. Management meas res for the forage fish category will be specified in reg lations and may include prohibitions on directed fishing, limitations on allowable bycatch retention amounts, or limitations on the sale, barter, trade or any other commercial exchange, as well as the processing of forage fish in a commercial processing facility. The forage fish species category wo ld include all species of the following families: Osmeridae (eulachon, capelin and other smelts), Myctophidae (lanternfishes), Bathylagidae (deep-sea smelts), Ammodytidae (Pacific sand lance),

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	Trichodontidae (Pacific sand fish), Pholidae (gunnels), Stichaeidae (pricklebacks, warbonnets, eelblennys, cockscombs and shannys), Gonostomatidae (bristlemouths, lightfishes, and anglemo ths), and the Order Euphausiacea (krill).
37	Amendment 37 implemented the following meas res: (1) A year round bottom trawl clos re in the Bristol Bay Red king Crab Savings Area to directed fishing for groundfish by (cont.) vessels sing non-pelagic trawl gear. The so thern edge of the Savings Area between 56° and 56°10 N. lat., however, wo ld open if a guideline harvest level for Bristol Bay red king crab is established. A portion of the annual PSC limit would be specified for the s barea; (2) A year round closure to all trawling in the nearshore waters of Bristol Bay, with the exception that a portion of this area- between 159° and 160°W. long. and between 58° and 58°43' N. lat. - would remain open to trawling during the period April 1 to June 15 each year; (3) Increased observer coverage on all vessels, including vessels using pot, jig, and longline gear fishing for groundfish in the Savings Area and on trawl vessels fishing in the seasonal open area of the Bristol Bay nearshore waters clos re; and (4) Adjustments to the Zone 1 PSC limit for red king crab taken in trawl fisheries. The PSC limit would be specified annually based on the abundance and biomass of Bristol Bay red king crab, as shown in the adjacent table.
38	The provisions of BSAI Amendment 18 became the basis of Amendment 38, and the provisions of GOA Amendment 23 became the basis for Amendment 40. Th s, in the BSAI the apportionments of pollock in each s barea and season would be allocated 35% for processing by the inshore sector and 65% by the offshore sector. In the GOA, the apportionment of pollock would be allocated entirely for processing by the inshore sector, and the apportionment of Pacific cod wo ld be allocated 90% for the inshore sector, 10% for the offshore sector. The amendments also reauthorized the CDQ pollock program with a few minor changes to the reg lations. The only two s bstantive changes from the original plan amendments were: 1) movement of the western CVOA boundary 30 min tes to the east, and 2) allowing catcher/processors to use the CVOA if the pollock quota for processing by the inshore sector had already been harvested for the year.
39	The final rule limited access to the commercial groundfish fisheries in the BSAI and GOA and commercial crab fisheries in the BSAI, except for demersal shelf rockfish east of 140° W. longitude and sablefish managed under the IFQ program. The rule provided for the following: issu ance of a single type of gro ndfish license; LLP is not applicable to waters of the State of Alaska; licenses would be iss ed to current owners (as of 6/17/95) of qualified vessels; licenses wo ld be designated as catcher vessel or catcher/processor and with one of three vessel length classes; the crab and groundfish base qualifying period is 1/1/88-6/27/92 and the groundfish area endorsement qualifying period is 1/1/92-6/17/95; endorsement areas are defined as Aleutian Islands, Bering Sea, Western Gulf, Central Gulf, and Southeast Outside, or state waters shoreward of those endorsement areas; landing requirements for general license and area endorsement q alifications by vessel class; and additional provisions addressing crossover vessels, transfers, and vessel linkages. The rule also

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	included in CDQ allocations 7.5% of the TAC of gro ndfish and crab in the BSAI that was not originally included in the CDQ programs for pollock, halibut, and sablefish.
40	Under Amendment 40 of the BSAI Groundfish FMP, PSC limits for snow crab (*C. opilio*) taken in gro ndfish fisheries are based on total abundance of *opilio* crab as indicated by the NMFS standard trawl s rvey (NPFMC 1996). The snow crab PSC cap is set at 0.1133% of the Bering Sea snow crab ab ndance index, with a minim m PSC of 4.5 million snow crab and a maxim m of 13 (cont.) million snow crab. Snow crab taken within the "C. Opilio Bycatch Limitation Zone" (COBLZ) accrue towards the PSC limits established for individual trawl fisheries. Upon attainment of a snow crab PSC limit apportioned to a particular trawl target fishery, the COBLZ would be closed to directed fishing for species in that trawl fishery category, except for pollock with nonpelagic trawl gear. The COBLZ within the EEZ is an area defined as that portion of the Bering Sea Subarea north of 56°30' N. latitude that are west of a line connecting the following coordinates in the order listed: 56°30' N. lat., 165°00' W. long. 58°00' N. lat., 165°00' W. long. 59°30' N. lat., 170°00' W. long. and north along 170°00' W. longitude to its intersection with the U.S.-R ssian Boundary.
41	The alternative adopted and approved under Amendment 41 provides for the annual specification of the revised PSC limits based on the total estimated abundance of *C. bai di* as shown in the adjacent table. *C. bai di* taken as bycatch within the zones accrue towards the PSC limits established for individual trawl fisheries. Upon attainment of a PSC limit apportioned to a particular trawl target fishery, that fishery is prohibited from fishing within the specified zone. Note that in 1998, the Co ncil adopted a provision to reduce opilio crab bycatch by an additional 50,000 *C. bai di* crab as part of the reg lation prohibiting the use of bottom trawl gear for pollock fisheries.
42	Amendment 42 and a reg latory amendment to the IFQ Program for fixed gear Pacific halibut and sablefish fisheries in and off Alaska allowed QS initially assigned to a larger vessel category to be used on smaller vessels, while contin ing to prohibit the use of QS or its associated IFQ assigned to smaller vessel categories on larger vessels. QS will contin e to be assigned to vessel categories by existing criteria at Sec. 679.40(a)(5) (i) through (vi) and will retain original vessel category assignments. However, halibut and sablefish QS and their associated IFQ assigned to vessel Category B, can be used on vessels of any size and halibut QS assigned to vessel Category C likewise can be used on vessels of categories C and D. The reg lations contin e to prohibit the use of QS and IFQ on vessels larger than the maxim m length on average (LOA) of the category to which the QS was originally assigned. It does not apply to halib t in IFQ reg latory areas 2C or to sablefish east of 140°. W. long. Halibut QS assigned to vessel Category B in IFQ reg latory areas 2C and sablefish QS east of 140° W. long. are prohibited from se on vessels less than or equal to 60 ft (18.3 m) LOA except in QS blocks equivalent to less than 5,000 lb (2.3 mt) based on the 1996 Total Allowable Catch (TAC).
43	Amendment 43 increased the sweep- p levels for small QS blocks for Pacific halibut and sablefish from a 1,000 lb (0.45 mt) maximum for Pacific halibut and 3,000 lb (1.4 mt) maxim m for sablefish to a 3,000 lb (1.4 mt) maxim m and a 5,000 lb (2.3 mt) maxim m, respectively. Two other changes were recommended to accompany these increases:

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	8) The base year TAC for determining the pounds wo ld be the 1996, rather than 1994, TAC which was sed for the first sweep- p levels; 9) Once QS levels are established for the appropriate reg latory areas based on the 1996 TAC, those QS levels would be fixed (cont.) and codified. This wo ld eliminate any conf sion as to the appropriate sweep- p level in po nds, which wo ld fluctuate with changes in the annual TAC. The maxim m n mber of QS units that may be consolidated into a single QS block in each IFQ reg latory area is shown in the above table.
44	Amendments 44/44 provided for more conservative definitions of ABC and OFL. The fishing mortality rate used to calculate ABC was capped by the overfishing rate. The maximum allowable fishing rates were prescribed through a set of 6 tiers which are listed in descending order of preference, corresponding to descending information availability. These tiers are shown in the adjacent table. Harvest rates sed to establish ABCs are reduced at low stock size levels, thereby allowing rebuilding of depleted stocks. If the biomass of any stock falls below Bmsy or $B_{40\%}$ (the long-term average biomass that wo ld be expected under average recruitment and $F=F_{40\%}$), the fishing mortality is red ced relative to stock status. This serves as an implicit reb ilding plan sho ld a stock fall below a reasonable abundance level.
45	Ten percent of pollock and 7.5% of all other groundfish and crab TACs are set aside for the Western Alaska CDQ program.
46	1) <u>BSAI Pacific cod TAC Apportionments</u>: Trawl sector: 47% (The trawl apportionment will be split between catcher vessels and catcher processors 50/50.) Fixed gear sector: 51% Jig gear sector: 2% 2) <u>Roll-overs</u>: On September 15 of each year, the Regional Director shall reallocate 100% of any projected unused amount of the Pacific cod allocated to jig vessels to the fixed gear vessels. If, during a fishing year, the Regional Director determines that vessels using trawl gear or hook-and-line or pot gear will not be able to harvest the entire amount of Pacific cod allocated to those vessels, then NMFS shall reallocate the projected unused amount of Pacific cod to vessels sing the other gear type(s). 3) <u>Halib t PSC Mortality Caps</u>: The trawl halibut PSC mortality cap for Pacific cod will be no greater than 1,600 mt. The hook-and-line gear halibut PSC mortality cap for Pacific cod will be no greater than 900 mt. 4. <u>Review</u>: No sunset provision, b t the Co ncil will review this agreement in fo r years following the date of implementation.
47	WITHDRAWN - At the December 1997 meeting the Co ncil was scheduled to take action approving an alternative observer program

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	structure - a Joint Partnership Agreement (JPA) between NMFS and the Pacific States Marine Fisheries Commission (PSMFC), (cont.) which would have established PSMFC as a third party procurement point for observers. This was being considered as a replacement for the repealed Research Plan (Amendment 30), in an effort to address conflict of interest and other iss es in the existing pay-as-yo -go program structure. Due to legal concerns of PSMFC this amendment was not approved by the Council and was never forwarded for Secretarial review. Instead, the existing pay-as-you-go program was extended for an additional time period, through year 2000. C rrently, NMFS and Co ncil staff are working on revised program structure alternatives, including a fee-based plan, and the current program will be extended through 2002.
48	This amendment was not formally submitted to the Secretary and no reg lations have been implemented.
49	Amendment 49 req ired all vessels fishing for gro ndfish in the BSAI to retain all pollock and Pacific cod beginning Jan ary 1, 1998, and all rock sole and yellowfin sole beginning Jan ary 1, 2003. It established a 15-percent minim m tilization standard for all at-sea processors.
50	This action authorized the voluntary donation of Pacific halibut taken as bycatch in specified groundfish trawl fisheries off Alaska to economically disadvantaged individuals. Under the prohibited species donation program, NMFS expanded the existing salmon donation program to also a thorize distrib tions by tax-exempt organizations through a NMFS-a thorized distributor. The program is limited to dead halibut landed by trawl catcher vessels to shoreside processors.
51	As adopted by the Council in June 1998, the BSAI amendment contemplated fo r changes to the current inshore/offshore allocation regime. In light of the AFA, the BSAI inshore/offshore pollock allocations were disapproved, and the only change (partially) approved related to the Catcher Vessel Operational Area (CVOA). The original Amendment 51 wo ld have changed the existing CVOA rules by excluding from the CVOA all catcher vessels that deliver pollock to the offshore component (catcher/processors and motherships). Motherships had previously been allowed to operate within the CVOA, receiving and processing pollock harvested by catcher vessels. Catcher/processor vessels had not been allowed to harvest pollock in the CVOA d ring the B season. In recommending the CVOA portion of Amendment 51, the Co ncil attempted to create parity between motherships and catcher/processor vessels. NMFS approved all of the proposed amendment maintaining the CVOA with the exception of that component. This is because the AFA specifies separate allocations of the pollock TACs for the mothership and catcher/processor sectors, thereby achieving the parity intended by the Council. Hence, the exclusion of catcher vessels from the CVOA that deliver to the offshore component was an unnecessary duplication of an AFA provision, and as such, was inconsistent with National Standard 7. Note that although the approved CVOA provisions are effectively the same as they were for 1996-98, f rther restrictions on fishing in the CVOA were implemented in 1999 to mitigate the effects of pollock fishing on Steller sea lions and their critical habitat, within which m ch of the CVOA lies.
52	Under a vessel registration program, NMFS wo ld establish criteria to determine which fisheries wo ld req ire registration. Based on these criteria, NMFS would create a roster of "registration fisheries" that wo ld be anno nced at the beginning of each year and (cont.) supplemented as necessary on an inseason basis throughout the year. Criteria for establishing a registration req irement for a fishery

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	could include: 1) the size of the TAC amo nt or PSC limit specified for the fishery relative to the degree of interest in that fishery, (2) a fishery for which the TAC or PSC limit was exceeded by a significant amount in the previous year and the current year's quota and expected effort are similar, (3) a fishery for which the above two criteria may not apply but an expanded interest has developed inseason, and (4) a "mop- p" fishery. Vessel operators wo ld be required to register with NMFS a certain n mber of days before beginning directed fishing in a registration fishery and penalties wo ld be established for non-compliance.
53	At its February 1998 meeting, the Council approved Amendment 53 to the FMP. After s btraction of reserves, this amendment would allocate 30 percent of the remaining SR/RE TAC to non-trawl gear and 70 percent of the remaining SR/RE TAC to trawl gear.
54	Regulations have not yet been drafted.
55	The alternative adopted and approved defined EFH as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat". EFH was described in text, tables, and maps. Habitat areas of particular concern were identified as living s bstrates in shallow and deep waters, and freshwater habitats sed by anadromous fish.
56	Amendment 56 revised the ABC and overfishing definitions set under Amendment 44 to be more precautionary. Like Amendment 44, the maxim m allowable rates are prescribed through a set of six tiers which are listed below in descending order of preference, corresponding to descending order of information availability. For most tiers, ABC is based on $F_{40\%}$, which is the fishing mortality rate associated with an eq ilibrium level of spawning per recruit (SPR) eq al to *40%* of the eq ilibrium level of spawning per recruit in the absence of any fishing. To f rther minimize the possibility of catches jeopardizing a stock's long term prod ctivity, there is a b ffer established between ABC and OFL. Amendment 56 modified the OFL definition from $F_{30\%}$ to $F_{35\%}$ for stocks having tiers 2-4 information.
57	Amendment 57 prohibited the se of non-pelagic trawl gear when participating in the BSAI pollock fisheries. The definition of a pelagic trawl is relatively complex, whereas non-pelagic trawls are all other trawls not meeting the pelagic trawl definition. Reg lations that define pelagic trawl gear are listed in the accompanying table. In addition, reg lations prohibit any vessel engaged in directed (cont.) pollock fishing from having 20 crabs larger than 1.5 inches carapace width onboard the vessel at any time. Crabs were chosen for the standard because they inhabit the seabed, and if caught, provide proof that a trawl has been in contact with the bottom. Vessels fishing for CDQ pollock were exempted from the non-pelagic trawl gear prohibition.

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	Amendment 57 also reduced the bycatch limits for halibut and crab due to the bottom trawl prohibition. Halibut bycatch mortality was reduced by 100 mt, and the PSC allowance for red king crabs was reduced by 3,000 animals, for *C. bai di* crabs by 50,000 animals, and for *C. opilio* crabs by 150,000 animals. For *C bai di* crabs, the limit was lowered by 20,000 in Zone 1 and by 30,000 in Zone 2.
58	Amendment 58 reduced the amount of chinook salmon allowed to be taken as bycatch in BSAI trawl fisheries. Specifically, the alternative adopted did the following (1) reduced the chinook salmon PSC bycatch limit from 48,000 to 29,000 chinook salmon over a 4-year period, (2) implemented year-round accounting of chinook salmon bycatch in the pollock fishery, beginning on Jan ary 1 of each year, (3) revised the boundaries of the Chinook Salmon Savings Areas, and (4) set new closure dates. In the event the limit is triggered before April 15, the Chinook Salmon Savings Area closes immediately. The clos re would be removed on April 16, but wo ld be reinitiated September 1 and continue through the end of the year. If the limit were reached after April 15, but before September 1, then the areas would close on September 1. If the limit were reached after September 1, the areas wo ld close immediately through the end of the year.
59	The final r le simply extended the Vessel Moratorium Program and the existing moratorium permits through December 31, 1999. The reg lation also provided that no person could apply for a new moratorium permit after the original moratorium program expiration date of December 31, 1998, unless the application was based on a moratorium qualification that was sed as a basis for obtaining a moratorium permit iss ed on or before that date.
60	Five changes were adopted and approved under these amendments: 1) a requirement that the vessel itself wo ld be a specific characteristic of the license and could not be severed (i.e., the license could not be used on any other vessel); 2) license designations for the type of gear authorized to harvest LLP groundfish as either "trawl" or "non-trawl" gear (or both); 3) rescission of the Comm nity Development Quota (CDQ) exemption and th s the req irement that CDQ vessels hold a crab or gro ndfish license; 4) the addition of a crab recency requirement which requires one landing during 1/1/96-2/7/98 in addition to the general license and area endorsement q alifications; and 5) allowance of limited processing (1 mt) for vessels <60' LOA with catcher vessel designations. The most significant addition nder these amendments was the recent participation requirement of at least one landing in the king and Tanner crab fisheries between Jan ary 1, 1996 and February 7, 1998, which applied only to the base qualifying period under the crab LLP.
61	Reg lations establish the sector allocations of pollock, define the eligible vessels and processors, define the vessel/processor co-op linkages (which vessels are eligible for which co-ops), make allocations of the pollock TAC among each of the co-ops, and define the sideboard amounts of crab and non-pollock groundfish (based on historical share) that can be harvested and processed by the (cont.) AFA operators, in both the BSAI and the GOA.
64	Specific provisions for the accounting of these directed fishing allowances and the transfer of unharvested amounts of these allowances to other vessels sing hook-and-line or pot gear wo ld be set forth in the implementing reg lations. As proposed, Amendment 64 wo ld expire December 31, 2003, based on the reasoning that three years is s fficient time to address the iss e of increasing competition in the BSAI cod fishery before reconsidering the iss e in light of other proposed impending changes, including proposed BSAI Pacific cod

Table 2.1. Amendments to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish.

Amendment	Summary
	fixed gear and species endorsements on permits iss ed under the license limitation program (see BSAI Amendment 67).
65	At the February 2000 meeting, the Council reviewed an initial draft of a proposed amendment that wo ld consider identifying additional HAPC, and two management meas res to protect HAPC from fishing effects. The first meas re considered wo ld potentially prohibit directed fishing for certain HAPC biota (corals, sponges, kelp [including rockweed] and m ssels). The second meas re wo ld establish several marine protected areas where Gorgonian corals are fo nd in abundance. Gorgonian corals have been shown to be important shelter for rockfish and other fish species, are very long lived, easily damaged by fishing gear, and slow to recover from damage. Based on p blic testimony, and inp t from its advisory committees, the Co ncil voted to split the amendment and associated analysis into two parts. Part one, which the Council took final action on in April, wo ld allow for control on the harvest of HAPC biota, based on the following problem statement. The Co ncil recognizes that some invertebrates (corals, sponges, m ssels, rockweed and kelp), which provide important habitat for fish have the potential to be developed into large-scale commercial fisheries. The Co ncil currently has little or no controls on the harvesting of these invertebrates. Adopting management meas res as a precautionary approach would allow the Council to control any commercial fishery that might develop.
67	The preferred alternative identified by the Council consists of different qualification criteria for freezer longliners, longline catcher vessels, pot catcher processors, and pot catcher vessels, as o tlined below. Additional provisions addressing the combining of catch histories, hardships, m ltiple endorsements, and bait landings will be detailed in the proposed rule upon Secretarial approval. __Vessel Type__ / __Participation Years__ / __Harvest Requirement__ Freezer longline vessels / Any one year 1996-1999 / 270 mt in any one year Longline catcher vessels / No action for vessels <60 feet LOA Vessels >60 feet: any one year 1995-1999 / 7.5 mt in any one year* Pot catcher processors / Any two years 1995-1998 / 300,000 lbs in each two years Pot catcher vessels / No action for vessels <60 feet LOA Vessels >60 feet: any two years 1995-1999 / >100,000 lbs in each two years (cont.) *Jig landings of cod (by vessels of any length) co nt towards q alification for the endorsement as if they had been made with longline gear.

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

Amendment	Summary
1	The regulation revised the original FMP only slightly, extending the measures through October 31, 1979, to coincide with a fishing season start of November 1.
2	The reg lation increased the amount of pollock held in reserve to 133,800 mt, with appropriate increases in the reserves of species taken incidental to fishing for pollock, and established the special joint reserve and stipulated the method for calculating the foreign allowance, wherein: TALFF = (0.8 OY) - domestic annual harvest - special joint venture reserve. The regulation also provided for 25% of the initial reserve to be allocated to the TALFF every two months, unless it was determined that the U.S. fleet could harvest all of the remaining reserve in the fishing year. That determination would be based on: 1) reported U.S. catch and effort by species and area; 2) projected U.S. catch and effort by species and area; and 3) projected and tilized processing capacity of U.S. fish processors. The reg lation also stipulated that if part of the scheduled 25% apportionment to the TALFFs was withheld and the U.S. fleet failed to achieve the anticipated harvest levels in the next period, the amo nt of fish previo sly withheld wo ld be made available to the TALFFs on the next bimonthly date.
3	The implementing reg lations allowed for the foreign longline fleet to take the entire Chirikof TALFF for Pacific cod (1,500 mt), and any apportioned reserves in that fishing area, in the Chirikof fishing area west of 157° W. longitude.
4	The reg lations implemented the following provisions: 1) Reduce the n mber of fishing areas in the GOA from five to three (Western, Central, Eastern), to reduce the reg latory burden on the fisheries while still preventing localized depletion. 2) Allow foreign fishing within the 3-12 mile zone between 169° and 170° W longitude to correct an omission in the FMP. 3) Remove the restriction which allowed only 25% of the total allowable level of foreign fishing (TALFF) to be taken from December 1 to May 31. The restriction was proved unnecessary since foreign trawl operations se pelagic trawls in the winter. 4) Allow foreign longlining for sablefish seaward of 400 meters (instead of 500 meters) from May 1 to September 30 in the area between 140° and 170° W longitude. Because incidental halibut catch by longliners is low during the s mmer, this change increased areas for foreign nations to catch sablefish while adequately protecting halibut stocks. 5) Permit a directed longline fishery for Pacific cod between 140° and 157° W longitude seaward of 12 miles, except during the U.S. halib t season. By enco raging longlining instead of trawling for Pacific cod, the incidental mortality of halib t wo ld be red ced. 6) Exempt foreign vessels from the requirement that fishing by all vessels of a nation in a fishing area cease when the allocation for any species has been taken. The exemption does not apply if the allocation reached is for a target species of the longliners. This was to prevent the foreign longline fishery from being closed by the foreign trawl fishery. 7) Increase the sq id optim m yield to 5,000 mt (from 2,000 mt) to allow a s fficient incidental catch for foreign nations. 8) Increase the Atka mackerel optim m yield to 26,800 mt (from 24,800 mt), based on new data indicating higher historical catches. 9) Remove the domestic one-hour tow restriction. This was deemed unnecessary protection for halibut given the separate incidental catch quota on halibut for domestic fisheries. (cont.) 10) Remove the domestic requirement for the use of off-bottom trawls from December 1- May 1. This meas re was also considered nnecessary for halib t protection.

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

	11) Require domestic permits to be renewed annually and domestic reporting (fish tickets) to be submitted within 7 days (instead of 3 days). This wo ld make the Federal and State reg lations consistent.
5	Amendment 5 created a new species category specifically for grenadiers with a separate domestic annual harvest, total allowable level of foreign fishing, and MSY/OY of 13,200 mt. The MSY/OY was based on the recorded average grenadier catch for the previous twelve years. Since the grenadier population was not considered in the development of the OY for the "Other Species" category, that category's OY remained the same. The deletion of grenadiers from the "Other Species" category was published in a separate rule on J ne 29, 1979 (44 FR 37937).
6	The regulations lowered the estimates of domestic annual harvest and reallocated the surplus to the TALFF, increasing the 1978 TALFF by 27,700 mt for all species of groundfish combined. Specifications by species are provided in the table below.
7	The reg lations implemented the following six provisions: 1) Extend the FMP through October 31, 1980; 2) Implement the provisions of the Processor Preference Amendment (PL 95-354), which wo ld establish a mechanism to periodically review and reassess the domestic annual harvest and the reserve to TALFF; 3) Increase the Pacific cod OY from 34,800 mt to 60,000 mt and increase the Atka mackerel OY from 26,800 mt to 28,700 mt; 4) Create a new category and a Gulf-wide OY of 3,750 mt for thornyhead rockfish; 5) Establish that the Co ncil will consider, on a case-by-case basis, the possibility of time and area closures to joint venture operations to allow a domestic processor to process the catch; (note: this provision was disapproved by the Secretary) 6) Create new domestic reporting req irements to facilitate better estimates of domestic annual harvesting and processing capabilities.
8	The amendment included six measures: 1. Change plan management year to Jan ary 1-December 31 and remove plan expiration date; 2. Set Gulfwide OY for sq id, thornyhead rockfish, other rockfish, and other species; 3. Establish fo r species categories: target species, other species, unallocated species, and nonspecified species; 4. Establish three regulatory districts for sablefish management- Yakutat, So theast O tside, and So theast Inside; 5. Adj st reserve release sched le to 40% in April, 40% in June, 20% in August; allow transfer of domestic allocations to foreign Total Allowable Level of Foreign Fishing (TALFF); and 6. Require biodegradable panels on sablefish pots. A seventh meas re which would have authorized the Regional Director to iss e field orders to resolve gear conflicts between foreign and domestic fishermen, was disapproved by NMFS for lack of specificity on Jan ary 11, 1982.
9	The amendment replaced six small fixed gear areas around Kodiak with a larger, single closed area to prevent gear conflicts between foreign trawlers and U.S. crab fishermen and to prevent preemption of crab grounds during the crab season by foreign trawlers. It remained closed from 2 days ahead of the Kodiak king crab season, normally September 15^{th} through February 15^{th}.

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

	The Kodiak Gear Area (a.k.a. Lechener Line) is bounded as indicated at right.
10	The amendment reduced the acceptable biological catch for POP from 29,000 mt in the Eastern Reg latory Area, to 875 mt, the OY from 14,400 mt to 875 mt, and allowed domestic and foreign fisheries 500 mt and 200 mt, respectively, for bycatch purposes. Federal waters east of 140° W were closed to all foreign fishing, and only pelagic trawling with recording net-sonde devices was allowed in waters between 140° and 147° W all year. All domestic fishing sanctuaries east of 140°W were consequently deleted as they were no longer necessary.
11	The amendment made the following changes: 1. Increased OY for pollock in the Central Area of the Gulf from 95,200 mt to 143,000 mt; 2. Divided the Yak tat district into east Yak tat (137°-140° W) and West Yak tat (140°-147° W) for sablefish management; 3. Reduced OY for sablefish from 12,300 mt to a range of 7,730-8,900 mt and apportioned it among the reg latory areas and districts; 4. Established a framework procedure for Regional Administrator to annually determine domestic (DAP) and joint venture (JVP) components of domestic annual harvest (DAH) for each species OY; 5. Eliminated the domestic non-processed (bait and personal cons mption) component of DAH, combining it within the p rely domestic component, DAP; 6. Increased flexibility of Regional Administrator to reapportion reserves and s rplus DAH to foreign fishing (TALFF); 7. A thorized Regional Administrator to impose time-area clos res on foreign nations to conserve resources; and 8. Imposed radio/telephone catch reporting requirements on domestic vessels leaving State waters to land fish outside Alaska.
12	Amendment 12 prohibited the use of pot longline gear for sablefish between 140°W longitude and Cape Addington.
13	The final reg lations contained the following two actions: 1) Adj sted the management of the pollock resource by combining the Western and Central Reg latory Areas of the Gulf of Alaska for managing the pollock fisheries only; and 2) Increased the optim m yield for the combined area from 200,000 mt to 400,000 mt.
14	The amendment made the following changes: 1. Established gear/area restrictions and OY apportionments to gear types for sablefish; 2. Established a Central Southeast Outside District with 600 mt OY for demersal shelf rockfish; (cont.) 3. Changed OYs for pollock, Pacific ocean perch, other rockfish, Atka mackerel, and other species; 4. Established catcher/processor reporting requirements; 5. Implemented framework procedure for setting and revising halibut PSC limits; 6. Implemented NMFS habitat policy; and 7. Set seasons for hook and longline and pot sablefish fisheries.

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

15	Regulations designated: (1) a m ltispecies OY as a Gulf-wide range of 116,000-800,000 mt, set a framework procedure to set target quotas for each species category, and set administrative proced res for setting PSC limits in the Gulf fishery; (2) revised recordkeeping and reporting requirements s ch that at-sea catcher/processor and mothership vessels m st s bmit weekly catch reports regardless of how long their catch was retained before landing; (3) Type I, Type II and Type III areas for special bottom trawl restrictions to protect king crab. Type I areas have very high king crab concentrations and, to promote rebuilding of the crab stocks, are closed all year to all trawling except with pelagic gear. Type II areas have lower crab concentrations and are only closed to non-pelagic gear from February 15 through J ne 15. Type III areas are adjacent to Type I and II areas and have been identified as important j venile king crab rearing or migratory areas. Type III areas become operational following a determination that a "recruitment event" has occurred. The Regional Administrator will classify the expanded Type III area as either Type I or II, depending on the information available. A "recruitment event" is defined as the appearance of female king crab in s bstantially increased n mbers (when the total n mber of females estimated for a given district eq als the n mber of females established as a threshold criterion for opening that district to commercial crab fishing). A recruitment event closure will contin e until a commercial crab fishery opens for that district or the n mber of crabs drops below the threshold level for that district. The Alitak Flats/Towers and Marmot Flats areas are Type I areas, closed to non-pelagic trawls all year. Chirikof Island and Barnabas are Type II areas, closed to non-pelagic trawls from February 15 to J ne 15. These areas encompass 80% to 90% of the known female king crab stocks. When necessary, Type III areas will be closed by reg latory amendment; the Regional Administrator will specify which of the Type III areas are closed and whether the clos re is for an entire year or only a portion of a year; (4) authority by the RD to open and close fisheries sing the best available data **(Check with FR)**.
16	The reg lations implemented the following provisions to the both the GOA and BSAI FMPs: 1) A gmented the current catcher/processor and mothership reporting requirements with at-sea transfer information, specifically, a Cargo Transfer/Off-Loading Log and Product Transfer Report; (cont.) 2) Revised the definition of prohibited species to include Pacific salmonids, Pacific herring, Pacific halib t, king crab, Tanner crab, and steelhead trout. Respecified the other three categories: a) Target species–pollock, Pacific cod, flounders, rockfish, and sablefish b) Other species–Atka mackerel, sq id, sc lpins, sharks, skates, eulachon, smelts, capelin, and octopus c) Non-specified species–those species taken incidentally in the groundfish fisheries but are not managed by the FMP. No catch records are required; 3) Required the public comment period for proposed annual specifications and prohibited species catch limits to be 30 days following the date of filing of the notice for p blic inspection with the Office of the Federal Register.

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

	In addition, several minor reg latory changes were included that apply only to the GOA FMP: 1) the term “target quotas” for groundfish was changed to “total allowable catches”; 2) general reorganization and editing; 3) the addition of a vessel safety section; and 4) removal of the reserve category for some species of groundfish.
17	Amendment 17 req ired that all vessels of the U.S. receiving EEZ-caught fish would have to hold a Federal permit and thus would have to comply with the weekly reporting requirements.
18	Amendment 18 to the groundfish FMPs authorized a comprehensive domestic fishery observer program. The 1990 and 1991 Observer Plans req ired specific levels of observer coverage which varied with size of fishing vessel and q antity of fish processed by floating and shoreside processors. These requirements were established because it was recognized that living marine resources could not be effectively managed without the types of information that were either available only or most efficiently through an observer program. The Observer Plans req ired that owners and operators of vessels and shoreside processing facilities participating in the gro ndfish fishery arrange for and pay for the cost of placing observers aboard their vessels and at their shoreside processing facilities beginning in Jan ary, 1990. Each vessel or processor required to have observer coverage is responsible for the cost of obtaining the required observers from a certified contractor. The cost averaged between $5,800 and $7,100 per observer month in 1991. Amendment 18 also: (1) established Shelikof Strait area as a management district; (2) closed areas around Kodiak Island to bottom trawl gear; (3) established for one year, interim Pacific halibut PSC limits for fixed gear (750 mt) and trawl gear (2,000 mt); (4) deleted fishing season dates from the FMPs b t retained them in reg lation; and (5) clarified authority to recommend TACs for additional or fewer target species within the “target species” category.
19	The amendment implemented rules that reg lated the practice of stripping roe (eggs) from female pollock and discarding female (cont.) and male pollock carcasses without f rther processing, and seasonally allocated the TAC of pollock. Season opening dates established were as follows for the GOA: Jan ary 1, April, J ly, and October, and for the BSAI: Jan ary 1 and J ne 1. To get at the issue of roe stripping, product recovery rate standards were established, which if exceeded would constitute a violation. The recovery rate standard established was 10 percent of the total round-weight equivalent of pollock and other pollock products onboard a vessel at any time during a fishing trip. To extrapolate round weight equivalents, the rule established product recovery rates as follows: fillet (18%), s rimi (15%), mince (17%), meal (17%), and head&g t (50%).
20	The IFQ Program was approved for the Pacific halibut (via reg latory amendment) and sablefish fixed gear fisheries in the Federal waters of the BSAI and GOA, and these fisheries have been managed under the program since 1995. The reg lations outline several key provisions of the program: initial allocation of q ota shares (QS); vessel categories; transfer provisions; use and ownership provisions; the annual process for allocating q ota shares; and the establishment of Community Development Q otas. The regulations state that legal landings of halibut or sablefish harvested with fixed gear had to occur at any time during 1988-1990 to qualify for an initial allocation of q ota share. Generally, if a vessel owner or lessee is q alified, their initial q ota share wo ld be based on their highest total landing of

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

	halibut for any 5 years of the 7-year base period 1984-1990. For sablefish, the initial quota share wo ld be based on the highest total landing of sablefish for any 5 years of the 6-year base period 1985-1990. Each person eligible to receive quota share wo ld have it assigned to one of four vessel categories: “A”-freezer vessels of any length; “B”- catcher vessels greater than 60'; “C”- catcher vessels less than or eq al to 60' for sablefish, or between 35'-60' for halib t; “D”- catcher vessels less than or eq al to 35' for halibut. Initial quota share wo ld be assigned to the vessel category that a person’s most recent fixed gear landings of groundfish or halibut were caught by that vessel.
21	The amendment contained 8 approved management meas res; those pertaining to the GOA follow: (6) Apportioned PSC limits into bycatch allowances for trawl fishery categories; (7) Allowed separate apportionment of halibut PSC to hook and line and pot gear in the GOA; (8) Allowed seasonal allocation of halibut and crab PSC; (9) Established procedures for interim TAC specifications; (10) Established fishing gear restrictions (definition of pelagic trawl, biodegradable panels & halibut excluders on pot gear); (11) Modified authorization language that allows demersal shelf rockfish in SE Alaska to be managed by the State; (12) Established definitions of overfishing. (13) Modified PSC limits and bycatch limitation zones for halibut, bairdi crab, and red king crab in the BSAI Later revisions to the amendment included addition of a vessel incentive program, which wo ld issue civil penalties (fines) to vessels that exceeded seasonal fixed bycatch rate standards for halibut and crab taken in specified target fisheries.
22	This amendment allows the NMFS Regional Director, after cons lting with the Director of the Alaska Fishery Science Center and with the Co ncil to authorize for limited experimental p rposes, the target or incidental harvest of gro ndfish that wo ld otherwise be (cont.) prohibited. The amendment also combined statistical area 68 with statistical area 65.
23	The alternative adopted and approved defined the inshore and offshore components of the fisheries. BSAI Amendment 18 was only partially approved, allocating 35% of the 1992 non-roe pollock season TAC to the inshore component, and the remaining 65% to the offshore component. The portion that was not approved wo ld have further allocated pollock through 1995: the inshore allocation would have increased to 40% in 1993 and 45% in both 1994 and 1995. A NMFS economic review indicating a large net loss to the Nation as a res lt of this action provided the rationale for disapproval by the Secretary of Commerce. The GOA inshore component was allocated 90% of the Pacific cod TAC and 100% of the pollock TAC for each fishing year. While catcher/processors from the offshore component wo ld not be able to cond ct directed pollock fishing in the GOA, they wo ld be allowed appropriate bycatch amo nts.
24	Amendments 19/24 established three FMP amendment management meas res. One pertained to the GOA FMP and its implementing regulations: (1) Delay the season opening date of the GOA groundfish trawl fisheries to Jan ary 20 of each fishing year to reduce salmon and halibut bycatch rates; (2) F rther delay the season opening date of the GOA trawl rockfish fishery to the Monday closest to J ly 1 to reduce halibut and

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

	chinook salmon bycatch rates; (3) Change directed fishing standards to f rther limit halib t bycatch associated with bottom trawl fisheries: (4) Expand the vessel incentive program to address halib t bycatch rates in all trawl fisheries.
25	Reg lations authorized by this amendment implemented the following meas res: (1) Areas are closed year-round to fishing by vessels sing trawl gear within 10 na tical miles of key Steller sea lion rookeries located in the GOA and BSAI management areas; (2) Areas are closed within 20 nm of five sea lion rookeries to directed pollock fisheries during the "A" season. These rookeries are Sea Lion Rocks, Akun Island, Akutan Island, Seguam Island, and Agligadak Island; (3) In the GOA, the specified total allowable catch for pollock in the combined western/central area is f rther divided among three pollock management districts: Area 61 (170º-159º W. longitudes), Area 62 (159º-154º W. longitudes), and Area 63 (154º-147º W. longitudes). The Shelikof Strait district was eliminated. To prevent excessive accum lation of unharvested portions in any q arterly allowance of the pollock TAC, a limit of 150 percent of the initial quarterly allowance in each pollock management district was established.
26	The reg lation simply made the provisions of Amendment 18 permanent. The Council designated Type I, Type II and Type III areas for special bottom trawl restrictions to protect king crab. Type I areas have very high king crab concentrations and, to promote reb ilding of the crab stocks, are closed all year to all trawling except with pelagic gear. Type II areas have lower crab concentrations and are only closed to non-pelagic gear from February 15 through June 15. Type III areas are adjacent to Type I and II areas and have been identified as important j venile king crab rearing or migratory areas. Type III areas become operational following a (cont.) determination that a "recruitment event" has occurred. The Regional Administrator will classify the expanded Type III area as either Type I or II, depending on the information available. A "recruitment event" is defined as the appearance of female king crab in substantially increased n mbers (when the total n mber of females estimated for a given district eq als the n mber of females established as a threshold criterion for opening that district to commercial crab fishing). A recruitment event closure will contin e ntil a commercial crab fishery opens for that district or the n mber of crabs drops below the threshold level for that district. The Alitak Flats/Towers and Marmot Flats areas are Type I areas, closed to non-pelagic trawls all year. Chirikof Island and Barnabas are Type II areas, closed to non-pelagic trawls from February 15 to J ne 15. These areas encompass 80% to 90% of the known female king crab stocks. When Type III areas are closed by reg latory amendment, the Regional Administrator will specify which of the Type III areas are closed and whether the clos re is for an entire year or only a portion of a year.
27	This amendment allows the Secretary to prom lgate reg lations establishing areas where specific types of fishing gear may be tested, to be available for use when the fishing grounds are closed to that gear type. Specific gear test areas contained in reg lations that implement the FMP, and changes to the reg lations, will be done by reg latory amendment. These gear test areas wo ld be established in order to provide fishermen the opportunity to ens re that their gear is in proper working order prior to a directed fishery opening. The test areas

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

	m st conform to the following conditions: (1) Depth and bottom type m st be suitable for testing the particular gear type; (2) Must be outside State waters; (3) Must be in areas not normally closed to fishing with that gear type; (4) Must be in areas that are not us ally fished heavily by that gear type; and (5) Must not be within a designated Steller sea lion protection area at any time of the year. The rule implementing this amendment established three trawl test areas: Dutch Harbor (54 º40' to 55º 00'N; 166º 00' to 167º 00W'), Sand Point (54 º35' to 54º 50'N; 160º 30' to 161º 00'W), and Kodiak (57 º23' to 57º 37'N; 151º 25' to 152º 02'W). The regulation further req ired that the trawl codend m st be left unzipped so as not to retain fish, that gro ndfish may not be onboard, and that the time used to test gear would not contribute to observer coverage requirements.
28	After several proposed moratoriums and revisions, the final rule required a moratorium permit for vessels within specific vessel categories that harvest groundfish and BSAI Area crab resources off Alaska. Generally, a vessel qualified for a moratorium permit if it made a legal landing of any moratorium species during the qualifying period of Jan ary 1, 1988 through February 9, 1992. In addition, a vessel that made a legal landing during the qualifying period, in either a groundfish or crab fishery, but not both, could cross over as a new vessel in the fishery in which it did not made a legal landing in the q alifying period provided: 1) it uses the same gear type in the new fishery as it used to q alify for the moratorium in the other fishery; or 2) it made a legal landing in the crossover fishery (cont.) d ring the q alifying period and it uses only the same gear type it used in that period.
29	The Salmon Donation Program authorizes the distribution of Pacific Salmon taken as bycatch in the groundfish trawl fisheries in the groundfish fisheries off Alaska to economically disadvantaged individuals through NMFS a thorized distributor selected by the Regional Director in accordance with federal reg lations implemented under the FMP.
30	The Magnuson-Stevens Act a thorized the Council and the Secretary to establish a North Pacific Fisheries Research Plan which: (1) req ires that observers be stationed on fishing vessels and at fish processing facilities, and (2) establishes a system of fees to pay for the cost of implementing the Research Plan. The Research Plan, as adopted under this amendment, contained four objectives and elements that included observer employment and contracts, observer d ties, data collection and transmission, annual determination on coverage level, inseason changes to coverage levels, establishment of an observer oversight committee, coordination between the NMFS groundfish and ADF&G shellfish observer programs, a fee assessment (up to 2% of ex-vessel value of harvested fish), and details on fee collection and contingency plans in case of f nding shortfalls.
31	Amendment 31 created a separate target category for Atka mackerel in the GOA groundfish FMP. This meant that harvest levels of Atka mackerel wo ld be based on biological stock assessments. Although the catch wo ld primarily occur in the Western Gulf, TAC's for Atka mackerel wo ld be set G lfwide to avoid waste and discarding of the small amount caught in the other subareas. The species composition of the other species category wo ld remain the same, with the exception of Atka mackerel. TACs for other species in the GOA would increase to include 5% of the TAC for Atka mackerel.

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32	The alternative chosen was projected in modeling sim lations to reb ild POP biomass to a target level (B_{MSY}) in about 14 years by harvesting POP at a fishing mortality rate lower than the optim m rate. The target biomass B_{MSY} is the total biomass of mature females that would produce the maxim m s stainable yield, on average; this n mber is currently estimated at 150,000 mt. The optimal fishing mortality rate is the rate that maximizes expected biological and economic yields over a range of plausible stock-recruitment relationships. Amendment 32 establishes the procedure for deriving the annual GOA TACs for POP. POP stocks are considered to be rebuilt when the total biomass of mature females is eq al to, or greater than, B_{MSY}. Annual TACs will be established as follows: 4) determine the current biomass, B_{MSY}, and the optimal fishing mortality rate; 5) determine the fishing mortality rate halfway between the optimal fishing mortality rate and the fishing mortality rate estimated to be s fficient to s pply navoidable bycatch of POP based on 1992 bycatch rates; 6) when the current biomass of mature females is less than B_{MSY}, adj st the resultant fishing mortality rate in (b) by the ratio of current biomass to B_{MSY}. When B_{MSY} is attained, the fishing mortality rate will be the optimal fishing mortality rate; 7) the GOA TAC of POP is the amo nt of fish resulting from the adj sted fishing mortality rate in (c); and 8) the TAC is apportioned among reg latory areas in proportion to POP biomass distribution.
33	None listed
34	The alternative adopted and approved raised the sablefish Comm nity Development Quota allocation limit for qualified applicants from 12% to 33% in order to allow total allocation of the sablefish CDQ reserve; removed the inadvertent inclusion of the CDQ program in the FMP for the GOA; and expanded the types of evidence that may be used to verify vessel leases for the halibut and sablefish individual fishing quota program. It was emphasized that this action did not change the amount of sablefish available for harvest by persons participating in the Pacific halib t and sablefish IFQ program.
35	The alternative adopted and approved provided that initial allocations of quota share that represent less than 20,000 lb of IFQ in the implementation year will be iss ed as a block, 2) quota share that represents 20,000 lb or more of IFQ in the implementation year will be " nblocked" quota share, and 3) quota share in a block cannot be separated and will have to be transferred as a block. Fishermen could own two blocks of halibut and two blocks of sablefish quota share in each area, but persons holding any amount of nblocked quota share are limited to one block of quota share per area. A sweep up provision allowed fishermen to combine small amounts into fishable amounts: halibut blocks can be combined to a s m of less than 1,000 lbs and sablefish blocks can be combined until the s m reaches 3,000 lbs. The amendment also clarified that blocked and nblocked quota share would be transferable s bject to the approval of the NMFS Regional Director and the reg lations. The Modified Block Proposal created the potential that some quota share wo ld become non-transferable because the size wo ld exceed the quota share use limits established in 50 CFR 676.22 (e) and (f); the alternative adopted solved the iss e of nontransferability by allowing the transfer of a quota share block exceeding the use limits by dividing the block into two blocks.
36	The amendment exempted some CDQ compensation QS from the block provision and allowed for a one year period of relief (one-time transfer) from the restriction against transferring CDQ compensation QS across vessel length categories. Reg lations state that if a

Table 2.2. Amendments to the Fishery Management Plan for Groundfish of the Gulf of Alaska.

	person is iss ed CDQ compensation QS for an area where the person already has reg lar QS, then their CDQ compensation QS is combined with their existing QS and is either "blocked" or " nblocked" depending on the sum total of their QS (this makes m ch of the CDQ compensation QS unidentifiable after iss ance). If a person is iss ed CDQ compensation QS for an area in which the person doesn't have other QS, the QS is left unblocked. The exemption does not include Category "A" vessels–vessels of any length authorized to process IFQ species.
37	The alternative adopted and approved authorized the processing of fish other than IFQ halibut or IFQ sablefish on board the harvesting vessel by persons authorized to harvest IFQ sablefish based on an annual allocation of IFQ assigned to vessel categories B or C. This authorization is not extended to persons authorized to harvest IFQ halib t, d e to the fact that halib t is characteristically prosecuted by local vessels that do not have onboard processing capabilities. Several modifications were also made to the reg lations implementing the IFQ program in order to accommodate the new provision. In addition, while non-IFQ species could be frozen onboard, the freezing of IFQ sablefish caught with catcher vessel q ota share on a freezer vessel would continue to be prohibited.
38	The alternative adopted and approved allowed the Co ncil to recommend a POP total allowable catch at or below the amo nt (cont.) dictated by the form la in the Rebuilding Plan. The reg lations specify that any downward adj stments would be based on biological or resource conservation concerns about the POP stock or associated with the POP fishery that are not accounted for in the Rebuilding Plan or the annual stock assessment reports. The amendment only gives the Council the alternative of recommending a lower POP TAC based on resource conservation concerns, and not socioeconomic concerns. Under Amendment 38, the form la in the Rebuilding Plan would be considered the pper bo nd limit for the POP TAC.
39	This amendment defined a forage fish species category and authorized that the management of this species category be specified in reg lations in a manner that prevents the development of a commercial directed fishery for forage fish which are a critical food so rce for many marine mammal, seabird and fish species. Forage fish species are not included in a target species category. Management meas res for the forage fish category will be specified in reg lations and may include prohibitions on directed fishing, limitations on allowable bycatch retention amounts, or limitations on the sale, barter, trade or any other commercial exchange, as well as the processing of forage fish in a commercial processing facility. The forage fish species category wo ld include all species of the following families: Osmeridae (eulachon, capelin and other smelts), Myctophidae (lanternfishes), Bathylagidae (deep-sea smelts), Ammodytidae (Pacific sand lance), Trichodontidae (Pacific sand fish), Pholidae (gunnels), Stichaeidae (pricklebacks, warbonnets, eelblennys, cockscombs and shannys), Gonostomatidae (bristlemouths, lightfishes, and anglemo ths), and the Order Euphausiacea (krill).

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40	The provisions of BSAI Amendment 18 became the basis of Amendment 38, and the provisions of GOA Amendment 23 became the basis for Amendment 40. Th s, in the BSAI the apportionments of pollock in each s barea and season would be allocated 35% for processing by the inshore sector and 65% by the offshore sector. In the GOA, the apportionment of pollock would be allocated entirely for processing by the inshore sector, and the apportionment of Pacific cod wo ld be allocated 90% for the inshore sector, 10% for the offshore sector.
41	The final rule limited access to the commercial groundfish fisheries in the BSAI and GOA and commercial crab fisheries in the BSAI, except for demersal shelf rockfish east of 140° W. longitude and sablefish managed under the IFQ program. The rule provided for the following: issu ance of a single type of gro ndfish license; LLP is not applicable to waters of the State of Alaska; licenses would be iss ed to current owners (as of 6/17/95) of qualified vessels; licenses wo ld be designated as catcher vessel or catcher/processor and with one of three vessel length classes; the crab and groundfish base qualifying period is 1/1/88-6/27/92 and the groundfish area (cont.) endorsement qualifying period is 1/1/92-6/17/95; endorsement areas are defined as Aleutian Islands, Bering Sea,Western Gulf Central Gulf, and Southeast Outside, or state waters shoreward of those endorsement areas; landing requirements for general license and area endorsement q alifications by vessel class; and additional provisions addressing crossover vessels, transfers, and vessel linkages. The rule also included in CDQ allocations 7.5% of the TAC of gro ndfish and crab in the BSAI that was not originally included in the CDQ programs for pollock, halibut, and sablefish.
42	Amendment 42 and a reg latory amendment to the IFQ Program for fixed gear Pacific halibut and sablefish fisheries in and off Alaska allowed QS initially assigned to a larger vessel category to be used on smaller vessels, while contin ing to prohibit the use of QS or its associated IFQ assigned to smaller vessel categories on larger vessels. QS will contin e to be assigned to vessel categories by existing criteria and will retain original vessel category assignments. However, halib t and sablefish QS and their associated IFQ assigned to vessel Category B can be used on vessels of any size and halibut QS assigned to vessel Category C likewise can be used on vessels of categories C and D. The reg lations contin e to prohibit the use of QS and IFQ on vessels larger than the maxim m length on average (LOA) of the category to which the QS was originally assigned. It does not apply to halib t in IFQ reg latory areas 2C or to sablefish east of 140 °. W. long. Halibut QS assigned to vessel Category B in IFQ reg latory areas 2C and sablefish QS east of 140°W. long. are prohibited from se on vessels less than or equal to 60 ft (18.3 m) LOA except in QS blocks equivalent to less than 5,000 lb (2.3 mt) based on the 1996 Total Allowable Catch (TAC).
43	Amendment 43 wo ld increase the sweep- p levels for small QS blocks for Pacific halibut and sablefish from the current 1,000 lb (0.45 mt) maxim m for Pacific halibut and 3,000 lb (1.4 mt) maxim m for sablefish to a 3,000 lb (1.4 mt) maxim m and a 5,000 lb (2.3 mt) maxim m, respectively. Two other changes were recommended to accompany these increases: 9) The base year TAC for determining the pounds wo ld be the 1996, rather than 1994, TAC which was sed for the first sweep- p levels; 10) Once QS levels are established for the appropriate reg latory areas based on the 1996 TAC, those QS levels would be fixed and codified. This wo ld eliminate any conf sion as to the appropriate sweep- p level in po nds, which wo ld fluctuate with changes in the annual TAC.

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44	Amendment 44 provided for more conservative definitions of ABC and OFL. The fishing mortality rate used to calculate ABC was capped by the overfishing rate. The maxim m allowable fishing rates were prescribed through a set of 6 tiers which are listed in descending order of preference, corresponding to descending information availability. These tiers are shown in the adjacent table. Harvest rates sed to establish ABCs are reduced at low stock size levels, thereby allowing rebuilding of depleted stocks. If the biomass of any stock falls below Bmsy or $B_{40\%}$ (the long-term average biomass that wo ld be expected under average recruitment and $F=F_{40\%}$), the fishing mortality is red ced relative to stock status. This serves as an implicit reb ilding plan sho ld a stock fall below a reasonable abundance level.
45	Amendment 45 authorized seasonal allowances of pollock total allowable catch (TAC) to be specified for the combined (cont.) Western/Central (W/C) Reg latory Areas of the Gulf of Alaska. The third and fourth quarterly allowances of pollock TAC were combined in the W/C areas into a single seasonal allowance that wo ld be available on September 1. Therefore, the pollock TACs were divided into three seasonal allowances: 25% of TAC available on Jan ary 1, 25% of TAC available on June 1, and 50% of TAC available on September 1. This action complemented a reg latory amendment to delay the start of the Bering Sea pollock "B" season from A gust 15 to September 1 starting in 1996.
46	Amendment 46 removed black and blue rockfishes from the FMP. No additional reg lations were prom lgated.
47	Withdrawn
48	This amendment was not formally submitted to the Secretary and no reg lations have been implemented.
49	Amendment 49 req ires all vessels fishing for gro ndfish in the Gulf of Alaska to retain all pollock and Pacific cod beginning January 1, 1998, and all shallow water flatfish beginning Jan ary 1, 2003. It established a 15-percent minim m tilization standard for all at-sea processors.
50	This action authorized the voluntary donation of Pacific halibut taken as bycatch in specified groundfish trawl fisheries off Alaska to economically disadvantaged individuals. Under the prohibited species donation program, NMFS expanded the existing salmon donation program to also a thorize distrib tion by tax-exempt organizations through a NMFS-authorized distributor. The program is limited to dead halibut by trawl catcher vessels and delivered to shoreside processors.
51	As adopted by the Council in June 1998, this amendment reestablishes, without change, the current inshore/offshore allocation regime in the GOA through December 31, 2001. The amendment maintains the current allocation: 100% of the pollock TAC to the inshore component, and 90% of the Pacific cod TAC to the inshore component and 10% to the offshore component.
52	Under a vessel registration program, NMFS wo ld establish criteria to determine which fisheries wo ld req ire registration. Based on these criteria, NMFS wo ld create a roster of "registration fisheries" that wo ld be anno nced at the beginning of each year and supplemented as necessary on an inseason basis throughout the year. Criteria for establishing a registration req irement for a fishery could include:

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	1) the size of the TAC amo nt or PSC limit specified for the fishery relative to the degree of interest in that fishery, (2) a fishery for which the TAC or PSC limit was exceeded by a significant amount in the previous year and the current year's quota and expected effort are similar, (3) a fishery for which the above two criteria may not apply but an expanded interest has developed inseason, and (4) a "mop- p" fishery. Vessel operators wo ld be required to register with NMFS a certain n mber of days before beginning directed fishing in a (cont.) registration fishery and penalties wo ld be established for non-compliance.
53	Reg lations have not yet been drafted. They will req ire f ll retention of DSR in the fixed gear fisheries in GOA Reg latory Area 650: (1) eliminate the maxim m retainable bycatch (MRB) limit for DSR; (2) req ire that all DSR caught by Federally-permitted vessels using fixed gear in the Southeast Outside District be retained, landed, weighed and reported; (3) limit the amount of DSR that may be sold to an amount that is no more than 10 percent of other retained catch; and (4) fishermen may do one or all of the following with amounts of DSR that are in excess of the amount that may be sold: 1. voluntarily s rrender to the State of Alaska amounts of DSR that are in excess of the amount that may be sold; 2. retain amounts of DSR that are in excess of the amount that may be sold for personal use; or 3. donate amounts of DSR that are in excess of the amount that may be sold to a state-recognized charity that provides meals for the homeless, the needy, the sick or infirm, or the elderly.
54	Regulations have not yet been drafted.
55	The alternative adopted and approved defined EFH as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat". EFH was described in text, tables, and maps. Habitat areas of particular concern were identified as living s bstrates in shallow and deep waters, and freshwater habitats sed by anadromo s fish.
56	Amendment 56 revised the ABC and overfishing definitions set under Amendment 44 to be more precautionary. Like Amendment 44, the maxim m allowable rates are prescribed through a set of six tiers which are listed below in descending order of preference, corresponding to descending order of information availability. For most tiers, ABC is based on $F_{40\%}$, which is the fishing mortality rate associated with an eq ilibrium level of spawning per recruit (SPR) eq al to *40%* of the eq ilibrium level of spawning per recruit in the absence of any fishing. To f rther minimize the possibility of catches jeopardizing a stock's long term prod ctivity, there is a b ffer established between ABC and OFL. Amendment 56 modified the OFL definition from $F_{30\%}$ to $F_{35\%}$ for stocks having tiers 2-4 information.
57	The final r le simply extended the Vessel Moratorium Program and the existing moratorium permits through December 31, 1999. The reg lation also provided that no person could apply for a new moratorium permit after the original moratorium program expiration date of

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	December 31, 1998, unless the application was based on a moratorium qualification that was sed as a basis for obtaining a moratorium permit iss ed on or before that date.
58	Five changes were adopted and approved under these amendments: 1) a requirement that the vessel itself wo ld be a specific characteristic of the license and could not be severed (i.e., the license could not be used on any other vessel); 2) license (cont.) designations for the type of gear authorized to harvest LLP groundfish as either "trawl" or "non-trawl" gear (or both); 3) recision of the Comm nity Development Quota (CDQ) exemption and th s the req irement that CDQ vessels hold a crab or gro ndfish license; 4) the addition of a crab recency requirement which requires one landing during 1/1/96-2/7/98 in addition to the general license and area endorsement q alifications; and 5) allowance of limited processing (1 mt) for vessels <60' LOA with catcher vessel designations. The most significant addition nder these amendments was the recent participation req irement of at least one landing in the king and Tanner crab fisheries between Jan ary 1, 1996 and February 7, 1998, which applied only to the base qualifying period under the crab LLP.
59	Amendment 59 would prohibit fishing in an area containing important fish habitat, totaling 3.1 sq are na tical miles, off Cape Edgecumbe near Sitka, Alaska. This clos re wo ld apply to commercial, sport, charter, bycatch and s bsistence fisheries for all species of bottomfish and halibut, and boat anchoring to prevent habitat degradation, and to create a groundfish ref ge. The area is defined by a sq are, with lines connecting the following points in a clockwise manner: 56º55.5' N L following, 135º54' N L clockwise 56º57' N Latitude.,135º54' N Longit de; 56º57' N Latitude,135º57' N Longitude; 56º55.5' N Latitude, 135º57' N Longitude.
61	Reg lations establish the sector allocations of pollock, define the eligible vessels and processors, define the vessel/processor co-op linkages (which vessels are eligible for which co-ops), make allocations of the pollock TAC among each of the co-ops, and define the sideboard amounts of crab and non-pollock groundfish (based on historical share) that can be harvested and processed by the AFA operators, in both the BSAI and the GOA. Additionally, the reg lations extend the GOA inshore/offshore allocations nder Amendment 51 through 2004.
65	At the April 2000 meeting, the Council took final action on Harvest Control meas res of HAPC Part 1. The Council adopted alternative 2 of the analysis which will add corals and sponges to the prohibited species category. This action will essentially split prohibited species into two types: the first type will contin e to allow no retention for halib t, salmon, and crab species, and the second type wo ld include only corals and sponges as prohibited species whose management wo ld be specified in the reg lations. The HAPC prohibited species will allow retention, b t will prohibit the sale, barter, trade or processing of corals and sponges. Kelp (including rockweed), and m ssels wo ld not be subject to any management actions at this time. This action will apply to both the Bering Sea and Gulf of Alaska gro ndfish fisheries in the EEZ; other fisheries may be considered for HAPC biota protection in the f t re. The Co ncil will relay concerns to the Alaska Board of Fisheries regarding protection of HAPC biota in state waters.

Table 2.3. Species categories listed in the BSAI FMP.

Target	Prohibited	Other	Forage fish	Nonspecified	
Finfishes					
Pollock	Pacific halibut	Sculpins	Osmeridae (eulachon, capelin, and other smelts)	Eelpouts (Zoarcidae)	
Pacific cod	Pacific herring	Sharks	Myctophidae (lanternfishes)	Poachers (Agonidae) and alligator fish	
Atka mackerel	Pacific salmon	Skates	Bathylagidae (deep-sea smelts)	Snailfish, lumpfishes, lumps ckers (Cyclopteridae)	
Sablefish	Steelhead		Ammodytidae (Pacific sand lance)	Rattails (Macrounidae)	
Pacific ocean perch	Other rockfishes		Trichodontidae (Pacific sand fish)	Ronquils, searchers (Bathymasteridae)	
Capelin			Pholidae (gunnels)	Lancetfish (Alepisanvidae)	
Yellowfin sole			Stichaeidae (pricklebacks, warbonnets, eelblennys, cockscombs, and shannys)	Prowfish	
T rbots			Gonostomatidae (bristlemo ths, lightfishes, and anglemouths)	Hagfish	
Other flatfishes				Lampreys	
Invertebrates					
King crab	Sq ids	Octop s	Krill (Eupha siacea)	Anemones	Jellyfish
Tanner crab				Starfishes	T nicates
				Egg cases	Sea cucumber
				Sea mo se	Sea pen
				Sea sl g	Isopods
				Sea potato	Barnacles
				Sand dollar	Polychaetes
				Hermit crab	Crinoids
				Mussels	Crab - nidentified
				Sea urchins	Sponge - unidentified

Table 2.4. Final TAC specifications for 1999 and 2000 BSAI groundfish fisheries.

Species	Area	2000 Biomass	2000 OFL	2000 ABC	2000 TAC	999 TAC	999 Catch
Pollock	EBS	7,700,000	1,680,000	1,139,000	1,139,000	992,000	884,133
	A+B seasons					40%	
	C+D seasons					60%	
	AI	106,000	31,700	23,800	2,000	2,000	1,003
	Bogoslof	475,000	30,400	22,300	1,000	1,000	21
Pacific cod	BS/AI	1,300,000	240,000	193,000	193,000	177,000	160,084
Yellowfin sole	BS/AI	2,820,000	226,000	191,000	123,262	207,980	67,392
Greenland turbot	BS/AI	233,000	42,000	9,300	9,300	9,000	
	BS			67%	67%	67%	5,315
	AI			33%	33%	33%	461
Arrowtooth	BS/AI	785,000	160,000	131,000	131,000	134,354	10,679
Rock sole	BS/AI	2,070,000	273,000	230,000	134,760	120,000	40,362
Flathead sole	BS/AI	611,000	90,000	73,500	52,652	77,300	17,777
Other flatfish	BS/AI	829,000	141,000	117,000	83,813	154,000	15,184
Sablefish	EBS	18,000	1,750	1,470	1,470	1,340	628
	AI	33,000	3,090	2,430	2,430	1,380	529
POP complex							
True POP	EBS	47,700	3,100	2,600	2,600	1,400	376
Other POP	EBS	8,200	259	194	194	267	217
True POP	AI	192,000	14,400	12,300	12,300	13,500	
	Eastern			3,120	3,120	3,430	2,416
	Central			3,510	3,510	3,850	2,815
	Weste n			5,670	5,670	6,220	6,545
Sharp/Northern	AI	115,000	6,870	5,150	5,150	4,230	5,181
Short/Rougheye	AI	41,500	1,180	885	885	965	474
Other rockfish	EBS	7,030	492	369	369	369	137
	AI	13,000	913	685	685	685	632
Atka mackerel	AI	565,000	119,000	70,800	70,800	66,400	
	Eastern			16,400	16,400	17,000	15,893
	Central			24,700	24,700	22,400	21,443
	Weste n			29,700	29,700	27,000	15,626
Squid	BS/AI	n/a	2,620	1,970	1,970	1,970	413
Other species	BS/AI	611,000	71,500	31,360	31,360	32,860	18,396
BS/AI TOTAL		**8,580,430**	**3,203,874**	**2,260,1 3**	**2,000,000**	**2,000,000**	**,223,618**

EBS = eastern Bering Sea
BS/AI = Bering Sea & Aleutians
BS = Bering Sea
AI = Aleutian Islands

OFL = Overfishing Level
ABC = Acceptable Biological Level
TAC = Total Allowable Catch

* (A/B):(C/D) season split for CDQ is 45%:55%
** AI pollock TAC is for bycatch only

Table 2.5. Species categories listed in the GOA FMP. A fifth category exists for foreign prohibited species, consisting of all of the listed species and other nallocated species.

Target	Prohibited Domestic	Other	Forage fish
Pollock	Pacific halibut	Squid	Osmeridae family (eulachon, capelin, and other smelts)
Pacific cod	Pacific herring	Sculpins	Myctophidae family (lanternfishes)
Atka mackerel	Pacific salmon	Sharks	Bathylagidae family (deep-sea smelts)
Rockfish	Steelhead trout	Skates	Ammodytidae family (Pacific sand lance)
- Other slope	King crab	Octopus	Trichodontidae family (Pacific sand fish)
- Demersal shelf	Tanner crab		Pholidae family (gunnels)
- Pelagic shelf			Stichaeidae family (pricklebacks, warbonnets, eelblennys, cockscombs and shannys)
- Northern rockfish			Gonostomatidae family (bristlemo ths, lightfishes, and anglemo ths)
- Thornyhead rockfish			Order Eupha siacea (krill)
- Shortraker/rougheye			
- Pacific ocean perch			
Flatfish			
- Deep water			
- Shallow water			
- Flathead sole			
- Rex sole			
- Arrowtooth			
Sablefish			

Table 2.6. Final TAC specifications for 1999 and 2000 GOA groundfish fisheries.

Species	Area	2000 Biomass	2000 OFL	2000 ABC	2000 TAC	999 TAC	999 Catch
Pollock	W (61)			38,350	38,350	23,120	23,387
	C (62)	588,000	130,760	22,820	22,820	38,840	38,135
	C (63)		(EYAK/SEO)	30,030	30,030	30,520	30,095
	WYAK	28,710		2,340	2,340	2,110	1,759
	EYAK/SEO		8,610	6,460	6,460	6,330	4
	Total	616,710	139,370	100,000	100,000	100,920	93,380
Pacific Cod	W			27,500	20,625	23,630	23,154
	C			43,550	35,165	42,935	44,559
	E			5,350	4,010	1,270	857
	Total	567,000	102,000	76,400	59,800	67,835	68,570
Flatfish, Deep Water	W			280	280	240	22
	C			2,710	2,710	2,740	1,865
	WYAK			1,240	1,240	1,720	389
	EYAK/SEO			1,070	1,070	1,350	9
	Total	74,370	6,980	5,300	5,300	6,050	2,285
Rex Sole	W			1,230	1,230	1,190	603
	C			5,660	5,660	5,490	2,391
	WYAK			1,540	1,540	850	41
	EYAK/SEO			1,010	1,010	1,620	22
	Total	74,600	12,300	9,440	9,440	9,150	3,057
Shallow water flatfish	W			19,510	4,500	4,500	252
	C			16,400	12,950	12,950	2,282
	WYAK			790	790	250	6
	EYAK/SEO			1,160	1,160	1,070	5
	Total	299,100	45,330	37,860	19,400	18,770	2,545
Flathead Sole	W			8,490	2,000	2,000	184
	C			15,720	5,000	5,000	680
	WYAK			1,440	1,440	1,270	16
	EYAK/SEO			620	620	770	11
	Total	207,520	34,210	26,270	9,060	9,040	891
Arrowtooth	W			16,160	5,000	5,000	3,656
	C			97,710	25,000	25,000	11,787
	WYAK			23,770	2,500	2,500	383
	EYAK/SEO			7,720	2,500	2,500	236
	Total	1,571,670	173,910	145,360	35,000	35,000	16,062
Sablefish	W			1,840	1,840	1,820	1,487
	C			5,730	5,730	5,590	5,828
	E/WYAK			5,760	2,207	2,090	1,704
	EYAK/SEO				3,553	3,200	3,080
	Total	169,000	16,660	13,300	13,300	12,700	12,099
Other slope rockfish	W			20	20	20	40
	C			740	740	650	615
	WYAK			250	250	470	122
	EYAK/SEO			3,890	3,890	4,130	12
	Total	102,510	6,390	4,900	4,900	5,270	789
Northern rockfish	W			630	630	840	573
	C			4,490	4,490	4,150	4,825
	E			0	0	0	0
	Total	85,360	7,510	5,120	5,120	4,990	5,398
Pacific Ocean Perch	W		1,460	1,240	1,240	1,850	1,935
	C		10,930	9,240	9,240	6,760	7,914
	WYAK			840	840	820	627
	EYAK/SEO		3,000	1,700	1,700	3,160	0
	Total	200,310	15,390	13,020	13,020	12,590	10,476

Table 2.6. cont.

Species	Area	2000 Biomass	2000 OFL	2000 ABC	2000 TAC	999 TAC	999 Catch
Shortraker/Rougheye	W			210	210	160	194
	C			930	930	970	577
	E			590	590	460	531
	Total	70,880	2,510	1,730	1,730	1,590	1,302
Pelagic shelf rockfish	W			550	550	530	130
	C			4,080	4,080	3,370	3,835
	WYAK			580	580	740	672
	EYAK/SEO			770	770	240	20
	Total	66,440	9,040	5,980	5,980	4,880	4,657
Demersal shelf rockfish		15,100	420	340	340	560	262
Atka Mackerel	Gulfwide	unknown	6,200	600	600	600	262
Thornyhead	W			430	430	260	282
	C			990	990	700	582
	E			940	940	1,030	410
	Total	52,950	2,820	2,360	2,360	1,990	1,274
Other Species	G lfwide	NA	NA	NA	14,270	14,600	3,735
GULF OF ALASKA	**TOTAL**	4,173,520	581,040	431,410	299,650	306,535	227,044

WYAK = Western Yak tat — OFL = Overfishing Level — 1999 Catch as of 11/6/99
EYAK = Eastern Yakutat — ABC = Acceptable Biological Catch
SEO = Southeast O tside — TAC = Total Allowable Catch

Table 2.7. Su rvey CVs by species/species groups. (EBS = eastern Bering Sea, AI = Aleutian Islands.)

Species or species group	FMP/Area	Survey type	Survey CV	Assessment method	ABC/OFL tier
Alaska Plaice	BSAI	Bottom trawl	12%	AD model builder	3a
Arrowtooth flounder	BSAI	Bottom trawl	12%	Stock synthesis	3a
Arrowtooth flounder	GOA	Bottom trawl	9%	AD model builder	3a
Atka mackerel	BSAI	Bottom trawl	38%	Stock synthesis	3a
Deepwater flatfish	GOA	Bottom trawl	9%	S rvey index	--
Flathead sole	GOA	Bottom trawl	12%	AD model builder	5
Flathead sole	BSAI	Bottom trawl	11%	Stock synthesis	3a
Greenland turbot	BSAI	Bottom trawl	31%	Stock synthesis	3a
Northern rockfish	GOA	Bottom trawl	41%	Survey index	4
Octopus	GOA	Bottom trawl	48%	Survey index	5
Other red rockfish	EBS	Bottom trawl	33%	Survey index	5
Other rockfish	AI	Bottom trawl	18%	Survey index	5
Other rockfish	EBS	Bottom trawl	15%	Survey index	5
Other slope rockfish	GOA	Bottom trawl	21%	Survey index	--
Other flatfish	BSAI	Bottom trawl	26%	Survey index	3a
Pacific ocean perch	BSAI	Bottom trawl	35%	Stock synthesis	3b
Pacific ocean perch	GOA	Bottom trawl	30%	Stock synthesis	3b
Pacific cod	BSAI	Bottom trawl	9%	Stock synthesis	3b
Pacific cod	GOA	Bottom trawl	15%	Stock synthesis	3a
Pacific ocean perch	BSAI	Bottom trawl	21%	Stock synthesis	3b
Pelagic rockfish	GOA	Bottom trawl	39%	S rvey index	4
Pollock	AI	Bottom trawl	19%	Survey index	5
Pollock	GOA	Bottom trawl/EIT	19%	AD model builder	3b
Pollock	Southeast	Bottom trawl	33%	Survey index	--
Pollock	EBS	Bottom trawl/EIT	23%	AD model builder	1a
Rex sole	GOA	Bottom trawl	9%	Survey index	5
Rock sole	BSAI	Bottom trawl	8%	AD model builder	3a
Sablefish	GOA	Longline	10%	AD model builder	3b
Sculpins	GOA	Bottom trawl	15%	Survey index	5
Shallow flatfish	GOA	Bottom trawl	15%	Survey index	5
Sharks	GOA	Bottom trawl	26%	Survey index	5
Sharpchin/Northern	BSAI	Bottom trawl	28%	Survey index	5
Shortraker/Rougheye	GOA	Bottom trawl	15%	Survey index	--
Shortraker/Rougheye	BSAI	Bottom trawl	32%	Survey index	5
Shortspine thornyhead	GOA	Bottom trawl	13%	Survey index	3a
Skates	GOA	Bottom trawl	13%	S rvey index	5
Smelts	GOA	Bottom trawl	14%	Survey index	5
Squid	GOA	Bottom trawl	17%	Survey index	6
Yellowfin sole	BSAI	Bottom trawl	10%	AD model builder	3a

Table 2.8. Maxim m retainable incidental catch amounts (expressed as percentages) for the BSAI. (na = not applicable)

Target species	**Incidental catch species**														
	Pollock	**Pacific cod**	**Atka mackerel**	**Arrow-tooth**	**Yellowfi n sole**	**Other flatfish**	**Rock-sole**	**Flathead Sole**	**Greenland turbot**	**Sable-fish**	**Raker/ rougheye (AI)**	**Aggregated rockfish**	**Squid**	**Forage fish**	**Other species**
Pollock	na	20	20	35	20	20	20	20	1	1	2	5	20	2	20
Pacific cod	20	na	20	35	20	20	20	20	1	1	2	5	20	2	20
Atka mackerel	20	20	na	35	20	20	20	20	1	1	2	5	20	2	20
Arrowtooth	0	0	0	na	0	0	0	0	0	0	0	0	0	2	0
Yellowfin sole	20	20	20	35	na	35	35	35	1	1	2	5	20	2	20
Other flatfish	20	20	20	35	35	na	35	35	1	1	2	5	20	2	20
Rocksole	20	20	20	35	35	35	na	35	1	1	2	5	20	2	20
Flathead sole	20	20	20	35	35	35	35	na	35	15	7	15	20	2	20
Greenland turbot	20	20	20	35	20	20	20	20	na	15	7	15	20	2	20
Sablefish	20	20	20	35	20	20	20	20	35	na	7	15	20	2	20
Other rockfish	20	20	20	35	20	20	20	20	35	15	7	15	20	2	20
Other red rockfish BS	20	20	20	35	20	20	20	20	35	15	na	15	20	2	20
Pacific Ocean perch	20	20	20	35	20	20	20	20	35	15	7	15	20	2	20
Sharpchin/Northern-AI	20	20	20	35	20	20	20	20	35	15	7	15	20	2	20
Shortraker/Rougheye-AI	20	20	20	35	20	20	20	20	35	15	na	15	20	2	20
Squid	20	20	20	35	20	20	20	20	1	1	2	5	na	2	20
Other species	20	20	20	35	20	20	20	20	1	1	2	5	20	2	na
Aggregated amount	20	20	20	35	20	20	20	20	1	1	2	5	20	2	20

Table 2.9. Maxim m retainable incidental catch amounts (expressed as percentages) for the GOA. (na = not applicable)

Target species	Incidental catch species													
	Pollock	**Pacific cod**	**Deep flatfish**	**Rex sole**	**Flathead sole**	**Shallo w flatfish**	**Arrow-tooth**	**Sable-fish**	**Aggregated rockfish**	**Raker/ rougheye, eastern GOA**	**Demersal shelf rockfish/ SEO**	**Atka mackerel**	**Aggregated forage fish**	**Other species**
Pollock	na	20	20	20	20	20	35	1	5	(7)	10	20	2	20
Pacific cod	20	na	20	20	20	20	35	1	5	(7)	10	20	2	20
Deep flatfish	20	20	na	20	20	20	35	7	15	7	1	20	2	20
Rex sole	20	20	20	na	20	20	35	7	15	7	1	20	2	20
Flathead sole	20	20	20	20	na	20	35	7	15	7	1	20	2	20
Shallow flatfish	20	20	20	20	20	na	35	1	5	(7)	10	20	2	20
Arrowtooth	5	5	0	0	0	0	na	0	0	0	0	0	2	0
Sablefish	20	20	20	20	20	20	35		15	7	1	20	2	20
Pacific ocean perch	20	20	20	20	20	20	35	7	15	7	1	20	2	20
Shortraker/rougheye	20	20	20	20	20	20	35	7	15	na	1	20	2	20
Other rockfish	20	20	20	20	20	20	35	7	15	7	1	20	2	20
Northern rockfish	20	20	20	20	20	20	35	7	15	7	1	20	2	20
Pelagic rockfish	20	20	20	20	20	20	35	7	15	7	1	20	2	20
DSR-SEO	20	20	20	20	20	20	35	7	15	7	na	20	2	20
Thornyhead	20	20	20	20	20	20	35	7	15	7	1	20	2	20
Atka mackerel	20	20	20	20	20	20	35	1	5	(7)	10	na	2	20
Other species	20	20	20	20	20	20	35	1	5	(7)	10	20	2	na
Aggregated amount of non-groundfish species	20	20	20	20	20	20	35	1	5	(7)	10	20	2	20

Table 2.10. Reg latory allocations of 2000 TAC specifications in the BSAI.

Species	Gear	Season	Other Allocations and Reserves
Pollock[2]	None	Season dates (outside SCA) %TAC A season: 1/20 to 4/1 30% B season: 4/1 to 6/10 10% C season: 6/10 to 8/20 30% D season: 8/20 to Nov 1 30%	CDQ 10% Incidental bycatch Of the remaining TAC: Inshore Mothership 10% Catcher/proc. 5% 40%
Pacific cod	Jig 2% Hook-&-line/pot 51% Trawl 47%	1/1 to 4/30--First allowance [71%][3] 5/1 to 8/31--Second allowance [0%] 9/1 to 12/31--Third allowance [29%] (hook-and-line/pot allocation only) Proportion recommended annually by Council	Trawl allocation is split 50% Catcher vessels 50% Catcher/processors 50% 7.5% of TAC to CDQ reserve
Sablefish	Bering Sea Hook&line/pot[4] 50% Trawl 50% Ale tian Islands Hook&line/pot[4] 75% Trawl 25%	1/20 to 12/31--for trawl gear 1/1 to 12/31--for non-trawl gear4	20% of hook-&-line/pot allocation to CDQ reserve 7.5% of trawl allocation to CDQ reserve
Atka mackerel	Jig gear - up to 2% of eastern AI and Bering Sea TAC. Amount recommended annually by Council	Season dates Trawl A season: 1/20 to 4/15 Trawl B season: 9/1 to 11/1 1/1 to 12/31--for non-trawl gear	Trawl allocation split A season 50% B season 50% 7.5% of TAC to CDQ reserve
Greenland turbot	None	5/1 to 12/31	7.5% of TAC to CDQ reserve
All other Species	None	1/20 to 12/31--for trawl gear 1/1 to 12/31--for non-trawl gear	7.5% of TAC to CDQ reserve

Notes:

1 = Except for pollock and sablefish, 25 % of each initial TAC (TAC min s reserves) is made available Jan ary 1 under interim specifications. The remainder is made available when the final specifications supercede the interim specifications, generally in February or March.

2 = AFA Allocations.

A. Pollock CDQ - effective January 1, 1999, 10 percent of the total allowable catch of pollock in the Bering Sea and Aleutian Islands Management Area shall be allocated as a directed fishing allowance to the western Alaska CDQ program .

B. Inshore/Offshore. - effective January 1, 1999, the remainder of the pollock total allowable catch in the Bering Sea and Ale tian Islands Management Area, after the subtraction of the allocation under subsection (a) and the subtraction of allowances for the incidental catch of pollock by vessels harvesting other groundfish species (including under the western Alaska community development quota program) shall be allocated as directed fishing allowances as follows.

(1) 50% to catcher vessels for processing by the inshore component;

(2) 40% to catcher/processors and catcher vessels for processing by catcher/processors in the offshore component; and

(3) 10% to catcher vessels for processing by motherships in the offshore component.

3 = Percentages in brackets [xx%] are 2000 examples; these percentages may vary from year to year.

4 = None of the hook-&-line/pot allocation of sablefish is made available under the interim specifications. Thus, hook-&-line/pot sablefish may not open until the final specifications are filed.

Table 2.11. Reg latory allocations of 2000 TAC specifications in the GOA.

Species	Gear	Season	Other Allocations and Reserves
Pollock	None	Western and central GOA: 1/20 to 3/1--1st allowance 30% 3/15 to 5/31--2nd allowance 15% 8/20 to 9/15--3rd allowance... 30% 10/1 to 11/1--4th allowance.. 25% Eastern GOA: 100% 1/1 to 12/31	Inshore component 100% Offshore (bycatch) 20% of TAC to initial reserve
Sablefish	Eastern Area[1] Trawl gear 5% --for trawl gear Hook-&-line gear 95% --for non-trawl gear Central and Western Area Trawl gear 20% Hook-&-line gear 80%	1/20 to 12/31 § 679.23(c) 1/1 to 12/31 § 679.23(a)	None
Pacific cod	--Trawl gear --Non-trawl gear	1/20 to 12/31 1/1 to 12/31	Inshore component 90% Offshore component 10% 20% of TAC to initial reserve
Flatfish and "other" species[2]	--Trawl gear --Non-trawl gear	1/20 to 12/31 1/1 to 12/31	20% of TAC to initial reserve
Rockfish[3]	--Trawl gear --Non-trawl gear	7/1 to 12/31 1/1 to 12/31	None
All other species	--Trawl gear --Non-trawl gear	1/20 to 12/31) 1/1 to 12/31	None

Notes: 1 = The trawl allocation of sablefish in the eastern regulatory area may be sed only for bycatch p rposes.
2 = Flatfish includes Dover sole, deep sea sole, sand sole, Alaska plaice, English sole, starry flounder, butter sole, and rex sole.
3 = Rockfish are any species of Sebastes or Sebastolobus except the black rockfish and the blue rockfish.

Table 2.12a. Steller sea lion protection areas in the Bering Sea s barea **.**

Bering Sea Subarea Management Area/Island/Site	Boundaries		ESA Listed Rookery (R) or Haulout (H)[2]	Notes	No transit zone (nm)[2]	Critical habitat area (nm)[2]	Directed fishing for pollock prohibited within. . .(nm)		Trawling prohibited within (nm)	
	Latitude (N)	Longitude (W)					Nov. 1 - Jun. 1	Jun. 1 - Nov.	Jan. 1 - Apr. 15	Year-round
St. Lawrence I./S Punuk I.	63 04.00 N	168 51.00 W	H			20				
Hall I.	60 37.00 N	173 00.00 W	H			20				
St Paul I./Sea Lion Rock	57 06.00 N	170 17.50 W	H			20				
St Paul I./NE Pt.	57 15.00 N	170 06.50 W	H			20				
Walrus I.	57 11.00 N	169 56.00 W	R	Whole Island	3	20	20	20		10
St. George I./Dalnoi Pt.	56 36.00 N	169 46.00 W	H			20				
St. George I./S Rookery	56 33.50 N	169 40.00 W	H			20				
Cape Newenham	58 39.00 N	162 10.50 W	H			20				
Uliaga	53 04.00 N 53 05.00 N	169 47.00 W 169 46.00 W						20		
Chuginadak	52 46.70 N	169 41.90 W	H			20		20		
Kagamil	53 02.10 N	169 41.00 W	H			20		20		
Samalga	52 46.00 N	169 15.00 W						20		
Adugak I.	52 54.70 N	169 10.50 W	R	Whole Island	3	20	20	20		10
Umnak I./Cape Aslik	53 25.00 N	168 24.50 W	H			20	20	20		
Ogchul I.	52 59.71 N	168 24.24 W	R	Whole Island	3	20	20	20		10
Bogoslof I./Fire Island	53 55.69 N	168 02.05 W	R	Whole Island	3	20	20	20		10
Emerald I.	53 17.50 N	167 51.50 W	H			20		20		
Unalaska/Cape Izigan	53 13.64 N	167 39.37 W					20	20		
Unalaska/Bishop Pt	53 58.40 N	166 57.50 W					20	20		
Unalaska I./Cape Sedanka	53 50.50 N	166 05.00 W	H			20				
Akutan I./Reef-lava	54 08.10 N 54 09.10 N	166 06.19 W 166 05.50 W	H			20	20	20		
Old Man Rocks	53 52.20 N	166 04.90 W	H			20	20	20		
Akutan I./Cape Morgan	54 03.39 N 54 03.70 N	165 59.65 W 166 03.68 W	R	SW corner, Cape Morgan	3	20	20	20	20	10

Table 2.12a. (cont.)

Bering Sea Subarea Management Area/Island/Site	Boundaries		ESA Listed Rookery (R) or Haulout (H)[2]	Notes	No transit zone (nm)[2]	Critical habitat area (nm)[2]	Directed fishing for pollock prohibited within. . .(nm)		Trawling prohibited within (nm)	
	Latitude (N)	Longitude (W)					Nov. 1 - Jun. 1	Jun. 1 - Nov.	Jan. 1 - Apr. 15	Year-round
Akun I./Billings Head	54 17.62 N 54 17.57 N	165 32.06 W 165 31.71 W	R	Billings Head Bight.	3	20	20	20	20	10
Rootok	54 03.90 N 54 02.90 N	165 31.90 W 165 29.50 W						20		
Tanginak I.	54 12.00 N	165 19.40 W	H			20	20			
Tigalda/Rocks NE	54 09.60 N 54 09.12 N	164 59.00 W 164 57.18 W	H			20	20	20		
Unimak/Cape Sarichef	54 34.30 N	164 56.80 W					20	20		
Aiktak	54 10.99 N	164 51.15 W					20			
Ugamak I.	54 13.50 N 54 12.80 N	164 47.50 W 164 47.50 W	R	Eastern End	3	20	20	20	20	10
Round I.	54 12.05 N	164 46.60 W	H			20		20		
Sea Lion Rock (Amak)	55 27.82 N	163 12.10 W	R	Whole Island	3	20	20	20	20	10
Amak I. and rocks	55 24.20 N 55 26.15 N	163 09.60 W 163 08.50 W	H			20	20	20		

[1] Where two sets of coordinates are given, the baseline extends in a clock-wise direction from the first set of geographic coordinates along the shoreline at mean lower-low water to the second set of coordinates. Where only one set of coordinates is listed, that location is the base point.
[2] Listed rookery and haulo t sites under the ESA designated in this table are defined at 50 CFR 226.202. Three nm no transit zones and other protections for listed rookery sites listed in this table are defined at 50 CFR 223.202. Sites in this table that do not have an R or H description have not been listed under the ESA as a rookery or haulo t with the appropriate crtical habitat designation. However, these sites are used as haulo ts by Steller sea lions and have been determined by NMFS to be of special importance to the endangered western population of Steller sea lions.

Table 2.12b. Steller sea lion protection areas in the Aleutian Islands subarea.

Aleutian Islands Area Management Area/Island/Site	Boundaries		ESA Listed Rookery (R) or Haulout (H)[2]	Notes	No transit zone (nm)[2]	Critical habitat area (nm)[2]	Trawling prohibited within. . . (nm)
	Latitude (N)	Longitude (W,E)					Year-round
Attu I./Cape Wrangell	52 54.60 N	172 27.90 E	R	S. Quadrant	3	20	10
	52 55.40 N	172 27.20 E					
Agattu I./Gillon Pt	52 24.13 N	173 21.31 E	R	Gillion Point	3	20	10
Attu I./Chirikof Pt.	52 49.75 N	173 26.00 E	H			20	
Agattu I./Cape Sabek	52 22.50 N	173 43.30 E	R	Cape Sabek	3	20	10
	52 21.80 N	173 41.40 E					
Alaid I.	52 46.50 N	173 51.50 E	H			20	
	52 45.00 N	173 56.50 E					
Shemya I.	52 44.00 N	174 08.70 E	H			20	
Buldir I.	52 20.25 N	175 54.03 E	R	SE side of Island	3	20	10
	52 20.38 N	175 53.85 E					
Kiska I./Cape St. Stephen	51 52.50 N	177 12.70 E	R	Cape St. Stephen	3	20	10
	51 53.50 N	177 12.00 E					
Kiska I./Sobaka & Vega	51 49.50 N	177 19.00 E	H			20	
	51 48.50 N	177 20.50 E					
Kiska I./Lief Cove	51 57.16 N	177 20.41 E	R	W. central, Lief Cove	3	20	10
	51 57.24 N	177 20.53 E					
Kiska I./Sirius Pt.	52 08.50 N	177 36.50 E	H			20	
Tanadak I. (Kiska)	51 56.80 N	177 46.80 E	H			20	
Seg la I.	51 59.90 N	178 05.80 E	H			20	
	52 03.06 N	178 08.80 E					
Ayugadak Point	51 45.36 N	178 24.30 E	R	SE coast of Rat Island	3	20	10
Little Sitkin I.	51 59.30 N	178 29.80 E	H			20	
Amchitka I./Column Rocks	51 32.32 N	178 49.28 E	R	Col mn Rocks	3	20	10
Amchitka I./East Cape	51 22.26 N	179 27.93 E	R	East Cape	3	20	10
	51 22.00 N	179 27.00 E					
Semisopochnoi/Petrel Pt.	52 01.40 N	179 36.90 E	R	N quadrant, Petrel Point	3	20	10
	52 01.50 N	179 39.00 E					
Semisopochnoi I./Pochnoi Pt.	51 57.30 N	179 46.00 E	R	E quadrant, Pochnoi Pt.	3	20	10
Amatignak I.	51 13.00 N	179 07.80 W	H	Nitrof Point		20	
Unalga & Dinkum Rocks	51 33.67 N	179 04.25 W	H			20	
	51 35.09 N	179 03.66 W					
Ulak I.	51 18.90 N	178 58.90 W	R	SE corner, Hasgox Point	3	20	10
	51 18.70 N	178 59.60 W					
Kavalga I.	51 34.50 N	178 51.73 W	H			20	
	51 34.50 N	178 49.50 W					

Table 2.12b. (cont.)

Aleutian Islands Area Management Area/Island/Site	Boundaries		ESA Listed Rookery (R) or Haulout (H)[2]	Notes	No transit zone (nm)[2]	Critical habitat area (nm)[2]	Trawling prohibited within. . . (nm)
	Latitude (N)	Longitude (W,E)					Year-round
Tag I.	51 33.50 N	178 34.50 W	R	Whole Island	3	20	10
Ugidak I.	51 34.95 N	178 30.45 W	H			20	
Gramp Rock	51 28.87 N	178 20.58 W	R	Whole Island	3	20	10
Tanaga I.	51 55.00 N	177 58.50 W	H	Bumpy Point		20	
	51 55.00 N	177 57.10 W					
Bobrof I.	51 54.00 N	177 27.00 W	H			20	
Kanaga I./Ship Rock	51 46.70 N	177 20.72 W	H			20	
Kanaga I./North Cape	51 56.50 N	177 09.00 W	H			20	
Adak I.	51 35.50 N	176 57.10 W	R	Cape Yakak-Lake Point	3	20	10
	51 37.40 N	176 59.60 W					
Little Tanaga Strait	51 49.09 N	176 13.90 W	H			20	
Great Sitkin I.	52 06.00 N	176 10.50 W	H			20	
	52 07.00 N	176 07.00 W					
Anagaksik I.	51 50.86 N	175 53.00 W	H			20	
Kasatochi I.	52 11.11 N	175 31.00 W	R	North half of Island	3	20	10
Atka I.	52 24.20 N	174 17.80 W	H	North Cape		20	
Amlia I./Sviech. Harbor	52 01.80 N	173 23.90 W	H			20	
Sagigik I.	52 00.50 N	173 09.30 W	H			20	
Amlia I./East	52 05.70 N	172 59.00 W	H			20	
	52 05.75 N	172 57.50 W					
Tanadak I. (Amlia)	52 04.20 N	172 57.60 W	H			20	
Agligadak I.	52 06.09 N	172 54.23 W	R	Whole Island	3	20	20
Seg am I./Saddleridge	52 21.05 N	172 34.40 W	R	N coast, Saddleridge Point	3	20	20
	52 21.02 N	172 33.60 W					
Seg am I./Finch Pt.	52 23.40 N	172 27.70 W	H			20	
	52 23.25 N	172 24.30 W					
Seg am I./South Side	52 21.60 N	172 19.30 W	H	Wharf Pt. to T rf Pt.		20	
	52 15.55 N	172 31.22 W					
Amukta I. & Rocks	52 27.25 N	171 17.90 W	H			20	
Chagulak I.	52 34.00 N	171 10.50 W	H			20	
Yunaska I.	52 41.40 N	170 36.35 W	R	NE end	3	20	10

[1] Where two sets of coordinates are given, the baseline extends in a clock-wise direction from the first set of geographic coordinates along the shoreline at mean lower-low water to the second set of coordinates. Where only one set of coordinates is listed, that location is the base point.

[2] Listed rookery and haulo t sites under the ESA designated in this table are defined at 50 CFR 226.202. Three nm no transit zones and other protections for listed rookery sites listed in this table are defined at 50 CFR 223.202. Sites in this table that do not have an R or H description have not been listed under the ESA as a rookery or haulo t with the appropriate crtical habitat designation. However, these sites are used as haulo ts by Steller sea lions and have been determined by NMFS to be of special importance to the endangered western population of Steller sea lions.

Table 2.12c. Steller sea lion protection areas in the Gulf of Alaska.

Gulf of Alaska Management Area/Island/Site	Boundaries		ESA Listed Rookery (R) or Haulout (H)[2]	Notes	No transit zone (nm)[2]	Critical habitat area (nm)[2]	Directed fishing for pollock prohibited within. . .(nm)		Trawling prohibited within ...(nm) Year-round
	Latitude (N)	Longitude (W)					Nov. 1 - Jun. 1	Jun. 1 - Nov.	
Bird I.	54 40.00 N	163 17.15 W	H			20	10	10	
South Rocks	54 18.14 N	162 41.25 W	H			20	10	10	
Clubbing Rocks (S)	54 41.98 N	162 26.74 W	R	Whole Island	3	20	10	10	10
Clubbing Rocks (N)	54 42.75 N	162 26.72 W	R	Whole Island	3	20	10	10	10
Caton I.	54 22.70 N	162 21.30 W	H			20			
Pinnacle Rock	54 46.06 N	161 45.85 W	R	Whole Island	3	20	10	10	10
S shilnoi Rocks	54 49.30 N	161 42.73 W						10	
Olga Rocks	55 00.45 N 54 59.09 N	161 29.81 W 161 30.89 W					10	10	
Jude I.	55 15.75 N	161 06.27 W	H			20	10	10	
Sea Lion Rocks (Shumagins)[3]	55 04.70 N	160 31.04 W	H			20	10	10	
Nagai/Mountain Pt.	54 54.20 N 54 56.00 N	160 15.40 W 160 15.00 W	H			20			
The Whaleback	55 16.82 N	160 05.04 W	H			20	10	10	
Chernabura I.	54 45.18 N 54 45.86 N	159 32.99 W 159 35.74 W	R	SE corner	3	20	10	10	10
Castle Rock	55 16.47 N	159 29.77 W	H			20		10	
Atkins I.	55 03.20 N	159 17.40 W	R	Whole Island	3	20	10	10	10
Spitz I.	55 46.60 N	158 53.90 W	H			20		10	
Mitrofania	55 50.20 N	158 41.90 W					10	10	
Kak	56 17.30 N	157 50.10 W						10	
Lighthouse Rocks	55 46.79 N	157 24.89 W	H			20	10	10	
S twik I.	56 31.05 N 56 32.00 N	157 20.47 W 157 21.00 W	H			20		10	
Chowiet I.	56 00.54 N 56 00.30 N	156 41.42 W 156 41.60 W	R	S quadrant	3	20	10	10	10
Nagai Rocks	55 49.80 N	155 47.50 W	H			20	10	10	
Chirikof I.	55 46.50 N 55 46.44 N	155 39.50 W 155 43.46 W	R	S quadrant	3	20	10	10	10
P ale Bay	57 40.60 N	155 23.10 W	H			20	10	10	

Table 2.12c. (cont.)

Gulf of Alaska Management Area/Island/Site	Boundaries		ESA Listed Rookery (R) or Haulout (H)[2]	Notes	No transit zone (nm)[2]	Critical habitat area (nm)[2]	Directed fishing for pollock prohibited within. . .(nm)		Trawling prohibited within ...(nm) Year-round
	Latitude (N)	Longitude (W)					Nov. 1 - Jun. 1	Jun. 1 - Nov.	
Kodiak/Cape Ikolik	57 17.20 N	154 47.50 W	H			20	10		
Takli I.	58 01.75 N	154 31.25 W	H			20		10	
Cape Kuliak	58 08.00 N	154 12.50 W	H			20			
Cape Gull	58 11.50 N 58 12.50 N	154 09.60 W 154 10.50 W	H			20		10	
Kodiak/Cape Ugat	57 52.41 N	153 50.97 W	H			20	10	10	
Sitkinak/Cape Sitkinak	56 34.30 N	153 50.96 W	H			20	10	10	
Shakun Rock	58 32.80 N	153 41.50 W	H			20	10	10	
Twoheaded I.	56 54.50 N 56 53.90 N	153 32.75 W 153 33.74 W	H			20	10	10	
Cape Do glas (Shaw I.)	59 00.00 N	153 22.50 W						10	
Kodiak/Cape Barnabas	57 10.20 N	152 53.05 W	H			20	10	10	
Kodiak/Gull Point	57 21.45 N	152 36.30 W	H			20	10	10	
Latax Rocks	58 40.10 N	152 31.30 W	H			20	10	10	
Ushagat I./SW	58 54.75 N	152 22.20 W	H			20		10	
Ugak I.	57 23.60 N 57 21.90 N	152 17.50 W 152 17.40 W	H			20		10	
Sea Otter I.	58 31.15 N	152 13.30 W	H			20	10	10	
Long I.	57 46.82 N	152 12.90 W	H			20	10		
Sud I.	58 54.00 N	152 12.50 W	H			20			
Kodiak/Cape Chiniak	57 37.90 N	152 08.25 W	H			20	10	10	
S garloaf I.	58 53.25 N	152 02.40 W	R	Whole Island	3	20	10	10	10
Sea Lion Rocks (Marmot)	58 20.53 N	151 48.83 W	H			20	10	10	
Marmot I.	58 13.65 N 58 09.90 N	151 47.75 W 151 52.06 W	R	SE quadrant	3	20	10	10	10
Nagahut Rocks	59 06.00 N	151 46.30 W	H			20			
Perl	59 05.75 N	151 39.75 W					10	10	

Table 2.12c. (cont.)

Gulf of Alaska Management Area/Island/Site	Boundaries		ESA Listed Rookery (R) or Haulout (H)[2]	Notes	No transit zone (nm)[2]	Critical habitat area (nm)[2]	Directed fishing for pollock prohibited within. . .(nm)		Trawling prohibited within ...(nm) Year-round
	Latitude (N)	Longitude (W)					Nov. 1 - Jun. 1	Jun. 1 - Nov.	
Gore Poiint	59 12.00 N	150 58.00 W	H			20			
O ter (Pye) I.	59 20.50 N 59 21.00 N	150 23.00 W 150 24.50 W	R	S quadrant	3	20	10	10	10
Steep Point	59 29.05 N	150 15.40 W						10	
Chiswell Islands	59 36.00 N	149 34.00 W	H			20	10	10	
Rugged Island	59 49.80 N 59 51.00 N	149 23.30 W 149 25.30 W					10		
Point Elrington[4]	59 56.00 N	148 15.20 W	H			20			
Perry I.	60 44.00 N	147 54.60 W	H			20			
The Needle[4]	60 06.64 N	147 36.17 W	H			20			
Point Eleanor	60 35.00 N	147 34.00 W	H			20			
Wooded I. (Fish I.)	59 52.90 N	147 20.65 W	R		([5])	20	10	10	
Glacier Island	60 51.30 N	147 14.50 W					10	10	
Seal Rocks	60 09.78 N	146 50.30 W	R,H		3	20	10	10	
Cape Hinchinbrook	60 14.00 N	146 38.50 W						10	
Middleton I.	59 28.30 N	146 18.80 W	H			20			
Hook Point	60 20.00 N	146 15.60 W	H			20		10	
Cape St. Elias	59 47.50 N	144 36.20 W	H			20	10	10	
Cape Fairweather[6]	58 47.50 N	137 56.30 W	H						
Graves Rock[6]	58 14.30 N	136 45.40 W	H						

[1] Where two sets of coordinates are given, the baseline extends in a clock-wise direction from the first set of geographic coordinates along the shoreline at mean lower-low water to the second set of coordinates. Where only one set of coordinates is listed, that location is the base point.

[2] Listed rookery and haulo t sites under the ESA designated in this table are defined at 50 CFR 226.202. Three nm no transit zones and other protections for listed rookery sites listed in this table are defined at 50 CFR 223.202. Sites in this table that do not have an R or H description have not been listed under the ESA as a rookery or haulo t with the appropriate crtical habitat designation. However, these sites are used as haulo ts by Steller sea lions and have been determined by NMFS to be of special importance to the endangered western population of Steller sea lions.

[3] Vessels less than or equal to 60 ft (18.3 m) LOA are exempt from the 10 nm clos re at Sea Lion Rocks (Shumagins).

[4] Restrictions at Point Elrington and The Needle will be considered by the Alaska Board of Fisheries because these areas fall completely within the State of Alaska management area of Prince William Sound.

[5] Wooded Island does not have a 3 nm no trawl zone described under 50 CFR 223.202, but is listed as a major rookery under 50 CFR part 226.202.

[6] Cape Fairweather and Graves Rock are east of 144 degrees west longitude and therefore does not include a 20 nm aquatic critical habitat zone (50 CFR part 226.202(a)).

Table 4.1. Life history table for Steller sea lions based on Calkins and Pitcher (1982) and York (1994). (From York 1994.)

Ages			Calkins-Pitcher life table			York life table		
From	To	Fecundity	Cum. survival	Annual survival	Percent at age	Cum. survival	Annual survival	Percent at age
0	1	0.000	1.000	0.776	16.676	1.000	0.782	16.251
1	2	0.000	0.776	0.776	12.546	0.782	0.782	12.709
2	3	0.000	0.603	0.776	9.438	0.612	0.782	9.938
3	4	0.105	0.468	0.868	7.100	0.478	0.930	7.772
		0.267	0.406	0.879	6.163	0.445	0.909	7.228
5	6	0.286	0.357	0.888	5.417	0.404	0.895	6.570
6	7	0.315	0.317	0.893	4.811	0.362	0.884	5.880
4 7	5 8	0.315	0.283	0.898	4.296	0.320	0.875	5.198
			0.254	0.874	3.857	0.280	0.867	4.548
9	10	0.315	0.222	0.899	3.372	0.242	0.859	3.943
10	11	0.315	0.200	0.893	3.031	0.208	0.853	3.338
11	12	0.315	0.178	0.896	2.707	0.178	0.847	2.889
12	13	0.315	0.160	0.895	2.425	0.150	0.841	2.447
13	31	0.315	0.160	0.895	15.99	0.150	p(x)d	11.239
8	9	0.315						

Table 4.2. Comparison of eastern and western stock Steller sea lion (*Eumetopias jubatus*) stomach collection study results from the 1950s through the 1990s.

EASTERN STOCK - 950s through 990s	**WESTERN STOCK - 950s through 990s**
1901-1958: AK,BC, and OR, Summer/Winter, (n=19). Reports a range of fish and cephalopods for 12 time/area studies from AK,BC, and OR. For his BC study: (in order of FO) included squid, herring, rockfish, octopus, salmon, skate, and hake. For other studies in his table: rockfish, perch, herring, skate, shark, squid, octopus, lamprey, salmon, "cod", "bass", m ssels, clam, crab, dogfish, flatfish, and sardines. Pike (1958)	**946:** CGOA, Summer, (n=7). 3 Collected from Barren Is. Contained pollock, starry flounder, tom cod, arrowtooth flounder, halibut, and octopus. 2 from Chiswell Is. Contained 100% salmon and 2 from Kodiak Is. Contained pollock and arrowtooth flounder(Imler & Sarber 1947)
946: SEAK, Summer, (n=15). 8 sampled in SEAK; 7 fed principally on pollock, and 1 contained a skate and an octopus (Imler & Sarber 1947)	**950:** Kuril Islands, Russia. Observation only: a sea lion feeding on octopus. (Sleptsov 1950 in Spalding 1964)
1956-1963: BC, Winter-Fall; feed primarily at night (n=269 or 393 sampled). Suggests animals prey mainly on one item per feeding period. Some seen feeding at surface on lingcod, rockfish, salmon, or halib t (n=8). Consumption of herring and salmon by sea lions, f r seals, and harbor seals estimated about 2% to 4% of commercial catch. Prey (in order of FO): octopus, rockfish, herring, whiting, salmon, dogfish, squid, hake, flatfish, clam, ratfish, shrimp, sandlance, graycod, lingcod, and single occ rrences of lamprey, skate, eulachon, halibut, and mackereljack. (Spalding 1964)	**949, 951:** EBS, St. Paul, Summer, (n=3) 1 sea lion stomach: primarily sandlance, starry flounder; 1 stomach: halibut, cod, pollock, and flounders; 1 stomach: a large cephalopod beak. (Wilke and Kenyon 1952)
	958: WGOA, Summer, (n=94); 14 yearlings, 42 adult females, 18 terr. males, 20 nonterr. males. Prey (in order of FO): squid/octopus, bivalves, smelts, greenlings shrimp/crabs, rockfish, sculpins, isopods, nclassified crustaceans, segmented worms, and single occurrences of lamprey, salmon, sandlance, sand dollar, and coelenterate. (Mathisen et al. 1962)
	959: WGOA, CGOA, EAI, Summer, (n=56); primarily adult males. Prey (in order of FO): squid/octopus, clam/mussel/snail, sandlance, rockfish, crab, greenling, sculpins, flatfish, and single occ rrences of halibut and lumpfish. (Thorsteinson and Lensink 1962)
	962: EBS, Winter-Spring, (n=unknown); Large numbers of sea lions in the southeastern Bering Sea, winter/spring of 1962. Suggests herring "staple food" of sea lions during this period. Suggests sea lion distribution was influenced by the distribution of herring. Tikhomirov (1964)

Table 4.2. Comparison of eastern and western stock Steller sea lion (*Eumetopias jubatus*) stomach collection study results from the 1950s through the 1990s.

EASTERN STOCK - 950s through 990s	**WESTERN STOCK - 950s through 990s**
958-1963: CA and OR, Summer, (n=1); Animals were adult and mixed age females. Prey (in order of FO): salmon (100%), rockfish (100%). Winter, (n=5); Mixed age females. Prey (in order of FO): rockfish (80%); arrowtooth flounder (20%), sanddab (20 %), herring (20%), flatfish (20%). Fiscus and Baines (1966)	**958-1963:** GOA, AI, BS Summer,(n=16); Animals (mixed sexes and ages) taken in Alaskan waters fed mainly on small, schooling fishes. Near Unimak Pass in 1962, capelin was the major food species. A Steller sea lion taken in EGOA in May 1958 had eaten three salmon. Most of the food species (capelin, sandlance, sc lpins, rockfishes and flatfishes) found in the stomachs of Steller sea lions suggest that they feed near land or in relatively shallow water (<100 fm, 180 m). Sea lions seen at distances of 70-85 miles from land by Fiscus and Kenyon in 1960 (Kenyon and Rice 1961). Fiscus and Baines (1966)
968-1973: CA, (n=9); 9 stomachs with fish, and 7 with squid and octopus. Grouped 127 identified fishes according to schooling (open-water), bottom-dwelling (rocky), and inshore-schooling species; suggested sea lions feed mainly on bottom-dwelling fishes. Jones (1981)	**966 - 969:** Ku ril Islands, R ssia. (n = 71 w/food) Important prey by FO: pollock (n=45, 63.4%), greenlings (n=7, 9.9%), smooth lumps cker (n=1, 1.4%), octopus (n=18, 25.4%), Gonatus sq ids (n=23, 32.4%), other sq id (n=7, 9.9%), mollusk shells (n=4, 5.6%). Perlov (1975)
973-1976: OR, Observations (84) of Steller sea lions (n=unknown # animals) feeding at surface, Rogue River, OR. Prey: 73 lampreys, 2 salmonids, 9 unidentified. Jameson and Kenyon (1977)	**974-1975:** St. Paul, S mmer, Observations (163) of Steller sea lions (n= nknown) taking 163 f r seal pups at St. George Island (Pribilof Is.) Estimated such predation may result in the mortality of abo t 3% to 7% of f r seal p ps born at St. George Island. Gentry and Johnson (1981)

Table 4.2. Comparison of eastern and western stock Steller sea lion (*Eumetopias jubatus*) stomach collection study results from the 1950s through the 1990s.

EASTERN STOCK - 950s through 990s	**WESTERN STOCK - 950s through 990s**
	975-1978: GOA, All seasons, (n=153). Stomach contents 95.7% fishes by volume, with 14 species of fish in 11 families. Gadids comprised 59.7% of total contents and occurred in 82.4% of stomachs with food. Walleye pollock comprised 58.3% of the total volume and occurred in 66.7% of stomachs with food. Cephalopods occurred in 36.6% of stomachs with contents b t made p only 4.2% of total volume. Predation on salmon and capelin appeared to be largely limited to spring and s mmer. Prey (by combination rank index) included pollock, sq ids, herring, capelin, cod, salmon, octopus, sculpins, flatfishes, rockfishes. Herring and sq ids were extensively sed in Prince William So nd b t appeared to be relatively nimportant in other areas. Results for sea lions similar to res lts for harbor seals. Mean fork length (pollock otoliths, n=2030) was 29.8 cm (range 5.6 to 62.9 cm, SD = 11.6 cm). Pitcher (1981)
	975-1978: GOA, All seasons, (n=153). NOTE: redundancy with previous res lts of Pitcher 1981. Fishes comprised 72.8%, cephalopods (octopus and Gonatid squids) 21.5%, decapod crustaceans (shrimps, tanner and spider crabs), 4.2% gastropods (marine snails) 0.8%, and mammals 0.4% of the prey occurrences. Fishes included minim m of 14 species of 11 families. Gadids composed nearly half of total occurrences and nearly 60% of total volume. Harbor seal remains were fo nd in two stomachs (see Pitcher and Fay 1982). Seven top-ranked prey (in order of modified Index of Relative Importance) were pollock, herring, sq ids, capelin, salmon, Pacific cod, and sc lpins. Pollock was dominant prey accounting for about 39% of all occurrences and 58% of the total volume. Pollock was top-ranked prey in all areas except Kodiak, where it was ranked second below capelin. Herring and sq id were used extensively in Prince William So nd, b t not in other areas. Predation on salmon and capelin was largely limited to spring and summer. Geographic differences in se of salmon and capelin may have been due to sampling at different - sites and seasons. Comparison with previous studies (Imler and Sarber 1947, Mathisen et al. 1962, Thorsteinson and Lensink 1962, and Fisc s and Baines 1966) which had more invertebrates, no herring, but included sandlance. Noted differences in sampling for this study (throughout year at wide range of locations) versus earlier studies (near rookeries during breeding season). Four of the five top-ranked prey were off-bottom schooling species. Calkins and Pitcher (1982)

Table 4.2. Comparison of eastern and western stock Steller sea lion (*Eumetopias jubatus*) stomach collection study results from the 1950s through the 1990s.

EASTERN STOCK - 950s through 990s	WESTERN STOCK - 950s through 990s
	976: EBS, Pribilofs, March, (n=4). Prey (in order of FO): pollock, sq ids, and single occurrences of octopus, flatfish, lamprey, and prickleback. Based on otoliths, pollock cons med ranged from 34 cm to 57 cm in length. Also mentions the following prey items from a preliminary examination of 111 stomach samples collected in the central and western Bering Sea (in no particular order): pollock, cod, Gonatid sq ids, herring, octopus, and sculpins. Lowry et al. 1982
	975-81: AI, March-October, (n=90; not stated how many had contents). Most pollock consumed (76%) were 20 cm or longer. Younger sea lions (≤4 yr, all males)) collected in 1981 ate significantly smaller fish (mean=26.9 cm, n=51). Animals collected in 1976 and 1979 (both near the Pribilofs) ate pollock averaging 46.9 cm in length (range 18.4-61.4 cm), while those collected in 1981 to the west ate substantially smaller pollock averaging 25.2 cm in length (range 8.3-64.2 cm). In 1981 sea lions collected in the central Bering Sea ate larger pollock than those off the Kamchatka Penins la (mean=26.8 cm vs 23.5 cm) "It is unknown whether the consumption patterns described above are a result of actual size selection of prey or if they res lt from coincidental distribution of predators and prey size classes." ".....the size range of pollock eaten by both young and old sea lions was similar." Frost and Lowry 1986

Table 4.2. Comparison of eastern and western stock Steller sea lion (*Eumetopias jubatus*) stomach collection study results from the 1950s through the 1990s.

EASTERN STOCK - 950s through 990s	**WESTERN STOCK - 950s through 990s**
985-1986: SEAK, Winter/Summer, (n=14). Fishes comprised 98% of volume, mostly Pacific cod (57%) and pollock (32%). Most frequently occurring were pollock (57%) and flatfishes (21%). Other prey observed were sq id and octopus. Mean fork length (80 pollock otoliths from 8 sea lions) was 25.5 cm (range 4.8 to 55.7 cm, SD=10.4 cm). Calkins and Goodwin (1988)	**985-1986:** CGOA, Winter/Summer, (n=74). Most important by volume were pollock (42%), octopus (26%), and flatfish (25%). Other prey: were fishes, sq id, decapod crustaceans, and clams. Prey rank (based on combined rank index [Pitcher 1981]) in Kodiak area were pollock, octopus, flatfishes, sandlance, Pacific cod, and salmon. Mean fork length (1064 otoliths from 43 sea lions) in Kodiak area was 25.4 cm (range 7.9 to 54.2 cm, SD = 12.4 cm). Pollock was the most important prey item in both 1975-1978 collection (39% by FO in the Kodiak area) and 1985-1986 collection (58%). Capelin was most important in Kodiak area in 1975-1978. Suggest difference in capelin may be due to seasonal differences when animals were collected (spring-s mmer 1975-1978 vs. spring-autumn/early winter 1985-1986). Th s, comparisons may be compromised by potential seasonal bias. Octopu s ranked second in 1985-1986 collection near Kodiak, but fifth in 1975-1978. Suggest difference may be due to collection site. Thus comparisons may be compromised by potential location bias. Sandlance occurred in 26% of sea lions from GOA in 1960s (Mathisen et al. 1962, Thorsteinson and Lensink 1962, Fisc s and Baines 1966), were not fo nd in 1975-1978 sample, but were fo rth in 1985-1986 sample. Calkins and Goodwin (1988)

Table 4.2. Comparison of eastern and western stock Steller sea lion (*Eumetopias jubatus*) stomach collection study results from the 1950s through the 1990s.

EASTERN STOCK - 950s through 990s	**WESTERN STOCK - 950s through 990s**
992: CA, Summer, (n=1 observation). Observation of a territorial male Steller sea lion attack, kill, and cons me what appeared to be a yearling California sea lion. Byrnes and Hood (1994)	**975-1978, 985-1986:** GOA, (note redundancy with Pitcher 1981, Calkins and Pitcher 1982, and Calkins and Goodwin 1988) Prey cons mption based on FO. Most stomachs contained prey of only one kind. Pollock most common prey of j venile (≤ 4 years old) and adult sea lions in virtually all seasons and areas during these two periods. Juvenile pollock were a major part of the diet in both periods. J venile sea lions ate smaller and relatively more j venile pollock. Small forage fish were cons med on a seasonal basis. Temporal comparisons were possible only in the Kodiak region. The proportion of sea lions eating pollock increased from 49% in 1975-1978 to 69% in 1985-1986 in the Kodiak area. Small forage fish were the second most common prey in the 1970s, and flatfish were second in the 1980s. Of the fish cons med, 73% were ≤30 cm, but they accounted for only 26.8% of the biomass cons med. Half (50.7%) of the pollock mass cons med by j venile sea lions came from fish ≤30 cm, while only 21% of the pollock mass cons med by ad lt sea lions came from j venile pollock. Seasonal differences were observed in the cons mption of all prey taxa, but differences were not fo nd in the 1980s. Between the 1970s and the 1980s, the proportion cons ming pollock and cephalopods increased significantly and the proportion cons ming small forage fish and other demersal fish decreased. The increase in pollock cons med was only evident in s mmer months (all ages combined), b t was evident in all seasons for j veniles. Note that sampling was not consistent with respect to seasons or specific locations between the two sampling periods, which weakens the basis for comparisons. Merrick and Calkins (1996)

Table 4.2. Comparison of eastern and western stock Steller sea lion (*Eumetopias jubatus*) stomach collection study results from the 1950s through the 1990s.

EASTERN STOCK - 950s through 990s	**WESTERN STOCK - 950s through 990s**
	981: EBS, Spring, (n = 92). Males (ages1-16 yrs) collected along the seasonal ice front in Bering sea. between March 24 and April 11, 1981. 37 collected in central Bering sea, "likely that most of the sea lions taken in this area originated at rookeries in the Aleutian Islands". 73 collected in R ssian far east waters near Oly torskiy Gulf (no. of Kamchatka peninsula) Stomach contents calculated by f ll wt. - empty wt. = total wt. of contents. Less than 0.25 kg considered trace amo nts. Prey identifications based primarily on fish otoliths, s bopercle bones, and cephalopod mandibles. Importance of prey was compared by ranking, taking into account mass (wt.) and frequency of occurrence, using combined ranked index (CRI). Otolith measurements used to calculate fork lengths sing regression analysis of otolith length and fish length (Frost & Lowry 1981). Pollock most important prey item in both st dy areas and occurred in 89% of stomachs with contents (322.1 kg; 67% by wt.) Pollock occurred in central Bering sea stomachs (100%); pollock in R ssian Far east stomachs (83%). Mean size of pollock cons med in Bering sea stomachs was 25.2 cm (range = 6.2 - 64.2, SD= 7.9) based on meas rement of 1299 otoliths. "Pollock cons med by sea lions in the Bering Sea were similar in size to those cons med in the Gulf of Alaska in the 1980s but were smaller than those cons med in the Gulf of Alaska in the 1970s." Older (larger) sea lions (≥5 yrs.) ate larger pollock, mean = 25.8 cm. Younger sea lions (≤4 yrs.) cons med smaller pollock, mean = 22.1 cm. Pacific cod second most important prey item in both study areas occurring in 38% of all stomachs (28.1% in C. Bering Sea; 43.3% in R ssian Far East) Other prey items: sq id and octop s, herring, sculpins, phocid seals, flatfishes, cartilagino s fishes, crabs, and snails.
	"Sea lions were not fo nd concentrated along the ice edge in any locations other than the two collection areas. It seems likely that they moved to and concentrated in these areas to take advantage of the pollock resources similar to the fishing fleets that were also present there at the time." Most of the study area in the Central Bering Sea waters fell within the northern portion of the area known as the "doughnut". Calkins (1998)

EASTERN STOCK - 950s through 990s	WESTERN STOCK - 950s through 990s
	982 - 984: CGOA, Shelikof Straits, Jan.-April, (n=36). Sea lion stomachs collected d ring Shelikof joint venture pollock fishery in Jan.-April. Both males (mean age 4.8 yrs.; 75% s badult or newly mature and probably not territorial) and females (age range 1-25 yrs, mean=6.43 yrs; 79% mature) were caught in d ring the trawl fishery. Prey from 1983 (n=19) stomachs: primarily pollock (range 34-49 cm, mean=39.3 cm, n=68). Sizes of pollock caught in the same net as sea lions ranged from 34-54 cm, mean=40 cm. Prey from 1984 (n=17) stomachs: primarily pollock (range 30-52 cm, mean=42.13 cm, n=93). Sizes of pollock caught in the same net as sea lions ranged from 31-54 cm (mean=43.5 cm, n=372). Loughlin and Nelson (1986)
	985-1986: EBS, St. Pa l, August, September and October, (n=11stomachs, 2 colons). Collected samples from dead animals along shore of St. Pa l Island. Age and sex groups : males 85%, females 15%. Otoliths (256) recovered from 7 stomachs (67%), octopus beaks from 3 (27%), crab from 2 (18%). Most common prey (from otoliths) was yellowfin sole (54% from 6 stomachs). Prey species (from otoliths): Yellowfin sole (149 of 256 otoliths or 58%), Pacific cod (5 stomachs, 41 of 256 otoliths or 16%), pollock (2.7%) and halibut (1 otolith recovered). Octopus beaks (4 individuals) were recovered in 3 stomachs. Gearin (unp blished) .
	994 - 996: Hokkaido, Japan, Jan.-March, (n=62) Stomachs collected off coast of Raus , Hokkaido, Japan. Sex of sea lions collected: 12 males, 24 females, but no ages given.. Prey identifications based on fish bones, otoliths and beaks. Important prey by FO: pollock (n=55, 88.7%), Pacific cod (n=47, 75.8%), Saffron cod (n=25, 40.3%), flatfish (n=15, 24.2%), other fish (n=24, 38.7%), sq ids (n=43, 69.4%), octopus (n=7, 11.3%). Prey size cons med: pollock 40 -50 cm (30.36 ± 3.04 (SD) in 1994 and 42.33 ± 2.84 (SD) cm in 1995). Noted that “this is almost the same size as that caught by the commercial fishery”. When sea lions were grouped by sex and age (≤4 yrs and ≥4 yrs old) there was no significant difference in the size of pollock cons med between the two age groups or between sexes. Goto and Shimazaki (1997)

Table 4.3. Locations of instrumented Steller sea lions inside and outside of critical habitat based on satellite data.

Breeding	Number of Locations Within Critical Habitat	Number of Locations Outside Critical Habitat	Percentage	Number of Locations Total	# of Animals (n)	Locations Per animal
Jan-Mar	260.00	5.00	1.89	265.00	5.00	53.00
Apr-June	101.00	22.00	17.89	123.00	4.00	30.75
July-Sept	401.00	0.00	0.00	401.00	13.00	30.85
Oct-Dec	4.00	5.00	55.56	9.00	2.00	4.50
Non-Breeding						
Jan-Mar	1210.00	10.00	0.82	1220.00	20.00	61.00
Apr-June	1110.00	66.00	5.61	1176.00	13.00	90.46
July-Sept	71.00	0.00	0.00	71.00	2.00	35.50
Oct-Dec	264.00	24.00	8.33	288.00	9.00	32.00

Table 4.4. Percent frequency of of occurrence of all taxa identified in stomach samples collected from 1956 to 1986 throughout the range of Steller sea lions. Values are shown for the entire range in all years and for the Eastern and Western stocks during two time periods; from the 1950-70's and the 1980's.

	All Years	**1950's - 1970's**		**1980's**	
	RANGE	**EASTERN**	**WESTERN**	**EASTERN**	**WESTERN**
	n=781	**n=196**	**n=394**	**n=14**	**n=177**
Species	**% Frequency of Occurrence**				
Pollock	**39.2**	**9.2**	**38.6**	**57.1**	**72.3**
Octopus sp.	16.5	23.0	9.9	7.1	24.9
Pacific Cod	**8.6**		**4.8**	**7.1**	**25.4**
Cephalopods	7.8	0.0	15.5	0.0	0.0
Clamshell	7.4	3.6	11.9	0.0	2.3
Rockfish nident.	6.7	16.3	4.8	0.0	0.6
Pacific herring	**6.5**	**9.7**	**4.1**	**4.3**	**7.9**
Gonatid sq id	4.5	0.0	8.9	0.0	0.0
Sandlance	3.5	1.5	4.8	0.0	2.8
Squid	3.5	5.6	0.8	14.3	6.2
Fish nident.	3.2	0.0	4.8	14.3	2.3
Capelin	3.2	0.0	6.3	0.0	0.0
Righteye flounder unident.	3.1	0.0	2.8	21.4	5.6
Sculpin unident.	2.8	0.0	3.0	0.0	5.6
Greenling unident.	2.7	0.0	5.3	0.0	0.0
Salmon	**2.7**	**5.6**	**.8**	**7.1**	**.1**
Gonatus magister	2.6	0.0	5.1	0.0	0.0
Flatfishes	1.9	3.6	0.3	0.0	4.0
Milk	1.8	6.6	0.3	0.0	0.0
Dogfish	1.7	6.6	0.0	0.0	0.0
Smelt nident.	1.7	0.0	3.3	0.0	0.0
Shrimps	1.7	1.5	2.0	0.0	1.1
Pacific Hake	1.4	5.6	0.0	0.0	0.0
Cr staceans	1.4	0.0	2.8	0.0	0.0
Stones and gravel	1.3	0.0	2.5	0.0	0.0
Sculpin unident.	1.2	0.0	1.5	0.0	1.7
Crab unident.	1.0	0.0	1.3	0.0	1.7
Yellowfin sole	0.9	0.5	0.0	0.0	3.4
Ommatostrephidae	0.8	0.0	1.5	0.0	0.0
Ratfish	0.6	2.6	0.0	0.0	0.0
Tanner Crab	0.6	0.0	0.5	0.0	1.7
Teliost fish nident.	0.5	0.0	0.0	0.0	2.3
Cartilaginous fish nident.	0.5	0.0	0.0	0.0	2.3
Pacific halibut	0.5	0.5	0.3	0.0	1.1
Gadidae	0.5	0.0	0.5	0.0	1.1
Shell fragments	0.4	0.0	0.0	0.0	1.7
Lamprey	0.4	0.5	0.5	0.0	0.0
Isopods	0.4	0.0	0.8	0.0	0.0
Buccin m sp.	0.4	0.0	0.0	0.0	1.7
Spotted seal	0.3	0.0	0.3	0.0	0.6
Skate unident.	0.3	0.5	0.3	0.0	0.0

Table 4.5a. Percent frequency of occurrence of prey items recovered from Steller sea lion scat collected in winter (December-April, 1990-1998; NMFS unpublished data).

Region	**RANGE**	**CGOA**	**WGOA**	**EAI**	**CAI**	**WAI**
Sample size	**n=1685**	**n=358**	**n=491**	**n=714**	**n=122**	**no data**
Species	**% Frequency of Occurrence**					
POLLOCK	**62.4**	**52.8**	**83.9**	**62.7**	**.6**	
PACIFIC COD	**27.2**	**28.8**	**37.1**	**21.4**	**7.2**	
ATKA MACKEREL	**6.5**	**5.0**	**4.3**	**21.7**	**68.9**	
SALMON	**3.4**	**0.6**	**9.8**	**7.5**	**.5**	
IRISH LORD SP	11.7	13.1	9.2	12.6	12.3	
SNAILFISH SP	9.0	10.6	4.7	10.4	13.9	
ARROWTOOTH FL	8.8	20.4	9.4	3.5	3.3	
SAND FISH	8.3	5.6	1.8	15.4	0.8	
SAND LANCE	7.1	16.8	8.6	2.4	0.0	
UNID. FLATFISH	6.8	7.0	6.1	8.0	1.6	
HERRING	**5.9**	**21.2**	**3.9**	**0.6**	**0.0**	
ROCK SOLE	5.8	11.2	5.9	3.5	2.5	
UNID GADID	5.6	11.5	4.1	4.5	1.6	
CEPHALOPODS	5.1	7.5	2.6	4.2	13.1	
ROCKFISH SP	4.3	3.6	3.9	5.3	2.5	
POLYCHAETE UNID	2.7	2.0	2.6	2.2	8.2	
GREENLING SPP	2.5	0.6	2.0	3.5	4.1	
SM. LUMPSUCKER	2.4	0.0	0.6	4.8	3.3	
ROCK GREENLING	2.4	0.0	0.0	1.1	26.2	
SCULPIN	2.1	3.1	0.6	2.8	0.8	
HALIBUT	1.6	0.8	0.6	2.8	0.8	
GUNNELS	1.3	1.7	1.2	1.1	1.6	
KELP GREENLING	1.3	0.0	0.0	3.1	0.0	
STARRY FLOUNDER	0.8	2.0	0.2	0.8	0.0	
POACHER SP	0.8	0.8	1.2	0.6	0.0	
RED IRISH LORD	0.8	0.3	1.0	0.7	1.6	
SKATE	0.7	1.7	0.0	0.6	1.6	
SMELT SPP	0.7	0.8	0.8	0.7	0.0	
BIRD or MAMMAL	0.5	0.0	0.0	1.3	0.0	
MYCTOPHID SP	0.5	0.6	0.2	0.3	2.5	
CAPELIN	0.4	1.1	0.0	0.3	0.0	
GYMNOCANTHUS SP	0.4	0.8	0.4	0.1	0.0	
RONQUIL SP	0.4	0.0	0.4	0.6	0.0	
STICHAEIDAE SP	0.4	0.6	0.4	0.3	0.0	
EULACHON	0.3	0.6	0.4	0.1	0.0	
CARTILAG. FISH	0.2	0.3	0.0	0.3	0.0	
SMOOTHTONGUE	0.2	0.0	0.4	0.1	0.0	
TUBESNOUT	0.2	0.6	0.2	0.0	0.0	
STICKELBACK SP	0.1	0.3	0.0	0.1	0.0	
scats containing unid. prey	*134*	*40*	*33*	*50*	*11*	

Table 4.5b. Percent frequency of occurrence of prey items recovered from Steller sea lion scat collected in summer (May-September, 1990-1998; NMFS unpublished data).

Region	**RANGE**	**CGOA**	**WGOA**	**EAI**	**CAI**	**WAI**
Sample size	**n=2168**	**n=245**	**n=282**	**n=408**	**n=884**	**n=349**
Species	**% Frequency of Occurrence**					
ATKA MACKEREL	**58.9**	**0.0**	**.8**	**30.6**	**92.3**	**95.1**
POLLOCK	**32.5**	**64.5**	**80.1**	**50.5**	**.9**	**2.9**
SALMON	**25.5**	**40.4**	**45.7**	**34.1**	**8.8**	**5.4**
CEPHALOPODS	12.4	4.1	0.7	6.4	21.8	10.6
HERRING	**7.5**	**6.9**	**3.2**	**33.1**	**0.1**	**0.0**
PACIFIC COD	**7.1**	**4.9**	**9.9**	**7.4**	**6.6**	**7.2**
ARROWTOOTH FL	6.2	35.1	11.0	2.9	0.6	0.0
SAND LANCE	5.5	9.4	18.4	8.1	0.9	1.1
IRISH LORD SP	4.6	0.4	5.7	6.4	2.9	8.6
UNID GADID	3.6	5.7	6.7	4.4	2.3	2.0
ROCK SOLE	2.3	0.8	1.4	9.6	0.6	0.0
POLYCAETE UNID	2.2	1.2	2.5	2.0	2.8	1.4
ROCKFISH SP	2.0	1.2	3.5	1.5	2.4	1.1
SKATE	1.5	1.2	0.4	3.7	1.5	0.3
SMOOTHTONGUE	1.5	0.0	0.0	3.4	2.0	0.0
FLATFISH SP	1.3	2.0	1.4	2.7	0.7	0.9
SAND FISH	1.2	1.2	0.7	4.7	0.2	0.0
SMELT SPP	1.1	7.3	1.1	0.5	0.0	0.0
CAPELIN	0.8	2.9	0.7	2.2	0.0	0.0
GREENLING SPP	0.8	0.0	1.4	1.5	0.5	0.9
HALIBUT	0.8	1.6	0.7	2.5	0.1	0.0
STURGEON POACHER	0.8	0.0	0.0	4.2	0.0	0.0
ROCK GREENLING	0.7	0.0	0.0	2.7	0.5	0.3
BIRD or MAMMAL	0.6	0.0	0.7	0.2	0.6	1.4
SM. LUMPSUCKER	0.6	0.0	0.0	0.0	1.4	0.0
SCULPIN	0.5	0.0	0.4	1.5	0.3	0.3
MYCTOPHID SP	0.5	0.4	0.0	0.0	1.0	0.0
HAKE	0.4	1.2	1.1	0.2	0.2	0.0
LAMPREY SPP	0.4	0.0	0.7	1.0	0.3	0.0
POACHER SP	0.4	0.0	0.0	2.0	0.1	0.0
SABLEFISH	0.4	2.4	0.4	0.5	0.0	0.0
SNAILFISH SP	0.4	0.4	0.4	0.0	0.7	0.3
YELLOWFIN SOLE	0.3	0.0	0.0	1.5	0.0	0.0
STARRY FLOUNDER	0.2	0.0	0.4	1.0	0.0	0.0
YELLOW IRISH LORD	0.2	0.0	0.4	0.2	0.0	0.9
GUNNELS	0.2	0.0	0.7	0.5	0.0	0.0
KELP GREENLING	0.2	0.0	0.0	0.5	0.1	0.3
PENPOINT GUNNEL	0.2	0.0	0.0	1.0	0.0	0.0
RED IRISH LORD	0.2	0.0	0.4	0.0	0.1	0.6
EULACHON	0.1	0.8	0.4	0.0	0.0	0.0
scats containing unid prey	*127*	*22*	*20*	*38*	*28*	*19*

Table 4.6. Counts of adult and j venile (non-pup) Steller sea lions at rookery and haulout trend sites by region (NMFS unpubl., Sease 2000). For the GOA, the eastern sector includes rookeries from Seal Rocks in Prince William Sound to O ter Island; the central sector extends from Sugarloaf and Marmot Islands to Chowiet Island; and the western sector extends from Atkins Island to Clubbing Rocks. For the Aleutian Islands, the eastern sector includes rookeries from Sea Lion Rock (near Amak Island) to Adugak Island; the central sector extends from Yunaska Island to Kiska Island; and the western sector extends from Buldir Island to Attu Island.

Year	Gulf of Alaska			Aleutian Islands			Southeast Alaska
	Eastern	Central	Western	Eastern	Central	Western	
1975				19,769			
1976	7,053	24,678	8,311	19,743			
1977				19,195			
1979					36,632	14,011	6,376
1982							6,898
1985		19,002	6,275	7,505	23,042		
1989	7,241	8,552	3,800	3,032	7,572		8,471
1990	5,444	7,050	3,915	3,801	7,988	2,327	7,629
1991	4,596	6,273	3,734	4,231	7,499	3,085	7,715
1992	3,738	5,721	3,720	4,839	6,399	2,869	7,558
1994	3,369	4,520	3,982	4,421	5,790	2,037	8,826
1996	2,133	3,915	3,741	4,716	5,528	2,190	8,231
1997		3,352	3,633				
1998		3,346	3,361	3,847	5,761	1,913	8,693
1999	1,952						
2000	1,894	3,117	2,842	3,842	5,427	1,071	

Table 5.1. Groundfish and Squid Catches (metric tons) in the Eastern Bering Sea, 1964-1985 (NMFS 1999).

	Catches of Pollock (in metric tons) and Percentages							Total Groundfish Catch (in metric tons)				
Year	**Bering Sea**	**%**	**Aleutian Islands**	**%**	**Gulf of Alaska**	**%**	**Total**	**Bering Sea**	**Aleutian Islands**	**Gulf of Alaska**	**Total**	**%**
1964	174,792	0.4438			1,126	0.0045	175,918	393,891		248,192	642,083	0.2740
1965	230,551	0.6695			2,749	0.0076	233,300	344,369		360,131	704,500	0.3312
1966	261,678	0.5788			8,932	0.0404	270,610	452,081		221,172	673,253	0.4019
1967	550,362	0.6581			6,276	0.0451	556,638	836,308		139,206	975,514	0.5706
1968	702,181	0.7261			6,164	0.0490	708,345	967,083		125,822	1,092,905	0.6481
1969	862,789	0.7238			17,553	0.1549	880,342	1,192,020		113,333	1,305,353	0.6744
1970	1,256,565	0.7885			9,343	0.1099	1,265,908	1,593,649		84,983	1,678,632	0.7541
1971	1,743,763	0.8159			9,458	0.0817	1,753,221	2,137,326		115,758	2,253,084	0.7781
1972	1,874,534	0.8722			34,081	0.2147	1,908,615	2,149,092		158,768	2,307,860	0.8270
1973	1,758,919	0.8520			36,836	0.2550	1,795,755	2,064,444		144,478	2,208,922	0.8130
1974	1,588,390	0.8360			61,880	0.4041	1,650,270	1,900,092		153,143	2,053,235	0.8037
1975	1,356,736	0.8246			59,512	0.4191	1,416,248	1,645,232		142,015	1,787,247	0.7924
1976	1,177,822	0.8245			86,527	0.4971	1,264,349	1,428,565		174,081	1,602,646	0.7889
1977	978,370	0.8375	7,625	0.1132	112,089	0.5726	1,098,084	1,168,144	67,348	195,768	1,431,260	0.7672
1978	979,431	0.7520	6,282	0.1028	90,822	0.5647	1,076,535	1,302,509	61,092	160,830	1,524,431	0.7062
1979	913,881	0.7881	9,504	0.1264	98,508	0.6056	1,021,893	1,159,547	75,195	162,675	1,397,417	0.7313
1980	958,279	0.7842	58,156	0.5358	110,100	0.5439	1,126,535	1,221,944	108,531	202,426	1,532,901	0.7349
1981	973,505	0.7728	55,516	0.5328	139,168	0.5811	1,168,189	1,259,666	104,199	239,476	1,603,341	0.7286
1982	955,964	0.7891	57,978	0.5902	168,693	0.7209	1,182,635	1,211,483	98,233	234,001	1,543,717	0.7661
1983	982,363	0.7673	59,026	0.6238	215,567	0.7258	1,256,956	1,280,285	94,617	296,988	1,671,890	0.7518
1984	1,098,783	0.7535	81,834	0.5566	307,400	0.8619	1,488,017	1,458,299	147,022	356,659	1,961,980	0.7584
1985	1,179,759	0.7154	58,730	0.5183	284,823	0.8883	1,523,312	1,649,109	113,310	320,656	2,083,075	0.7313

Notes:
a = Arrowtooth flounder included in Greenland turbot catch statistics.
b = Includes POP shortraker, rougheye, northern and sharpchin.
c = Rocksole prior to 1991 is included in other flatfish catch statistics.
d = Through December 31, 1998.
e = Through Dec 31,1999 compiled from NMFS Region website.
N mbers don't include fish taken for research.

Table 5.2. Major fish prey from stomachs of Steller sea lions collected in Southeast Alaska, Kodiak Island, and the Gulf of Alaska during 1975-1993. Ranks are determined from the frequency of occurrence of prey in stomachs with contents (shown as percentage). The rank of stomach contents from Kodiak Island during 1990-1993 was determined from the percent frequency of occurrence of prey in scats with contents. The sizes of the various samples are shown below the location and sampling period.

Rank	**Gulf of Alaska** **975-1978** **n = 178**	**Kodiak** **975 - 978** **n = 63**	**Kodiak** **985-1986** **n = 67**	**Kodiak** **990-1993** **n = 54**	**SE Alaska** **986** **n = 4**
1	walleye pollock 69.1%	walleye pollock 49.2%	walleye pollock 68.7%	walleye pollock 64.8%	walleye pollock 64.3%
2	capelin 13.4%	capelin 28.1%	flatfish 13.4%	salmon 24.1%	flatfish 28.6%
3	Pacific cod 12.8%	Pacific cod 14.1%	Pacific cod 10.3%	Atka mackerel 16.7%	Pacific herring 14.3%
4	Pacific herring 8.9%	flatfish and salmon 7.9%	sand lance 7..4%	flatfish 14.8%	-
5	flatfish 5.1%	-	-	sand lance 7.4%	-

Table 5.3 Summary of estimates of Steller sea lion (SSL) mortality caused by killer whale (KW) predation. In alternatives 1-4, it was assumed that the SSL population was fixed at 42,000 animals and the crude death rate was 20% excluding killer whale predation. In alternative 5, the SSL population was fixed at 100,000. All models used an nderlying decline of 5% per year for SSLs in estimating the percent mortality due to killer whale predation.

	Alternative Models				
I put parameters for model	***1***	***2***	***3***	***4***	***5***
Amount Consumed by KW (kg/day)	74	74	74	74	74
Number of Days Feeding	365	365	365	365	365
Number of Killer Whales	125	125	125	125	125
Weight Per SSL (kg)	160	160	160	160	160
Percent of SSL in KW Diet	12.5%	10%	15%	5%	12.5%
Estimates regardi g predatio by killer whales					
Number of SSLs Eaten Per Year	2638	2110	6330	5275	5275
Mortality Rate = (# SSL eaten) /(total # of SSL)	6%	5%	8%	2.5%	3%
Total Mortality Rate Due to Killer Whales	**24%**	**20%**	**27%**	**%**	**2%**

Table 5.4 Census information for selected communities in the Bering Sea, Aleutian Islands, and G lf of Alaska.

Area	980s	990s	999
Alaska	401,851	550,043	619,500
Aleutians East Borough	1,643	2,464	2,179
Aleutians West Borough	6,125	9,478	3,913
Anchorage Borough	174,431	226,338	257,808
Bethel Census Area	10,999	13,656	16,215
Bristol Bay Borough	1,094	1,410	1,061
Dillingham Census Area	3,232	4,012	4,565
Kenai Peninsula Borough	25,282	40,802	48,993
Kodiak Island Borough	9,939	13,309	14,350
Lake and Peninsula Borough	1,384	1,668	1,748
Valdez - Cordova Census Area	8,348	9,952	10,229

Table 5.5. N umber of fin whales killed in the North Pacific prior to the whaling ban (from Tilman 1977)

Year	No. Whales Taken	Year	No. Whales Taken	Year	No. Whales Taken
1963	2503	1967	2272	1971	802
1964	3991	1968	1942	1972	758
1965	3165	1969	1276	1973	455
1966	2885	1970	1012	1974	413

Table 5.6. N umber of sei whales killed in the North Pacific prior to the whaling ban (from Tilman 1977)

Year	No. Whales Taken	Year	No. Whales Taken	Year	No. Whales Taken
1963	2590	1967	6053	1971	2993
1964	3642	1968	5740	1972	2327
1965	3172	1969	5157	1973	1856
1966	4406	1970	4503	1974	1280

Table 5.7 Estimate of Steller Sea lion baseline mortality due to take for 1959-1999 in the action area[1]

Description of Take	Dates	Rate of Take	Total Estimated Take
Entanglement in Marine Debris	(1970-1990) 1985	100 per year 0.07%	2,000 no estimate
Commercial Harvests	(1959) (1963-1972)		630 males 45,178 pups
Subsistence Harvests	1959-1991 (1992-1995) (1996-1999)	no estimate 448/ year (est) 178/year (est)	 2,000 600
Incidental Catch	1959-1966 1966-1977 1978-1988 1989-1999	no estimate 1,000-2,000/yr 100-2,000/yr <50/yr	no estimate 14,000-16,000 5,700-7,400 no estimate
Research	1975/78 1985/86 1989	62/yr 89/yr 16	250 178 16
Intentional Fisheries Take	(1956-1990)		52,000
Total Estimated Take	1970-1999		**23,000 – 26,000**

[1] Based on the following reviews: Entanglement (Calkins 1985; Loughlin et al. 1986), Commercial Harvest (Merrick et al. 1987), Subsistence Harvest (Wolfe and Mishler [all 4 pubs]), Incidental catch (Perez and Loughlin 1991), Research (Calkins and Goodwin 1988; Calkins et al. 1994), and Intentional take (Trites and Larkin 1992)

Table 5.8 Groundfish and Squid Catches in the eastern Bering Sea from 1954 to 1999 (in metric tons).

Year	Pollock	Pacific Cod	Sable Fish	Pacific Ocean Perch Complex	Other Rock Fish	Yellow Fin Sole	Greenland Turbot	Arrow-Tooth Flounder	Other Flatfish	Rock Sole	Atka Mackerel	Squid	Other Species	Total
1954						12,562								12,562
1955						14,690								14,690
1956						24,697								24,697
1957						24,145								24,145
1958	6,924	171	6			44,153							147	51,401
1959	32,793	2,864	289			185,321							380	221,647
1960			1,861	6,100		456,103	36,843	a						500,907
1961			15,627	47,000		553,742	57,348	a						673,717
1962			25,989	19,900		420,703	58,226	a						524,818
1963			13,706	24,500		85,810	31,565	a	35,643					191,224
1964	174,792	13,408	3,545	25,900		111,177	33,729	a	30,604				736	393,891
1965	230,551	14,719	4,838	16,800		53,810	9,747	a	11,686				2,218	344,369
1966	261,678	18,200	9,505	20,200		102,353	13,042	a	24,864				2,239	452,081
1967	550,362	32,064	11,698	19,600		162,228	23,869	a	32,109				4,378	836,308
1968	702,181	57,902	4,374	31,500		84,189	35,232	a	29,647				22,058	967,083
1969	862,789	50,351	16,009	14,500		167,134	36,029	a	34,749				10,459	1,192,020
1970	1,256,565	70,094	11,737	9,900		133,079	19,691	12,598	64,690				15,295	1,593,649
1971	1,743,763	43,054	15,106	9,800		160,399	40,464	18,792	92,452				13,496	2,137,326
1972	1,874,534	42,905	12,758	5,700		47,856	64,510	13,123	76,813				10,893	2,149,092
1973	1,758,919	53,386	5,957	3,700		78,240	55,280	9,217	43,919				55,826	2,064,444
1974	1,588,390	62,462	4,258	14,000		42,235	69,654	21,473	37,357				60,263	1,900,092
1975	1,356,736	51,551	2,766	8,600		64,690	64,819	20,832	20,393				54,845	1,645,232
1976	1,177,822	50,481	2,923	14,900		56,221	60,523	17,806	21,746				26,143	1,428,565
1977	978,370	33,335	2,718	2,654	311	58,373	27,708	9,454	14,393			4,926	35,902	1,168,144
1978	979,431	42,543	1,192	2,221	2,614	138,433	37,423	8,358	21,040		831	6,886	61,537	1,302,509
1979	913,881	33,761	1,376	1,723	2,108	99,017	34,998	7,921	19,724		1,985	4,286	38,767	1,159,547
1980	958,279	45,861	2,206	1,097	459	87,391	48,856	13,761	20,406		4,955	4,040	34,633	1,221,944
1981	973,505	51,996	2,604	1,222	356	97,301	52,921	13,473	23,428		3,027	4,182	35,651	1,259,666

Table 5.8 Groundfish and Squid Catches in the eastern Bering Sea from 1954 to 1999 (in metric tons).

Year	Pollock	Pacific Cod	Sable Fish	Pacific Ocean Perch Complex	Other Rock Fish	Yellow Fin Sole	Greenland Turbot	Arrow-Tooth Flounder	Other Flatfish	Rock Sole	Atka Mackerel	Squid	Other Species	Total
1982	955,964	55,040	3,184	224	276	95,712	45,805	9,103	23,809		328	3,838	18,200	1,211,483
1983	982,363	83,212	2,695	221	220	108,385	43,443	10,216	30,454		141	3,470	15,465	1,280,285
1984	1,098,783	110,944	2,329	1,569	176	159,526	21,317	7,980	44,286		57	2,824	8,508	1,458,299
1985	1,179,759	132,736	2,348	784	92	227,107	14,698	7,288	71,179		4	1,611	11,503	1,649,109
1986	1,188,449	130,555	3,518	560	102	208,597	7,710	6,761	76,328		12	848	10,471	1,633,911
1987	1,237,597	144,539	4,178	930	474	181,429	6,533	4,380	50,372		12	108	8,569	1,639,121
1988	1,228,000	192,726	3,193	1,047	341	223,156	6,064	5,477	137,418		428	414	12,206	1,810,470
1989	1,230,000	164,800	1,252	2,017	192	153,165	4,061	3,024	63,452		3,126	300	4,993	1,630,382
1990	1,353,000	162,927	2,329	5,639	384	80,584	7,267	2,773	22,568		480	460	5,698	1,644,109
1991	1,268,360	165,444	1,128	4,744	396	94,755	3,704	12,748	30,401	46,681	2,265	544	16,285	1,647,455
1992	1,384,376	163,240	558	3,309	675	146,942	1,875	11,080	34,757	51,720	2,610	819	29,993	1,831,954
1993	1,301,574	133,156	669	3,763	190	105,809	6,330	7,950	28,812	63,942	201	597	21,413	1,674,406
1994	1,362,694	174,151	699	1,907	261	144,544	7,211	13,043	29,720	60,276	190	502	23,430	1,818,628
1995	1,264,578	228,496	929	1,210	629	124,746	5,855	8,282	34,861	54,672	340	364	20,928	1,745,890
1996	1,189,296	209,201	629	2,635	364	129,509	4,699	13,280	35,390	46,775	780	1,080	19,717	1,653,355
1997	1,115,268	209,475	547	1,060	161	166,681	6,589	8,580	42,374	67,249	171	1,438	20,997	1,640,590
1998/d	1,101,428	160,681	586	1,134	203	101,310	8,303	14,985	39,940	33,221	901	891	23,156	1,486,739
1999/e	998,703	147,281	677	653	141	69,265	5,206	10,628	34,389	40,505	1,165	392	18,973	1,327,978

Notes:
a = Arrowtooth flounder included in Greenland turbot catch statistics.
b = Includes POP shortraker, rougheye, northern and sharpchin.
c = Rocksole prior to 1991 is included in other flatfish catch statistics.
d = Thro gh December 31, 1998.
e = Through Dec 31,1999 compiled from NMFS Region website.
N mbers don't include fish taken for research.

Table 5.9a Groundfish catch in the BSAI groundfish fisheries and associated bycatch of chinook salmon and "other" salmon (Source: NMFS, Alaska Region, Juneau, AK).

Year	Gear Type	Groundfish (metric tons)	Chinook (#'s)	Other Salmon (#'s)
1999*	Trawl	1,113,572	13,533	49,752
	Hook-and-line	91,141	3	31
	Pot Gear	15,788	9	0
	Jig	137	0	0
	Total	1,220,637	13,545	49,783
1998	Trawl	1,476,210	58,967	69,242
	Hook-and-line	130,359	4	62
	Pot Gear	14,155	0	0
	Jig	196	0	0
	Total	1,620,920	58,971	69,305
1997	Trawl	1,653,841	50,519	66,916
	Hook-and-line	153,853	11	79
	Pot Gear	22,658	0	0
	Jig	201	0	0
	Total	1,830,553	50,530	66,994
1996	Trawl	1,698,562	63,179	77,991
	Hook-and-line	116,169	26	69
	Pot Gear	33,639	0	0
	Jig	273	0	0
	Total	1,848,643	63,205	78,060
1995	Trawl	1,781,965	22,691	21,817
	Hook-and-line	126,069	745	57
	Pot Gear	21,101	0	1
	Jig	616	0	0
	Total	1,929,751	23,436	21,875

* Amounts calculated on October 1999.

Table 5.9b Groundfish catch in the GOA groundfish fisheries and associated bycatch of chinook salmon and other salmon (Source: NMFS, Alaska Region, Juneau, AK)

Year	Gear Type	Groundfish (metric tons)	Chinook (#'s)	Other Salmon (#'s)
1999*	Trawl	155,541	18,214	7,031
	Hook-and-line	25,686	0	0
	Pot Gear	18,125	0	0
	Jig	75	0	0
	Total	199,427	18,214	7,031
1998	Trawl	208,761	16,941	13,539
	Hook-and-line	25,467	0	0
	Pot Gear	10,806	0	0
	Jig	79	0	0
	Total	245,114	16,941	13,539
1997	Trawl	195,261	15,230	3,014
	Hook-and-line	25,937	0	0
	Pot Gear	9,417	0	0
	Jig	340	0	0
	Total	230,955	15,230	3,014
1996	Trawl	161,895	15,761	4,176
	Hook-and-line	27,261	0	0
	Pot Gear	12,296	0	0
	Jig	604	0	0
	Total	202,055	15,761	4,176
1995	Trawl	167,172	14,646	64,510
	Hook-and-line	31,863	6	179
	Pot Gear	16,251	0	0
	Jig	600	0	0
	Total	215,886	14,652	64,688

* Amounts calculated on October 1999.

Table 5.10. Breakdown of "other" salmon bycatch in BSAI and GOA groundfish fisheries (Source: NMFS, Alaska Fisheries Science Center; from the Observer Database)

			Percent of "Other" Salmon Category				
Area	**Year**	**Gear Type**	**Chum Salmon**	**Coho**	**Sockeye**	**Pink**	**Steelhead**
BSAI	1999	Trawl	96.891	2.912	0.004	0.193	0.000
		Hook-and-line	100.000	0.000	0.000	0.000	0.000
	1998	Trawl	99.704	0.220	0.016	0.060	0.000
		Hook-and-line	81.061	18.939	0.000	0.000	0.000
	1997	Trawl	99.738	0.160	0.098	0.004	0.000
		Hook-and-line	100.000	0.000	0.000	0.000	0.000
	1996	Trawl	99.707	0.289	0.002	0.002	0.000
		Hook-and-line	79.289	13.971	0.000	6.740	0.000
	1995	Trawl	95.917	3.985	0.000	0.098	0.000
		Hook-and-line	100.000	0.000	0.000	0.000	0.000
	Average	Trawl	98.391	1.513	0.024	0.071	0.000
		Hook-and-line	92.070	6.582	0.000	1.348	0.000
GOA	1999	Trawl	75.923	20.526	1.761	1.790	0.000
		Hook-and-line	15.686	84.314	0.000	0.000	0.000
	1998	Trawl	71.723	22.035	1.490	4.752	0.000
		Hook-and-line	12.800	53.600	25.600	8.000	0.000
	1997	Trawl	98.095	0.939	0.234	0.732	0.000
		Hook-and-line	60.561	39.439	0.000	0.000	0.000
	1996	Trawl	95.902	3.947	0.060	0.091	0.000
		Hook-and-line	38.327	50.348	0.000	11.325	0.000
	1995	Trawl	99.060	0.862	0.064	0.014	0.000
		Hook-and-line	20.109	75.043	0.000	4.848	0.000
	Average	Trawl	88.141	9.662	0.722	1.476	0.000
		Hook-and-line	29.497	60.549	5.120	4.835	0.000

Table 5.1 . Alaska OCS oil and gas lease sales.

Planning Area	Sale Number	Sale Date	No. leases issued	Disposition
Aleutian Basin [North]	Sale 92	Oct 1988	23	all leases have been relinquished
Cook Inlet	Sale 60	Sep 1981	13	all leases have expired
Cook Inlet	Sale CI	Oct 1987	87	all leases have expired
Cook Inlet	Sale 149	Oct 1997	87	sale area has two active leases
Gulf of Alaska	Sale 39	Apr 1976	76	all leases have expired
Gulf of Alaska	Sale 55	Oct 1980	35	all leases have expired
Navarin Basin	Sale 83	Apr 1984	163	all leases have been relinquished
Norton Basin	Sale 57	Mar 1983	59	all leases have been relinquished
St. George Basin	Sale 70	Apr 1983	96	all leases have been relinquished

Table 6.1. Analysis of recruitment of various groundfish species in the EBS, AI, and GOA. The Dickey-Fuller test takes as the null hypothesis that the variable is nonstationary. A statistically significant number for that test means that the null hypothesis is rejected and the series is stationary. The KPSS test (Kwiatowski et al. 1992) takes as the null hypothesis that the variable is stationary. A significant positive number indicates that the null hypothesis is rejected and the series is nonstationary. The last column indicates if there are autoregressive terms, order 0 means no significant autoregressive terms, order 1 means a first order autoregressive process. Where results of the stationary tests are contradictory, the residuals were also tested after running the model.

Management unit	Dickey-Fuller	KPSS	Autoregressive order
EBS pollock	?	?	0
EBS Pacific cod	N	N	0
EBS yellowfin sole	N	S	1
esiduals	S	S	
EBS Greenland turbot	S	N	1
esiduals	S	S	0
EBS arrowtooth flounder	N	S	0
EBS rock sole	N	S	1
esiduals	S	S	
EBS flathead sole	N	?	1
EBS Alaska plaice	N	N	1
Sablefish	N	S	0
AI POP	N	N	0
EBS POP	S	S	1
AI Atka mackerel	N	S	0
GOA pollock	S	N	1
esiduals	S	S	
GOA Pacific cod	N	N	0
GOA arrowtooth flounder	N	S	1
esiduals	N	S	
GOA POP	N	S	0
GOA thornyhead rockfish	N	N	1
esiduals	S	S	

Table 6.2. Summary of the possible effects of harvesting groundfish in the BSAI and GOA with various gear types.

	Trawl	Hook-and-line	Pot	Jig
Percentage of total catch in 999	BSAI = 86% GOA = 73%	BSAI = 12% GOA = 14%	BSAI = 2% GOA = 13%	BSAI = 0.02% GOA = 0.1%
Maximum rate of removal (mt/week in1999)	BSAI = 96,072 GOA = 18,357	BSAI = 10,155 GOA = 4,336	BSAI = 5,753 GOA = 4,087	BSAI = 47 GOA = 34
Number of vessels in1998	BSAI = 166 GOA = 198	BSAI = 115 GOA = 876	BSAI = 79 GOA = 178	
Bycatch of prohibited species	salmon herring halibut crab	halibut some crab	crab	
Effects on habitat	Bottom trawl disturbance of benthic habitat, modification of hard s bstrate. Long term ecological effects are likely to reduce biodiversity. Incidental catch of living s bstrates (corals, anemones, sponges, and sea whips) and modification to non-living s bstrates.	Some disturbance with similar effects as bottom trawl (although on a smaller scale). Incidental catch of living s bstrates (mostly anemones and sponges) and modification to non-living substrates.		Significant negative impacts to benthic habitat is nlikely.

Table 6.3. Portion of the catch of BSAI and GOA groundfish in Steller sea lion critical habitat by gear type (average from 1995-1999).

Catch of groundfish in Steller sea lion critical habitat				
Area	**All gear**	**Trawl**	**Pot**	**Hook-and-line**
BSAI inside critical habitat around rookeries and haulouts only	14%	13%	63%	18%
BSAI inside critical habitat around rookeries and haulouts plus special foraging areas	49%	50%	81%	27%
GOA inside critical habitat around rookeries and haulouts only	48%	51%	60%	25%
GOA inside critical habitat around rookeries and haulouts plus special foraging areas	54%	58%	71%	25%

Table 6.4. Amo nts of groundfish harvested on observed vessels and in ha ls sampled by observers compared with amounts estimated using the "blend" catch estimation procedure. Recall from chapter 2 that the "blend" approach consists of a set of rules for determining whether total catch is estimated from observer data or from the fishing vessel records. HAL = hook-and-line gear, POT = pot gear, TRW = trawl gear.

FMP	Gear	Target	Blend estimate (mt)	Catch on observed vessels (mt)[2]	Catch on observed vessels / blend estimate of total[3]	Catch in hauls observed (mt)[4]	Catch in hauls observed / blend estimate of total[5]
BSAI							
	HAL	Pac. Cod	144,912	135,694	94%	95,827	66%
	HAL	Sablefish	2,549	1,041	41%	473	19%
	HAL	T rbot	4,909	5,387	110%*	2,703	55%
	POT	Pac. Cod	22,639	7,359	33%	5,511	24%
	TRW	Atka Mack.	72,379	73,385	101%*	51,599	71%
	TRW	Pac. Cod	137,930	126,581	92%	89,175	65%
	TRW	O. Flats	3,938	4,199	107%*	2,406	61%
	TRW	Rockfish	12,283	11,989	98%	9,023	73%
	TRW	Flathead	19,671	14,182	72%	8,010	41%
	TRW	Pollock	1,008,898	876,911	87%	634,683	63%
	TRW	Rock Sole	57,928	59,342	102%*	31,742	55%
	TRW	Yellowfin	248,865	237,625	95%	145,362	58%
		Totals	1,736,901	1,553,695	89%	1,076,514	62%
GOA							
	HAL	Pac. Cod	11,511	1,667	14%	984	9%
	HAL	Rockfish	526	19	4%	15	3%
	HAL	Sablefish	14,963	3,139	21%	1,244	8%
	POT	Pac. Cod	9,419	355	4%	257	3%
	TRW	Pac. Cod	53,128	11,020	21%	8,844	17%
	TRW	Deep Flat	7,157	3,225	45%	1,540	22%
	TRW	Shallow Flat	10,068	2,523	25%	1,706	17%
	TRW	Rockfish	20,051	16,369	82%	9,599	48%
	TRW	Flathead	4,137	1,980	48%	1,065	26%
	TRW	Other Spp.	857	61	7%	47	5%
	TRW	Pollock	87,999	31,295	36%	27,829	32%
	TRW	Rex Sole	8,574	5,493	64%	2,956	34%
		Totals	228,390	77,146	34%	56,086	26%

[1] Grou ndfish metric tons from the blend database.

[2] Grou ndfish metric tons from observer official total catch -- all hauls/sets while the observer is onboard, includes observer transcription of skipper estimates for ha ls not independently estimated by the observer.

[3] Percent of observer official total catch compared to blend total catch estimate. This indicates the proportion of groundfish harvested on observed vessels.

[4] Grou ndfish metric tons from hauls actually sampled by the observer. On trawl vessels, a single observer can typically sample 40-60 percent of the hauls. These are the weights of the haul/set from which a sample was taken, not the weight of the sample.

[5] Percentage of weight of sampled ha ls compared to the blend total catch estimate.

* Indicates that the catch estimate from the observer exceeded the catch estimated using the blend approach.

Table 6.5. Summary of the spawning and total biomass in 1999 of a fished stock relative to an unfished stock

Species or species group	1999 spawning biomass/unfished stock	999 total biomass/unfished stock
EBS Pollock	43%	51%
EBS Pacific cod	50%	50%
EBS Atka Mackerel	66%	56%
All EBS Species	54%	58%
GOA Pollock and Pcod	59%	46%
All GOA and EBS Combined	54%	58%

Table 6.6. Scores based on answers to questions about competitive interactions between target fisheries and the western stock of Steller sea lions in the Bering Sea/Aleutian Islands and Gulf of Alaska fishery management areas.

Fished Species or Target Fishery	Bering Sea/ Aleutian Islands	Gulf of Alaska
Pollock	**8**	**8**
Pacific cod	**8**	**8**
Sablefish	0	0
Atka mackerel	**8**	0
Yellowfin sole	0	1
Rock sole	1	1
Greenland turbot	1	1
Arrowtooth flounder	2	2
Flathead sole	0	1
Other flatfish	1	1
Pacific ocean perch	1	1
Other red rockfish	1	n/a
Sharpchin/northern rockfish	1	1
Shortraker/rougheye rockfish	1	0
Squid	2	n/a
Other species	1	1
Flatfish, Deep	n/a	0
Flatfish, Shallow	n/a	1
Rex sole	n/a	0
Rockfish, other slope	n/a	0
Rockfish, pelagic shelf	n/a	1
Rockfish, demersal shelf	n/a	1
Thornyhead	n/a	0
Forage fish	2	2

n/a = not applicable; this target fishery definition is not applicable in this fishery management area.

Table 6.7. Permitted seafood processing facilities in the action area. Data from the Alaska Division of Environmental Health (available through www.state.ak.us).

Location of Facility	**Canneries**	**Land-based**	**Vessel**	**Direct-Marketing**
Adak		1		
Anchorage		20	5	5
Chignik	1			
Cordova	4	5	1	2
Dillingham	2	2		
Egegik	1	1	1	
Kenai - Homer	1	22	2	4
King Cove	1		1	
King Salmon	1	5		2
Kodiak	4	12	8	1
Larsen Bay	1			
Ninilchik	1			
Seward	2	3		2
Unalaska		6	2	
Valdez	1	3	1	3
Totals	20	80	21	19

Table 9.1. Area (in km^2) of CH-RFRPA areas, their status relative to being closed or open to regulated pollock, Pacific cod, and Atka mackerel fisheries, and the fishery management region or 3-digit area they are within. Percent of total CH-RFRPA area (including CH foraging areas and the SCA) closed and open are also shown

Fishery	CH-RFRPA	Status			Percent	
Region/Area	Area	Closed	Open	Total	Closed	Open
EBS	7	166	20,579	20,746	1%	99%
	8	54,390		54,390	100%	0%
	9	37,287		37,287	100%	0%
EBS Total		91,844	20,579	112,423	82%	18%
541	12	1,407	37,530	38,937	4%	96%
542	13	40,587		40,587	100%	0%
543	13	20,576		20,576	100%	0%
AI Total		62,570	37,530	100,100	63%	37%
610	5	662	14,310	14,971	4%	96%
	6	13,854		13,854	100%	0%
	10	7,362		7,362	100%	0%
	11	8,491		8,491	100%	0%
610 Total		30,368	14,310	44,677	68%	32%
620	3	395	21,623	22,018	2%	98%
	4	17,261		17,261	100%	0%
	5	174	3,663	3,837	5%	95%
620 Total		17,830	25,286	43,116	41%	59%
630	1	501	3,536	4,037	12%	88%
	2	31,364		31,364	100%	0%
	3	457	7,599	8,056	6%	94%
630 Total		32,322	11,135	43,457	74%	26%
640	1	406	11,781	12,187	3%	97%
GOA Total		80,926	62,512	143,437	56%	44%
Grand Total		235,339	120,620	355,960	66%	34%

Table 9.2. Description of CH-RFRPA areas 1-13 shown in Figures 10-1, 10-2, and 10-3.

Area	Description
1	All waters 20 nm seaward of sites in area 1 west to 148°°45'W and outside of statistical areas 639 and 649
2	All waters 20 nm seaward of sites in area 2 east to 148°45'W, in the Shelikof Strait critical habitat foraging area east of 154°W, and on the east side of Kodiak Island south to a line connecting the following 2 points: 57°31'3" N 152°17'48"W 57°24'36"N 151°40'29"W
3	All waters 20 nm seaward of sites in area 3 north on the east side of Kodiak Island to a line connecting the above 2 points, and in the Shelikof Strait critical habitat foraging area west of 154°W
4	All waters 20 nm seaward of sites in area 4 north to the southern boundary of the Shelikof Strait critical habitat foraging area
5	All waters 20 nm seaward of sites in area 5 west to 161°15'W
6	All waters 20 nm seaward of sites in area 6 east to 161°15'W
7	All waters 20 nm seaward of sites in area 7 and in the Sea Lion Conservation Area west to a line connecting the following 2 points: 55°30'N °W 54°51'N °33'33"W
8	166 All waters within the southeastern Bering Sea critical habitat foraging area east of 164 management area 518 and west to a line connecting the above 2 points
9	All waters within both management area 518 (Bogoslof) and the southeastern Bering Sea critical habitat foraging area
10	All waters 20 nm seaward of sites in area 10 in management area 610
11	All waters 20 nm seaward of sites in area 11 in management area 610
12	All waters 20 nm seaward of sites in area 12, in the Seguam Pass critical habitat foraging area, and in statistical area 541
13	All waters 20 nm seaward of sites in area 13 and in statistical areas 542 and 543

Table 9.3 CH-RFRPA sites in the Gulf of Alaska (GOA), eastern Bering Sea (EBS), and Aleutian Islands (AI). CH-RFRPA areas (1-13) and their status relative to constrained fishing for pollock, Pacific cod, and Atka mackerel (open or closed) are listed and shown in Figures 10-1, 10-2 and 10-3. Each sites' status relative to critical habitat (Y), rookery, haulout (H), and the RFRPA/BO (Y) is shown. Sites listed in fishery management area EBS/GOA are located inside the EBS, but near the border with the GOA. Similarly, sites listed as GOA/EBS are located in the GOA, but near the border with the EBS.

CH/RFRP Area	Open (O) or Closed (C)	Site Name	Rookery or Haulo t (H)	Critical Habitat	RFRPA	Fishery Mgt. Area
1	O	CAPE ST. ELIAS	H	Y	Y	GOA
1	O	HOOK POINT	H	Y	Y	GOA
1	O	MIDDLETON ISLAND	H	Y		GOA
1	O	CAPE HINCHINBROOK	H		Y	GOA
1	O	SEAL ROCKS	Rookery	Y	Y	GOA
1	O	GLACIER ISLAND	H		Y	GOA
1	O	WOODED ISLAND (FISH)	Rookery	Y	Y	GOA
1	O	POINT ELEANOR	H	Y		GOA
1	O	THE NEEDLES	H	Y	Y	GOA
1	O	PERRY ISLAND	H	Y		GOA
1	O	POINT ELRINGTON	H	Y	Y	GOA
2	C	RUGGED ISLAND	H		Y	GOA
2	C	CHISWELL ISLANDS	H	Y	Y	GOA
2	C	SEAL ROCKS (KENAI)	H	Y		GOA
2	C	STEEP POINT	H		Y	GOA
2	C	OUTER (PYE) ISLAND	Rookery	Y	Y	GOA
2	C	GORE POINT	H	Y		GOA
2	C	PERL	H		Y	GOA
2	C	NAGAHUT ROCKS	H	Y		GOA
2	C	MARMOT	Rookery	Y	Y	GOA
2	C	SEA LION ROCKS	H	Y	Y	GOA
2	C	SUGARLOAF	Rookery	Y	Y	GOA
2	C	KODIAK/CAPE CHINIAK	H	Y	Y	GOA
2	C	SUD/SUD ISLAND	H	Y		GOA
2	C	LONG	H	Y	Y	GOA
2	C	SEA OTTER ISLAND	H	Y	Y	GOA
2	C	USHAGAT/SW	H	Y	Y	GOA
2	C	LATAX ROCKS	H	Y	Y	GOA
2	C	CAPE DOUGLAS	H		Y	GOA
2	C	SHAKUN ROCK	H	Y	Y	GOA
2	C	KODIAK/CAPE UGAT	H	Y	Y	GOA
3	O	UGAK	H	Y	Y	GOA
3	O	KODIAK/GULL POINT	H	Y	Y	GOA
3	O	KODIAK/CAPE BARNABAS	H	Y	Y	GOA
3	O	TWO HEADED ISLAND	H	Y	Y	GOA
3	O	SITKINAK/C. SITKINAK	H	Y	Y	GOA
3	O	CAPE GULL	H	Y	Y	GOA
3	O	CAPE KULIAK	H	Y		GOA
3	O	TAKLI	H	Y	Y	GOA
3	O	KODIAK/CAPE IKOLIK	H	Y	Y	GOA
3	O	PUALE BAY	H	Y	Y	GOA
4	C	CHIRIKOF	Rookery	Y	Y	GOA
4	C	NAGAI ROCKS	H	Y	Y	GOA
4	C	CHOWIET	Rookery	Y	Y	GOA
4	C	SUTWIK	H	Y	Y	GOA

CH/RFRP Area	Open (O) or Closed (C)	Site Name	Rookery or Haulo t (H)	Critical Habitat	RFRPA	Fishery Mgt. Area
4	C	LIGHTHOUSE ROCKS	H	Y	Y	GOA
4	C	KAK	H		Y	GOA
5	O	MITROFANIA	H		Y	GOA
5	O	SPITZ	H	Y	Y	GOA
5	O	ATKINS	Rookery	Y	Y	GOA
5	O	CASTLE ROCK	H	Y	Y	GOA
5	O	CHERNABURA	Rookery	Y	Y	GOA
5	O	THE WHALEBACK	H	Y	Y	GOA
5	O	NAGAI	H	Y		GOA
5	O	SEA LION ROCKS	H	Y	Y	GOA
5	O	JUDE	H	Y	Y	GOA
6	C	OLGA ROCKS	H		Y	GOA
6	C	SUSHILNOI ROCKS	H		Y	GOA
6	C	PINNACLE ROCK	Rookery	Y	Y	GOA
6	C	CATON	H	Y		GOA
6	C	CLUBBING ROCKS	Rookery	Y	Y	GOA
6	C	SOUTH ROCKS	H	Y	Y	GOA
6	C	BIRD	H	Y	Y	GOA
7	O	AMAK+ROCKS	H	Y	Y	EBS
7	O	SEA LION ROCK (AMAK)	Rookery	Y	Y	EBS
8	C	UNIMAK/CAPE SARICHEF	H		Y	EBS/GOA
8	C	AKUN/BILLINGS HEAD	Rookery	Y	Y	EBS/GOA
8	C	AKUTAN/REEF-LAVA	H	Y	Y	EBS/GOA
8	C	UNALASKA/BISHOP PT	H		Y	EBS
8	C	CAPENEWENHAM	H	Y		EBS
8	C	ST.LAWRENCE-SWCAPE	H	Y		EBS
8	C	ST. LAWRENCE-S.PUNUK	H	Y		EBS
8	C	ST. GEORGE-DALNOI PT	H	Y		EBS
8	C	ST. GEORGE-S. ROOKRY	H	Y		EBS
8	C	ST. PAUL-SEA LION RK	H	Y		EBS
8	C	ST. PAUL-NE POINT	H	Y		EBS
8	C	ROUND (WALRUS IS)	H	Y		EBS
8	C	HALL	H	Y		EBS
8	C	WALRUS	Rookery	Y	Y	EBS
9	C	BOGOSLOF/FIRE ISLAND	Rookery	Y	Y	EBS
9	C	UMNAK/CAPE ASLIK	H	Y	Y	EBS
9	C	ADUGAK	Rookery	Y	Y	EBS/GOA
9	C	KAGAMIL	H	Y	Y	EBS/GOA
9	C	ULIAGA	H	Y	Y	EBS/GOA
10	C	ROUND	H		Y	GOA/EBS
10	C	UGAMAK	Rookery	Y	Y	GOA/EBS
10	C	AIKTAK	H		Y	GOA/EBS
10	C	TIGALDA/ROCKS NE	H	Y	Y	GOA/EBS
10	C	TANGINAK	H	Y	Y	GOA/EBS
10	C	ROOTOK	H		Y	GOA/EBS
10	C	AKUTAN/CAPE MORGAN	Rookery	Y	Y	GOA/EBS
10	C	OLD MAN ROCKS	H	Y	Y	GOA/EBS
10	C	UNALASKA/CAPE	H	Y		GOA/EBS
11	C	UNALASKA/CAPE IZIGAN	H		Y	GOA/EBS
11	C	EMERALD	H	Y	Y	GOA/EBS
11	C	POLIVNOI ROCK	H	Y		GOA/EBS

CH/RFRP Area	Open (O) or Closed (C)	Site Name	Rookery or Haulo t (H)	Critical Habitat	RFRPA	Fishery Mgt. Area
11	C	OGCHUL	Rookery	Y	Y	GOA/EBS
11	C	SAMALGA	H		Y	GOA/EBS
11	C	CHUGINADAK	H	Y	Y	GOA/EBS
12	O	YUNASKA	Rookery	Y	Y	AI
12	O	CHAGULAK	H	Y	Y	AI
12	O	AMUKTA AND ROCKS	H	Y	Y	AI
12	O	SEGUAM/OTHER	H	Y	Y	AI
12	O	SEGUAM/FINCH POINT	H	Y		AI
12	O	SEGUAM/SADDLERIDGE	Rookery	Y	Y	AI
12	O	AGLIGADAK	Rookery	Y	Y	AI
12	O	AMLIA/EAST	H	Y	Y	AI
12	O	TANADAK (AMLIA)	H	Y	Y	AI
12	O	SAGIGIK	H	Y	Y	AI
12	O	AMLIA/SVIECH. HARBOR	H	Y	Y	AI
12	O	ATKA/N. CAPE-C.KOROVIN	H	Y	Y	AI
12	O	KASATOCHI	Rookery	Y	Y	AI
12	O	ANAGAKSIK	H	Y	Y	AI
12	O	GREAT SITKIN	H	Y		AI
12	O	LITTLE TANAGA STRAIT	H	Y	Y	AI
12	O	ADAK/C.YAKAK-LAKE PT	Rookery	Y	Y	AI
13	C	KANAGA/N CAPE	H	Y	Y	AI
13	C	KANAGA/SHIP ROCK	H	Y	Y	AI
13	C	BOBROF	H	Y	Y	AI
13	C	TANAGA/BUMPY POINT	H	Y	Y	AI
13	C	GRAMP ROCK	Rookery	Y	Y	AI
13	C	UGIDAK	H	Y	Y	AI
13	C	TAG	Rookery	Y	Y	AI
13	C	KAVALGA	H	Y		AI
13	C	ULAK	Rookery	Y	Y	AI
13	C	UNALGA & DINKUM RKS	H	Y	Y	AI
13	C	AMATIGNAK/NITROF PT.	H	Y	Y	AI
13	C	SEMISOPOCHNOI/POCHNO	Rookery	Y	Y	AI
13	C	SEMISOPOCHNOI/PETREL	Rookery	Y	Y	AI
13	C	AMCHITKA/EAST CAPE	Rookery	Y	Y	AI
13	C	AMCHITKA/C. IVAKIN	H		Y	AI
13	C	AMCHITKA/COLUMN	Rookery	Y	Y	AI
13	C	LITTLE SITKIN	H	Y	Y	AI
13	C	AYUGADAK	Rookery	Y	Y	AI
13	C	RAT	H		Y	AI
13	C	SEGULA/GULA POINT	H	Y	Y	AI
13	C	SEGULA/CHUGUL POINT	H	Y		AI
13	C	TANADAK (KISKA)	H	Y	Y	AI
13	C	KISKA/SIRIUS POINT	H	Y	Y	AI
13	C	KISKA/SOBAKA & VEGA	H	Y	Y	AI
13	C	KISKA/LIEF COVE	Rookery	Y	Y	AI
13	C	KISKA/CAPE ST STEPHN	Rookery	Y	Y	AI
13	C	BULDIR	Rookery	Y	Y	AI
13	C	SHEMYA	H	Y	Y	AI
13	C	ALAID	H	Y	Y	AI
13	C	AGATTU/CAPE SABAK	Rookery	Y	Y	AI
13	C	ATTU/CHIRIKOF POINT	H	Y	Y	AI
13	C	AGATTU/GILLON PT.	Rookery	Y	Y	AI
13	C	ATTU/CAPE WRANGELL	Rookery	Y	Y	AI

Table 9.4. Seasonal fraction of the biomass of pollock, Pacific cod, and Atka mackerel in critical habitat in the Steller sea lion management area which is open for fishing (see figure 9.1). These fractions are then m ltiplied by the seasonal apportionment of TAC by management area to get the TAC limit for the specified area.

	Seasonal fraction of biomass inside open CH-RFRPA areas			
Area	**A**	**B**	**C**	**D**
Eastern Bering Sea (area 7)				
Pollock	.364	.231	.029	.046
Pacific cod	.344	.065	.083	.200
Gulf of Alaska				
Pacific cod				
Area 610 (SSL area 5)	.238	.008	.006	.010
Area 620/630 (SSL areas 1,3,5)	.636	.172	.195	.201
Pollock				
Area 610 (SSL area 5)	.048	.048	.021	.021
Area 620 (SSL area 3&5)	.107	.107	.046	.046
Area 630 (SSL area 1&3)	.001	.001	.022	.022
Area 640 (SSL area	.002	.002	.003	.003
Aleutian Islands (area 12)				
Atka mackerel	.110	.110	.110	.110
Pollock	.042	.049	.058	.054
Pacific cod	.687	.371	.142	.324

Table 9.5. Summary statistics of Steller sea lion count data by area. Data are from the NMFS 2000 Steller sea lion survey.

Block	Area	Non-pups	Non-pup sites	Pups	Pup sites
I	1	2314	9	689	2
	2	2935	21	1458	3
	3	779	9	0	0
	4	1262	8	418	2
	5	2033	12	406	2
	6	2398	7	1087	2
II	7	1204	2	134	1
	8	624	6	56	1
	9	884	6	355	2
	10	1105	7	1063	2
	11	1316	9	42	1
III	12	4925	39	1240	5
	13	3588	23	2425	14

Table 9.6. Summary statistics of the number of Steller sea lion non-pups and pups by block and open/closed areas. Data are from the NMFS 2000 Steller sea lion survey.

Block	Status for Fishing	Non-pup	Pup
I	open	4946	1095
	closed	6595	2963
	% open	43	27
II	open	1204	134
	closed	3929	1516
	% open	23	8
III	open	4925	1240
	closed	3588	2425
	% open	58	34
Total (pooled)	open	11075	2469
	closed	14112	6904
	% open	44	26

Table 9.7. Summary of Steller sea lion non-pup count data in the 13 areas. Count data are from 1991 to 2000 (pers. comm. John Sease, National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, WA).

Area	**991**	**992**	**994**	**996**	**998**	**2000**	**Trend (r)**
	4276	3956	3344	2302	1790	2134	-0.10
2	5002	4951	4812	3941	2977	2935	-0.07
3	1197	923	1165	822	943	779	-0.04
4	2385	2246	1744	1579	1647	1262	-0.06
5	2524	2417	2727	2523	2814	2033	-0.01
6	2474	2850	2702	2884	2669	2398	-0.01
7	910	1198	1160	1570	1390	1204	0.03
8	303	532	778	659	836	624	0.07
9	1127	1067	921	879	736	884	-0.04
0	1419	1363	1437	1361	1349	1105	-0.02
	1757	1734	1686	1608	1654	1316	-0.03
2	6049	5254	4877	4620	4969	4925	-0.02
3	7599	7396	6000	5847	5439	3588	-0.07
Total	37022	35887	33353	30595	29213	25187	-0.04

Table 9.8. Summary of Steller sea lion non-pup trend data in the three blocks. Count data are from 1991 to 2000 (pers. comm. John Sease, National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, WA).

Block	Status	Trends (r)	Lower CI	Upper CI
I	open	-0.05	-0.07	-0.03
	closed	-0.05	-0.06	-0.04
II	open	-0.01	-0.03	0.01
	closed	0.0	-0.04	0.05
III	open	-0.02	-0.05	0.01
	closed	-0.07	-0.11	-0.04

Table 9.9. Catch estimates (mt) of pollock, Pacific cod, and Atka mackerel by each target fishery (all gear types) in 1998 and 1999 in the open and closed portions of each block.

		Pollock		Pacific cod		Atka mackerel		Total	
Block	**Status**	**998**	**999**	**1998**	**999**	**998**	**999**	**998**	**999**
I	Open	82,434	63,964	12,912	11,423			95,346	75,387
	Closed	21,620	13,841	17,045	16,581			38,665	30,421
II	Open	308,467	237,433	18,680	18,247			327,147	255,679
	Closed	358,525	114,460	31,503	28,864	605	1,944	390,028	143,323
III	Open	1,509	27	16,766	18,561	5,523	12,226	18,275	18,588
	Closed	15,712	140	7,795	5,314	38,973	15,318	23,506	5,454

Table 9.10. Possible outcomes of jointly examining whether trends in closed and open areas have improved after implementation of conservation measures.

Outcome	**Evidence**	**Possible conclusions**		**Supporting evidence**
	Open better Closed better	Fishery contributed to decline of sea lions	Conservation measures in open areas are adequate	Indication that more fish are available in critical habitat in both closed and open areas
2	Open not better Closed better	Fishery contributed to decline of sea lions	Conservation measures in open areas are not adequate	Indication that more fish are available in critical habitat in only closed areas
3	Open not better Closed not better	Fishery did not contribute to decline of sea lions	Fishery has no effect on sea lions	Indication that more fish are available in critical habitat in both closed and open areas
4	Open better Closed not better	Fishery did not contribute to decline of sea lions	Fishery helps sea lions	

Table 9.1 . Statistical power to detect an improvement in the population trend before and after conservation measures are implemented, by block, for 4-8 years of annual counts of non-pups. The improvement in population trend was set at 0.04. The future precision of the abundance estimates was assumed to be the same as observed previously, estimated by the standard error of the Y variable, SE(Y), from the regression on log abundance from 1991 to 2000. This represents the coefficient of variation of the abundance estimates. The significance level was set to 0.10.

Block	Status	SE(Y) (1991-2000)	4 years	5 years	6 years	7 years	8 years
I	Open	0.053	0.41	0.68	0.84	0.92	0.97
	Closed	0.036	0.80	0.95	0.98	1.00	1.00
II	Open	0.056	0.68	0.83	0.91	0.96	0.99
	Closed	0.123	0.42	0.47	0.59	0.64	0.71
III	Open	0.078	0.20	0.33	0.50	0.64	0.78
	Closed	0.106	0.41	0.54	0.63	0.71	0.73

Table 9.12. Probability of making a correct decision after 5 additional annual counts of non-pup are performed (6 years of data), using a significance test. The probability of a correct outcome is, for example, the probability that concludes outcome 1 has occurred when it truly has occurred (e.g., one concludes both the closed and open areas have trends that have improved when they both actually have improved). The probability of not making a major error is, for O tcome 1 and 2, the probability of concluding either 1 or 2, and, for O tcome 3 and 4, the probability of concluding either 3 or 4.

Block	Outcome	Probability of correct outcome	Probability of not making a major error
I	1	0.82	.99
	2	0.91	.98
	3	0.80	.85
	4	0.67	.83
II	1	0.54	.59
	2	0.48	.57
	3	0.64	.82
	4	0.74	.82
III	1	0.33	.63
	2	0.61	.65
	3	0.78	.81
	4	0.41	.80

Table 9.13. Relative loss values for a decision analysis, showing the possible combinations of true conditions (columns) and decision options (rows).

		True condition			
		Fishery contributes to decline of sea lions		Fishery does not contribute to decline of sea lions	
Decision options		Both better	Closed better Open not better	Both not better	Closed not better, open better
Both better		0	1	3	3
Closed better	Open not better	1	0	3	3
Both not better		3	3	0	1
Closed not better	Open better	3	3	1	0

Table 9.14. Probability of making a correct decision after 5 additional annual counts of non-pup are performed (6 years of data), using a decision analysis approach with the loss functions specified in Table 9.12.

Block	Outcome	Probability of correct outcome	Probability of not making a major error
I	1	0.96	1.00
	2	0.77	1.00
	3	0.57	0.72
	4	0.69	0.72
II	1	0.90	0.92
	2	0.47	0.92
	3	0.19	0.39
	4	0.38	0.39
III	1	0.79	0.94
	2	0.74	0.94
	3	0.31	0.39
	4	0.34	0.39

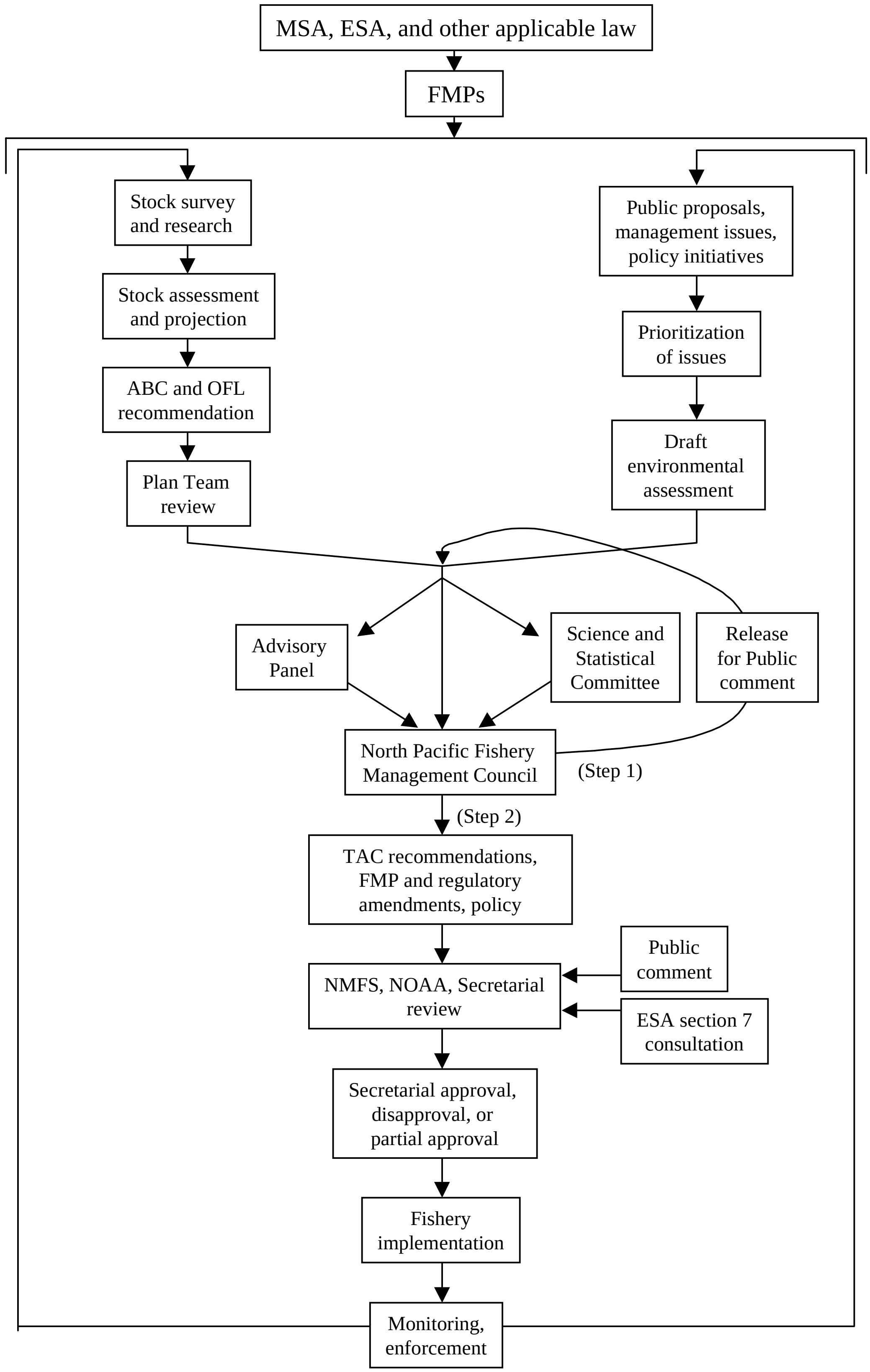


Figure 2.1. Management process for the Alaska groundfish fisheries.

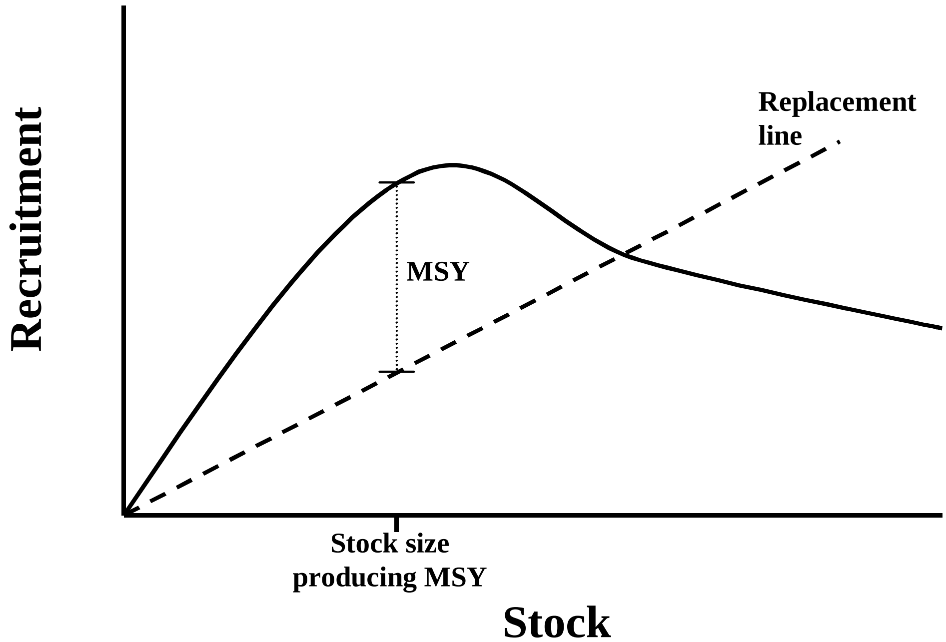


Figure 2.2. Hypothetical Ricker curve showing expected recruitment as a function of stock size. The replacement line indicates the level of recruitment necessary to sustain the population at any particular size. The positive difference between recruitment and the replacement line (to the left of the point where the two cross) indicates recruitment in excess of that needed to replace the stock, and is considered surplus in an single-species context. The maximum excess is the maximum sustainable yield (MSY) and the stock size that results in the maximum excess is the stock size producing MSY.

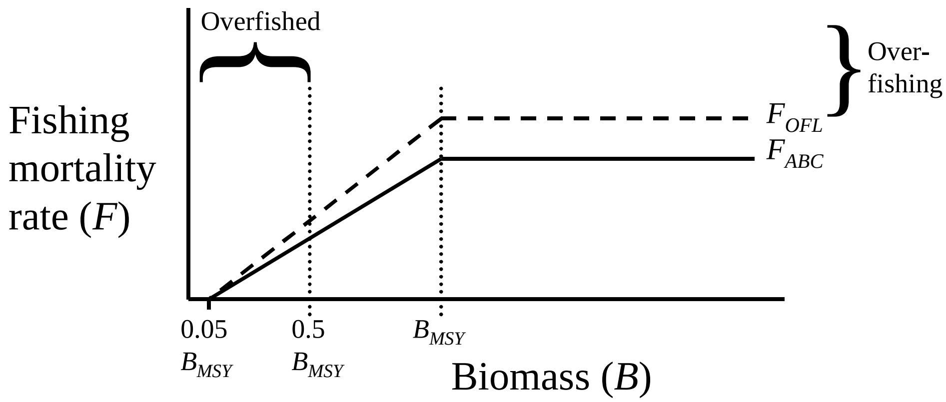


Figure 2.3. Graphic illustration of "overfishing" and "overfished." Overfishing occurs when the fishing mortality rate exceeds a prescribed maximum rate. Overfished indicates that the fished stock has declined below a certain level. The illustration indicates that the level is ½ B_{MSY}, which may or may not be the actual level. The actual level is determined as the maximum of either ½ B_{MSY} or the smallest level at which the population would be expected to recover to B_{MSY} within 10 years of random recruitment and fishing at F_{OFL}.

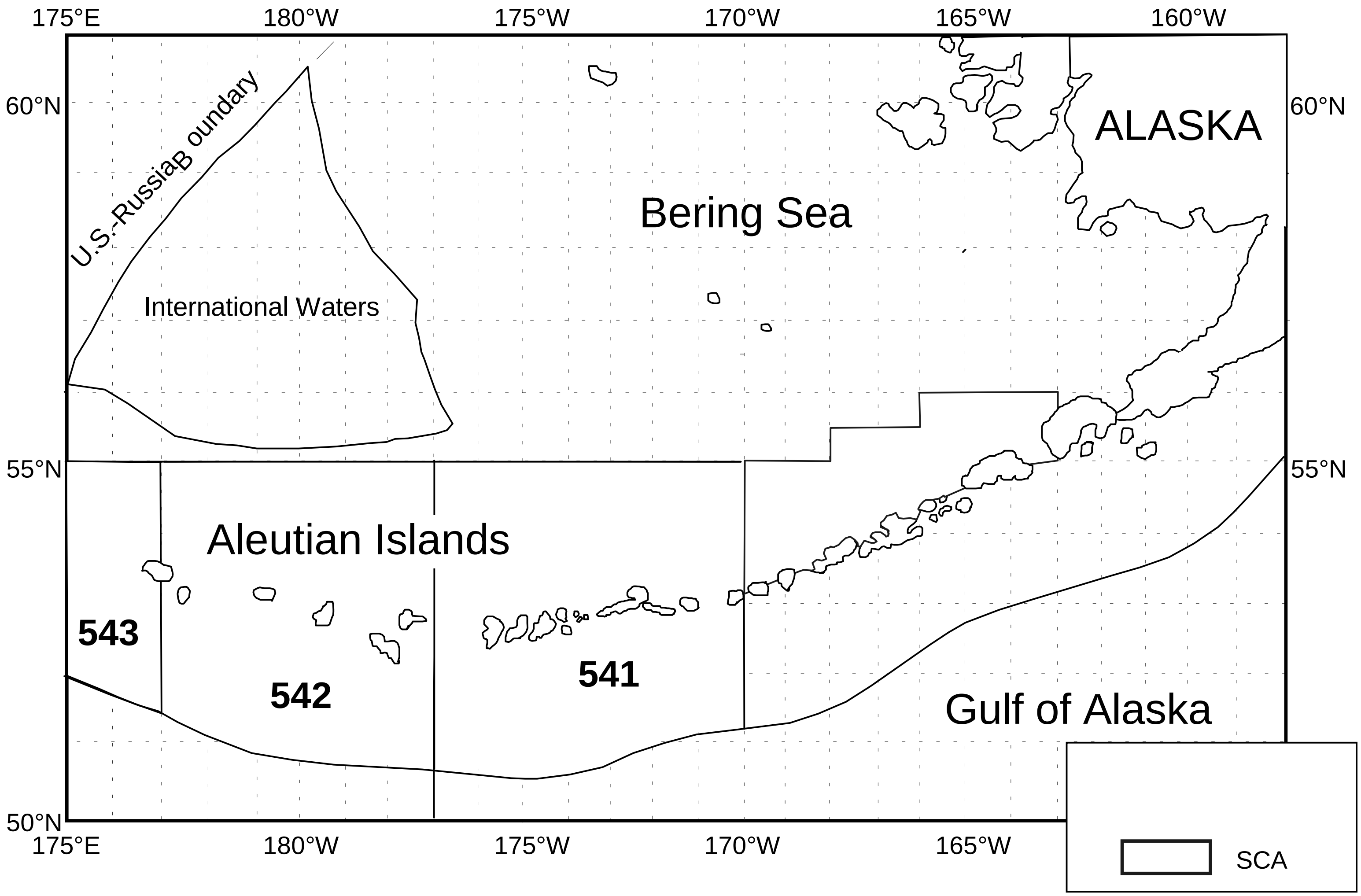


Figure 2.4. Management areas for the BSAI groundfish fishery. The SCA is used for pollock fishing only.

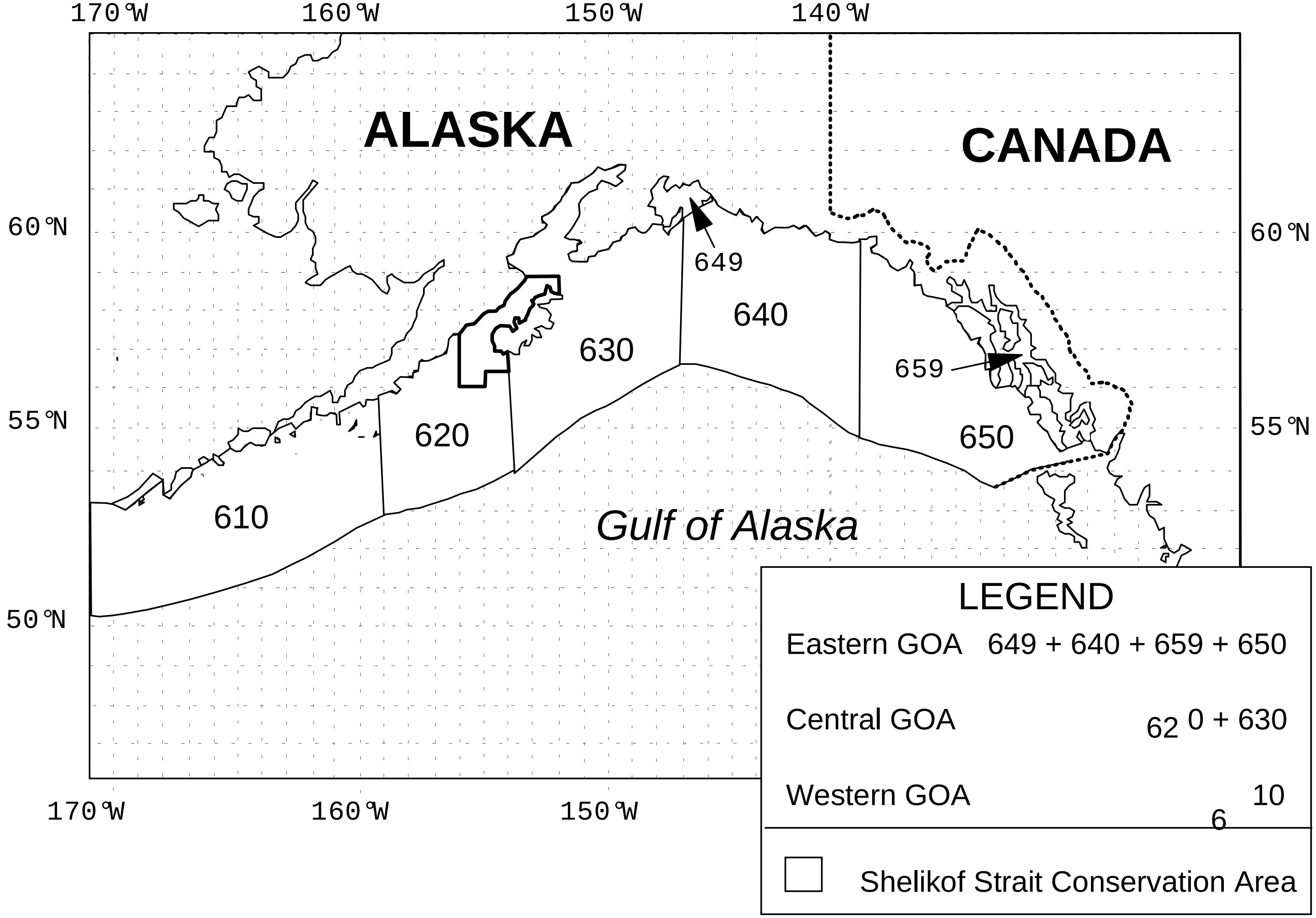


Figure 2.5. Management areas for the GOA groundfish fishery. The Shelikof Strait area is used for pollock fishing in the A and B seasons only.

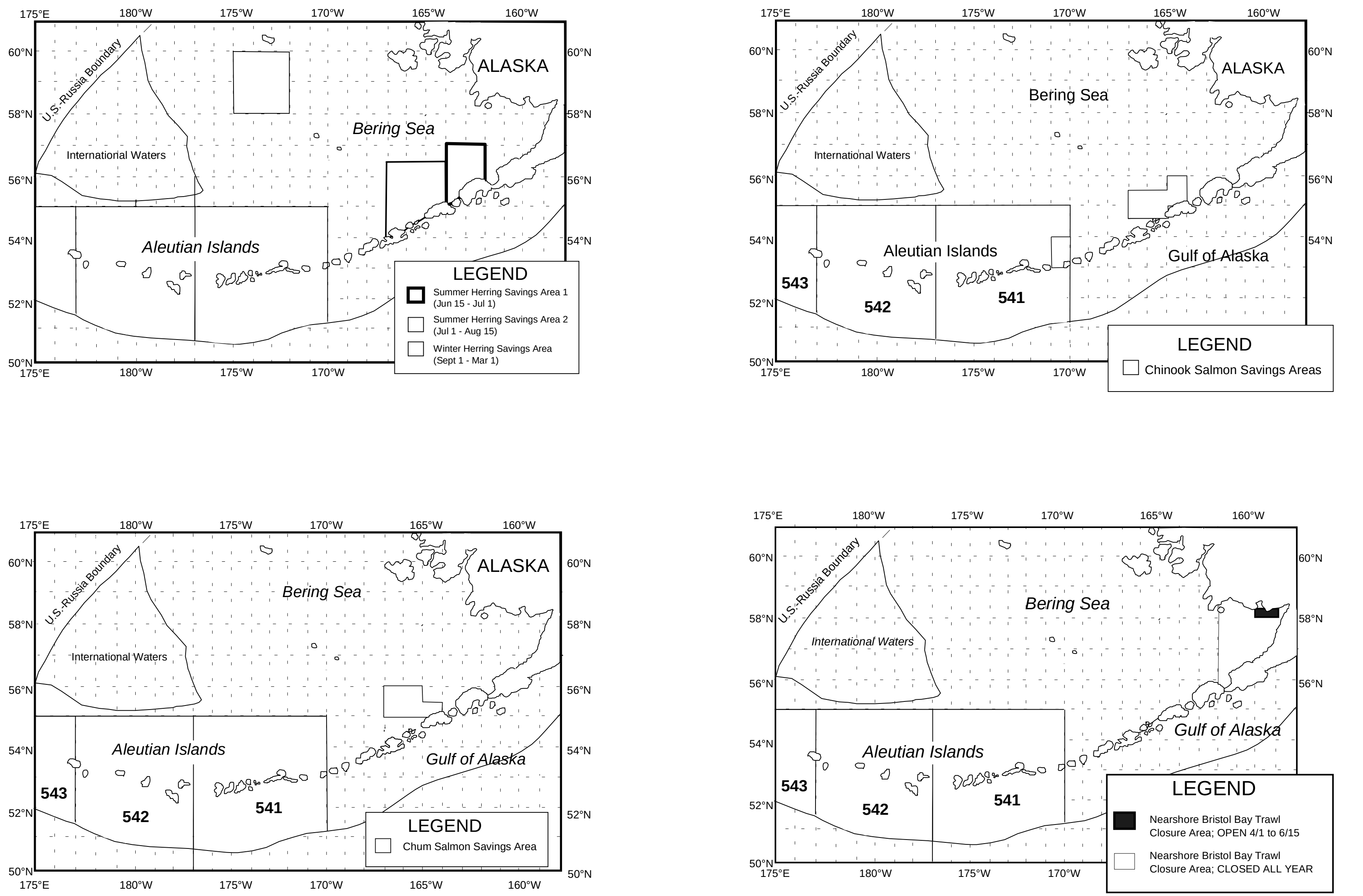


Figure 2.6. Locations used for time/area management of the BSAI and GOA groundfish fisheries: Herring Savings Areas (upper left), Chinook Salmon Savings Area (upper right), Chum Salmon Savings Area (lower left), and Bristol Bay Trawl Closure Areas (lower right). (continued next page)

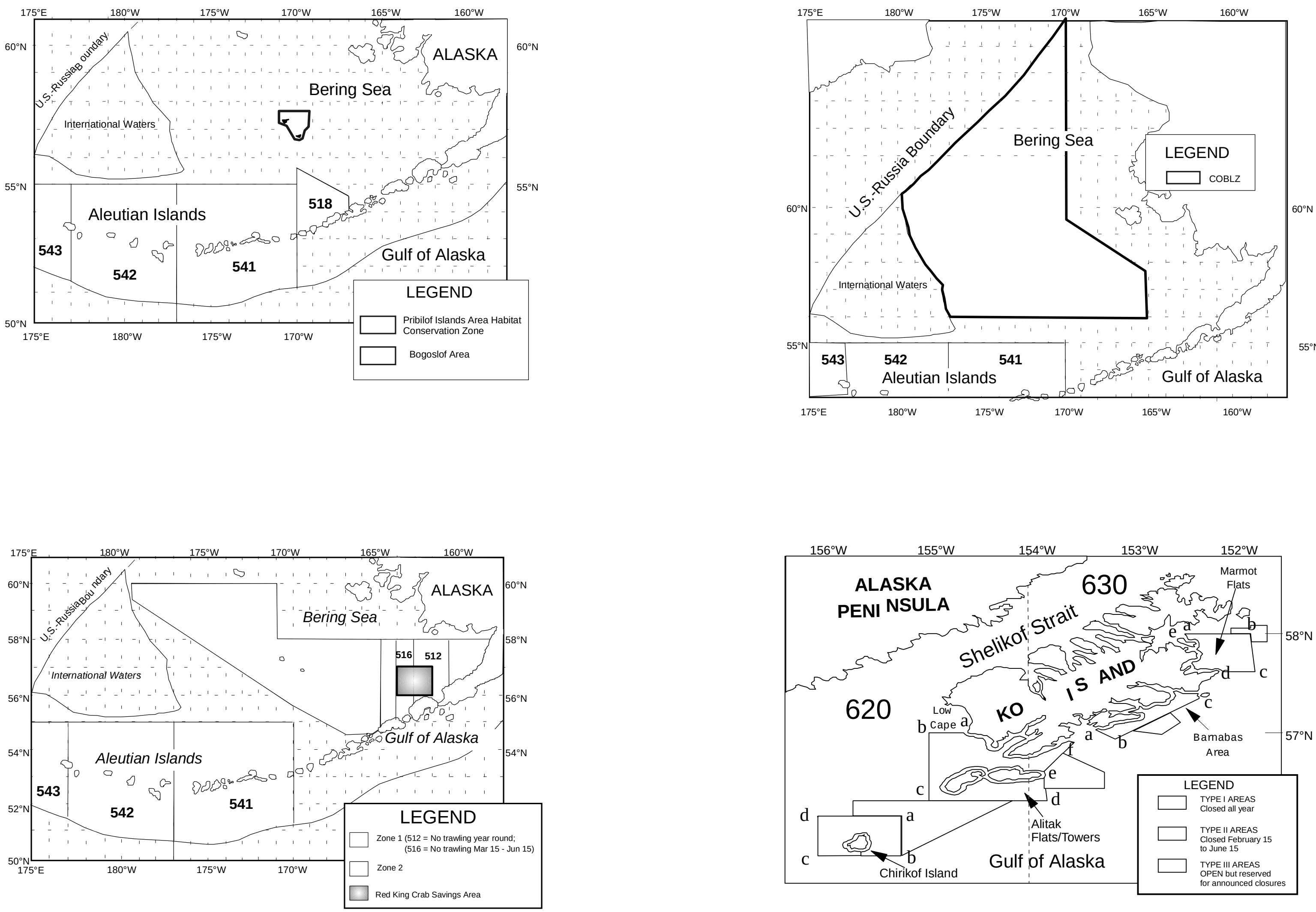


Figure 2.6. (continued) Locations used for time/area management of the BSAI and GOA groundfish fisheries: Pribilof Islands Habitat Conservation Area and Bogoslof area (Bogoslof closed to pollock fishing only; upper left), C. Opilio Bycatch Limitation Zone (upper right), Prohibited Species Bycatch Limitation Zones (for red king crab and C. bairdi Tanner crab; lower left), and Kodiak Island Areas for crab protection (lower right).

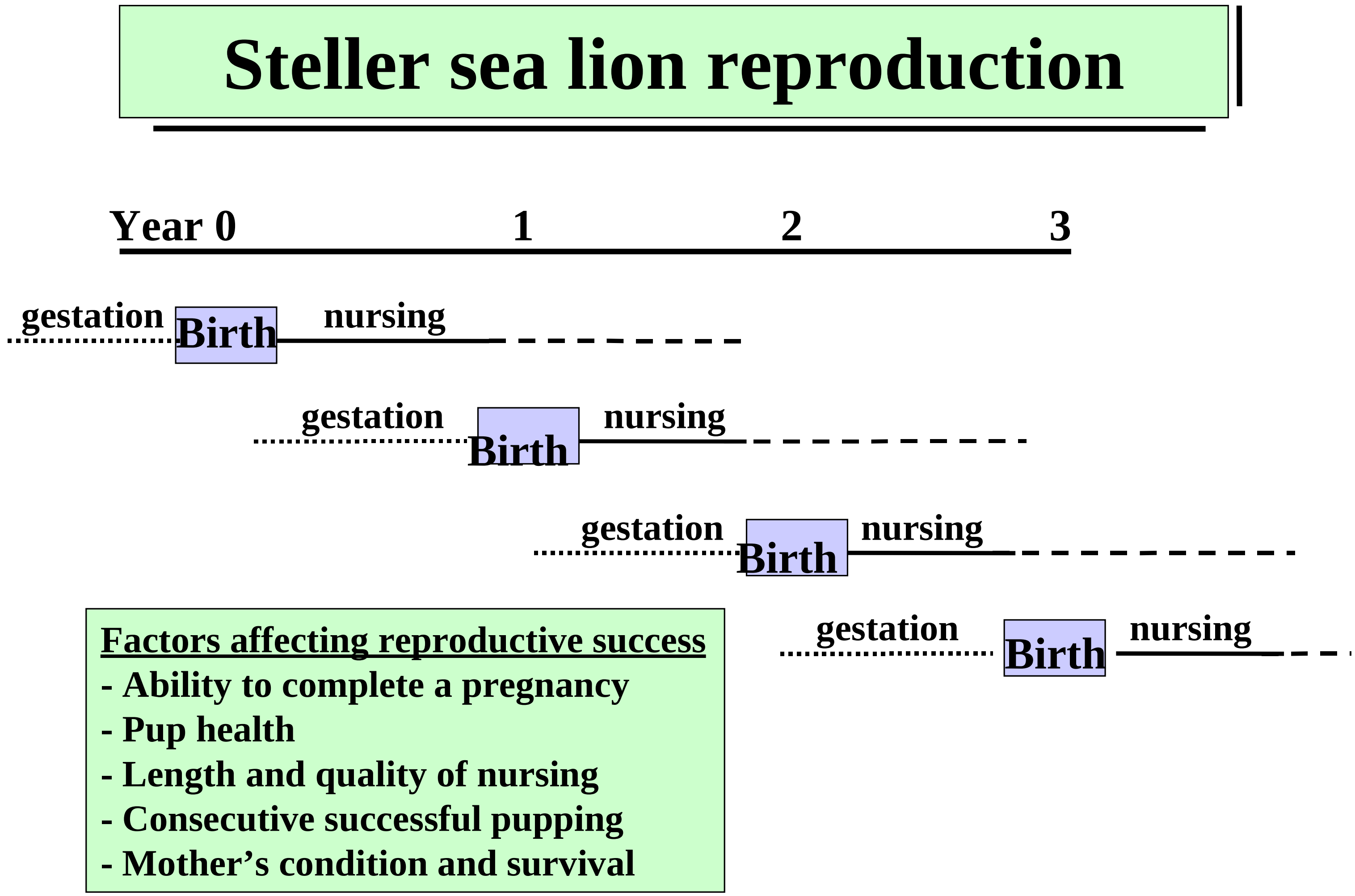
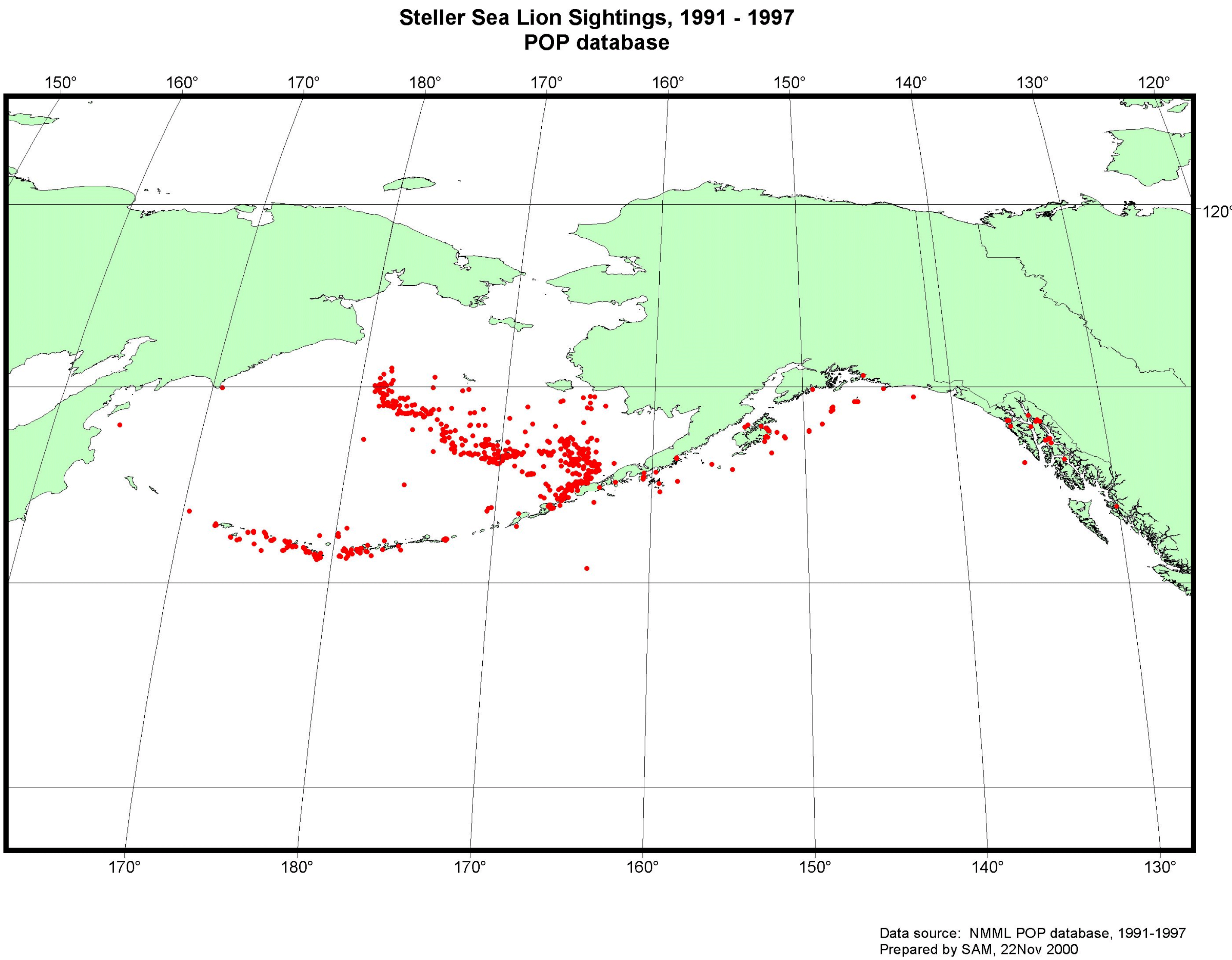


Figure 4.1. Schematic representation of the reproductive cycle of an adult female Steller sea lion over a period of years, indicating the elements of the cycle that 1) contribute to overall reproductive success and 2) may be affected by nutritional stress.

Figure 4.2. Sighting locations for Steller sea lions in the BSAI and GOA based on data from the Platforms-of-Opportunity Program, 1958-1995.



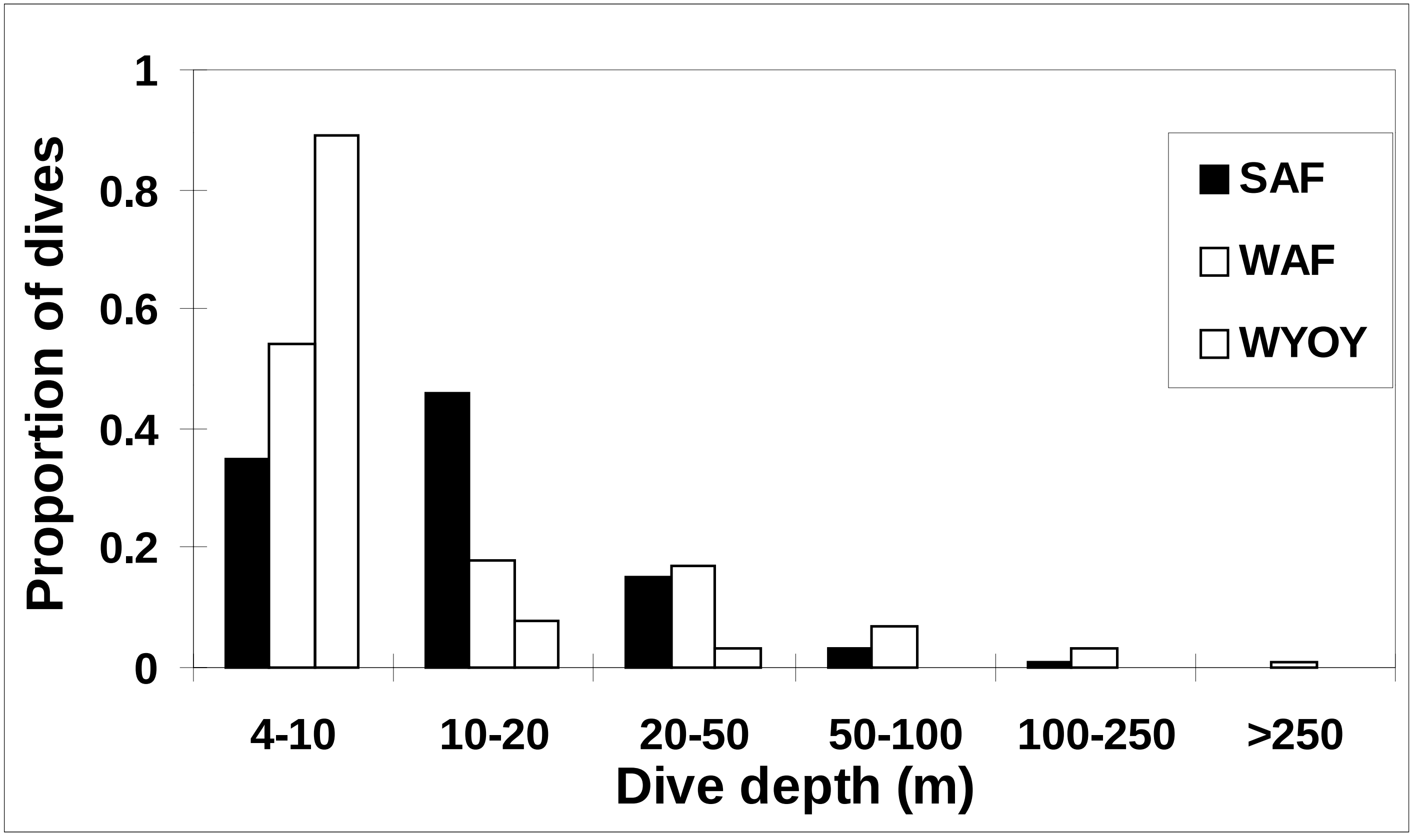


Figure 4.3. Portion of dives by depth range for young-of-the-year (WYOY) and adult female Steller sea lions in summer (SAF) and winter (WAF) tracked during 1990-1993 (from Merrick and Loughlin 1997).

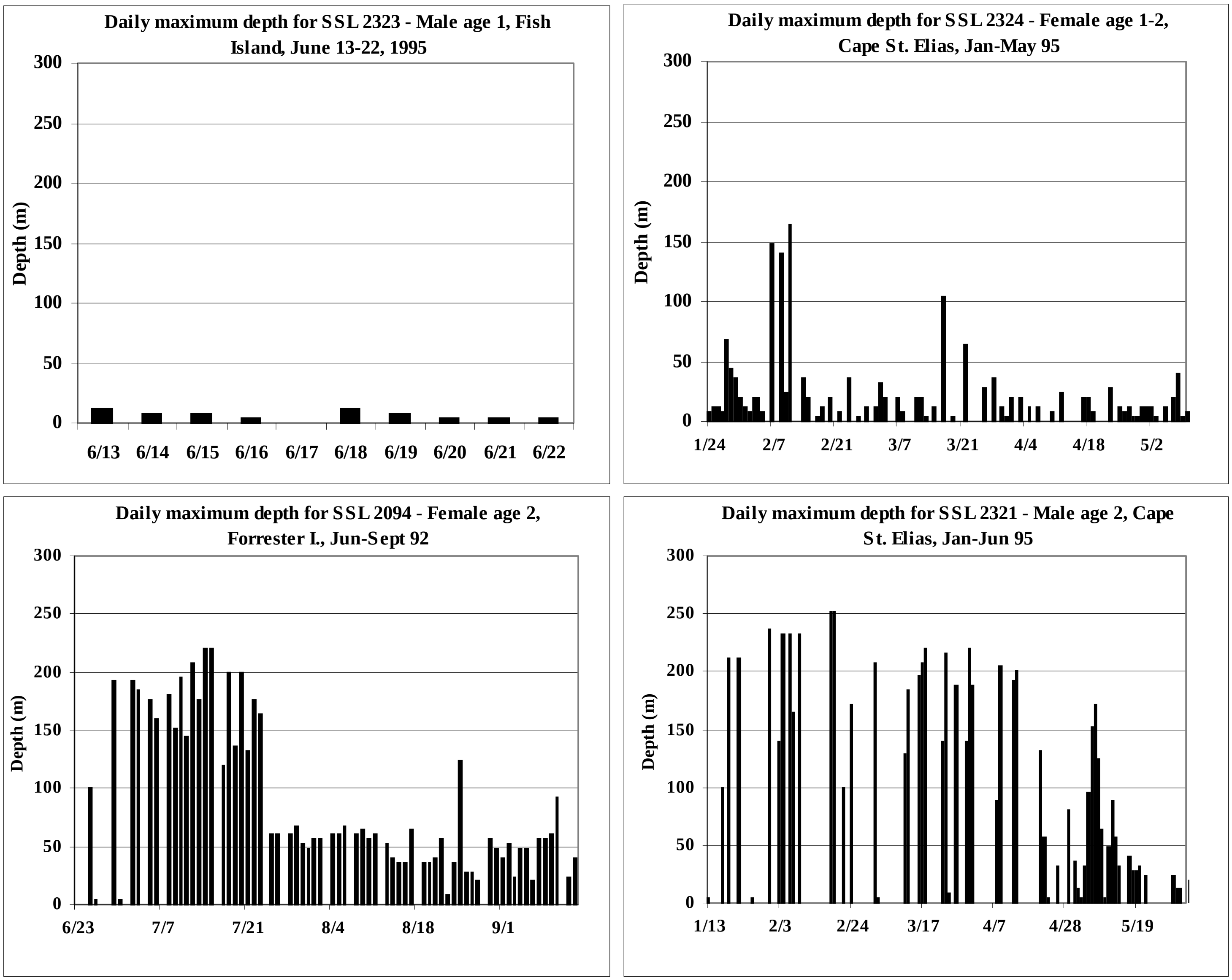


Figure 4.4. Maximum daily dive depths for four juvenile Steller sea lions (based on data from U. Swain, Alaska Department of Fish and Game).

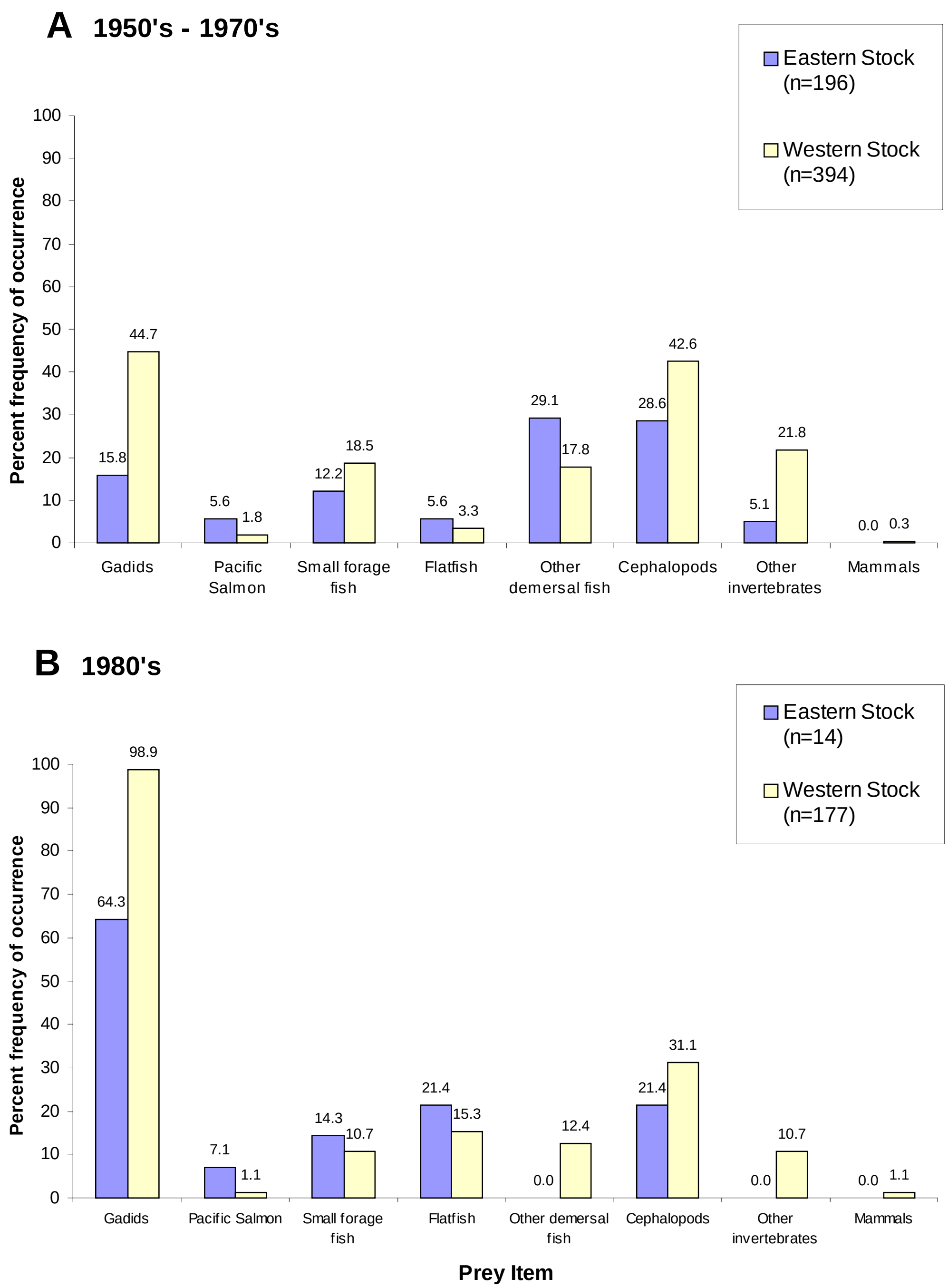
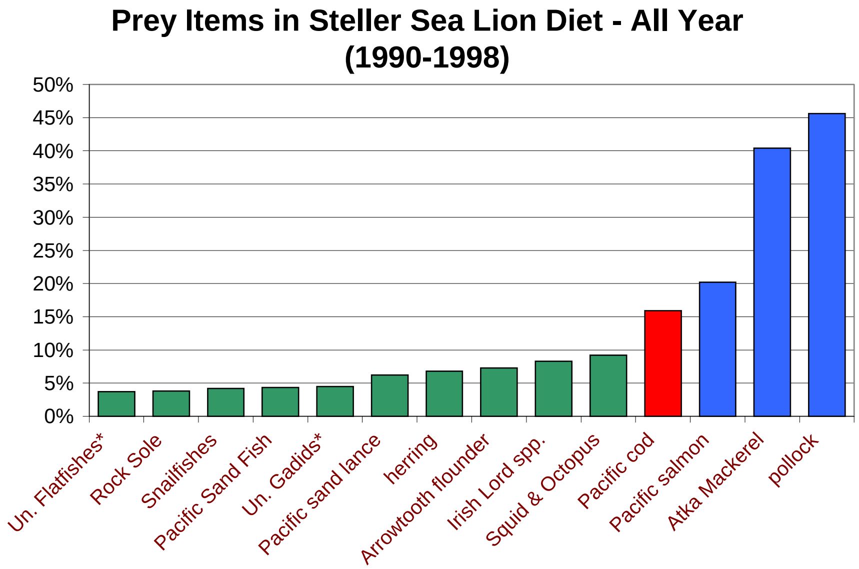
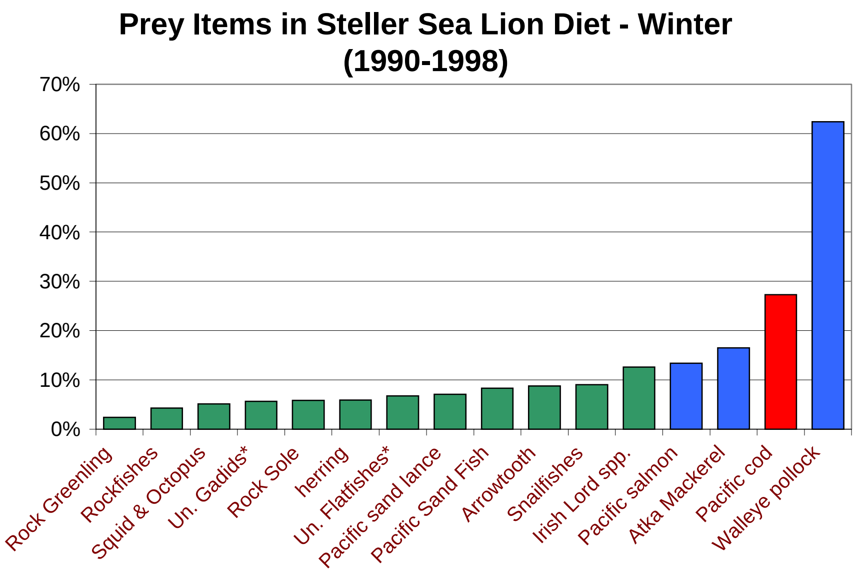
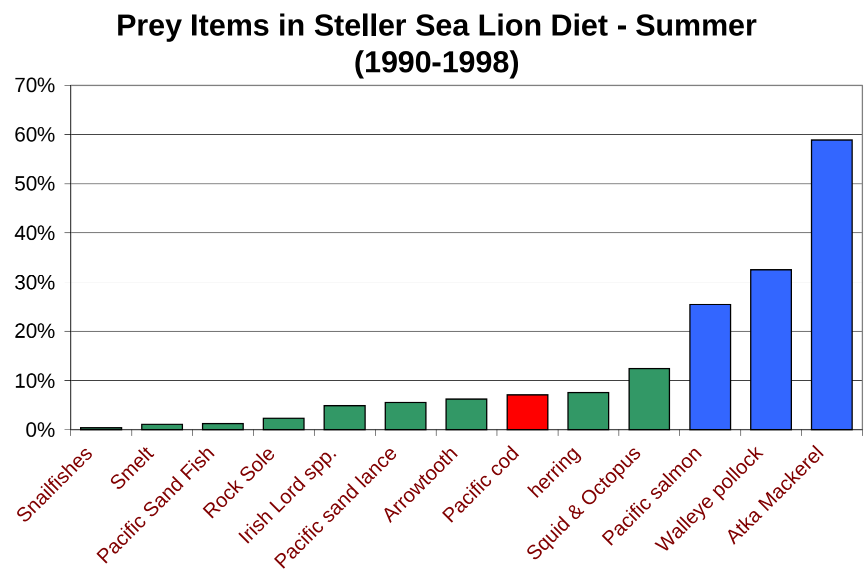


Figure 4.5. Frequency of occurrence of Steller sea lion prey items found in stomach samples (n= 781 stomachs with prey remains) collected in studies conducted from 1956 to 1986 in locations ranging from the Kuril Islands to California. Prey taxa are grouped following Merrick and Calkins (1996) with the addition of the Other invertebrate and Mammal catagories. Panel A shows the eastern and western portions of the range from the 1950's through the 1970's. Panel B shows the the same geographic areas during the 1980's.

Figure 4.6. Percent frequency of occurrence of prey items identified in Steller sea lion scat samples form 1990-1998.







Winter

Percent Frequency of Occurrence of Top Three Prey Items found in Steller Scats collected December through April, 1990 – 1998
(n = number of scats collected containing identifiable prey items.)

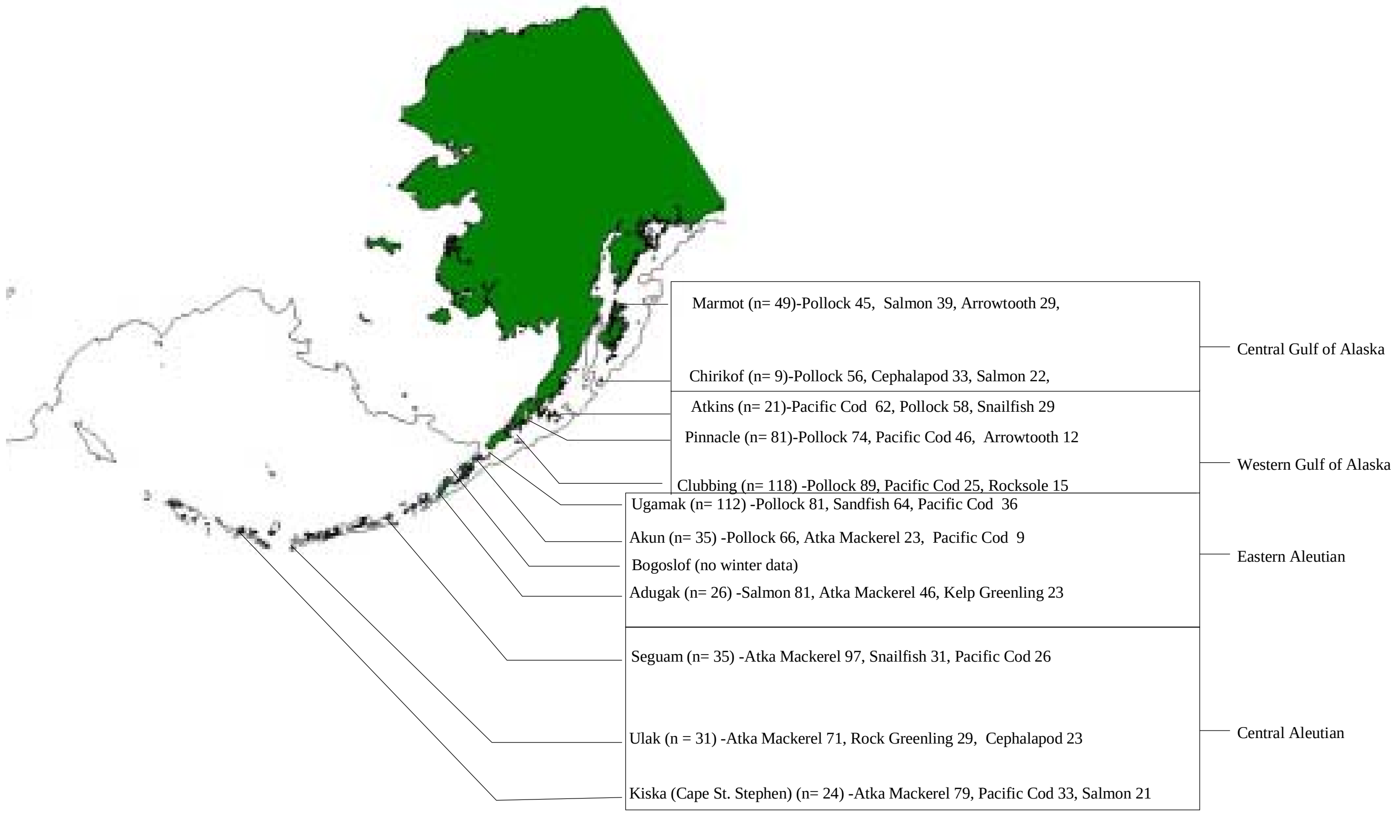


Figure 4.7a. Percent frequency of occurrence of prey items identified in Steller sea lion scat collections in winter from 1990-1998.

Summer

Percent Frequency of Occurrence of Top Three Prey Items found in Steller Scats collected June through August, 1990 – 1998
(n = number of scats collected containing unidentifiable prey items.)

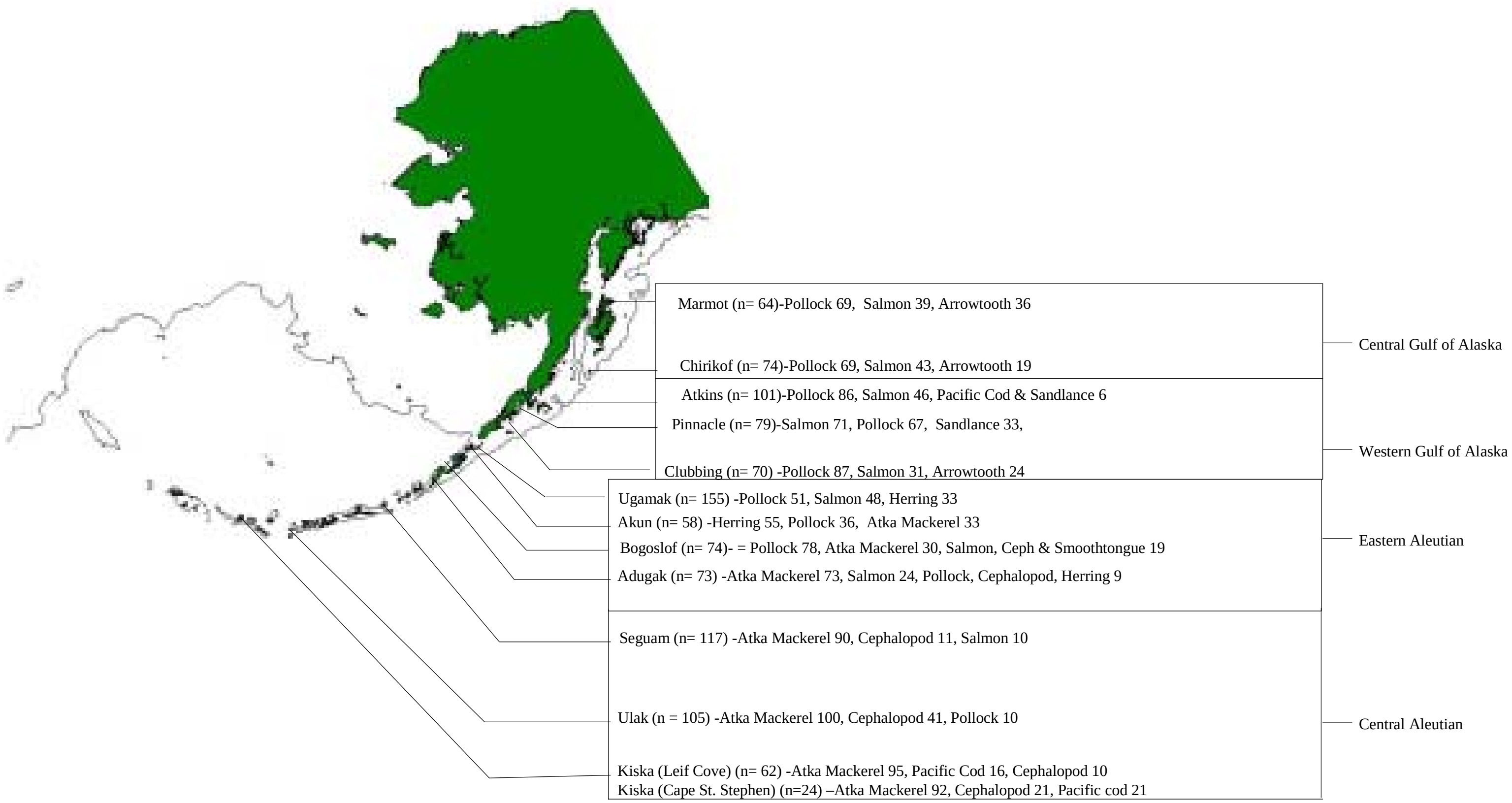


Figure 4.7b. Percent frequency of occurrence of prey items identified in Steller sea lion scat collections in summer from 1990-1998.

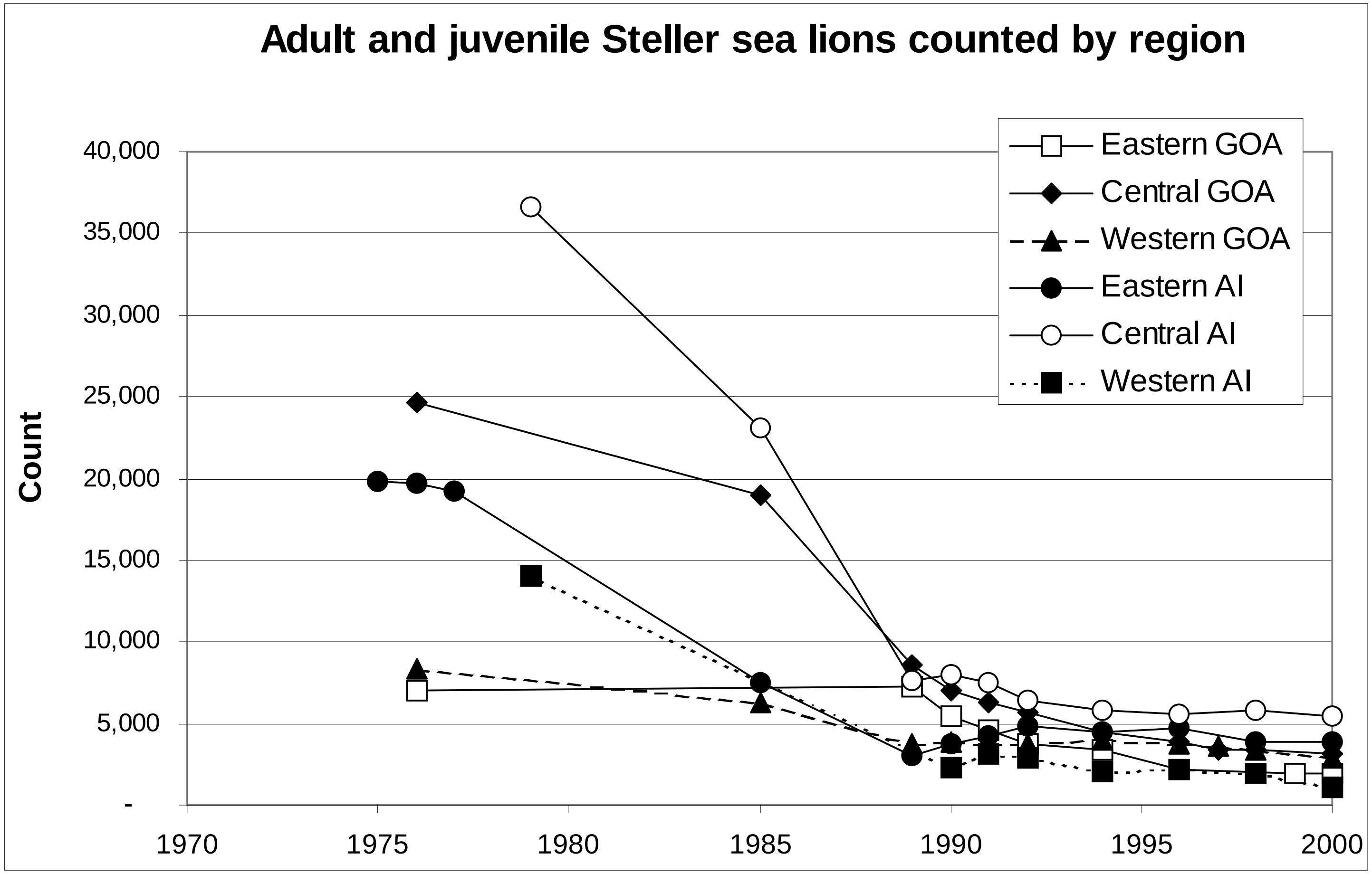


Figure 4.8. Counts of adult and juvenile Steller sea lions in the western population (by region) from the late 1970s to 2000.

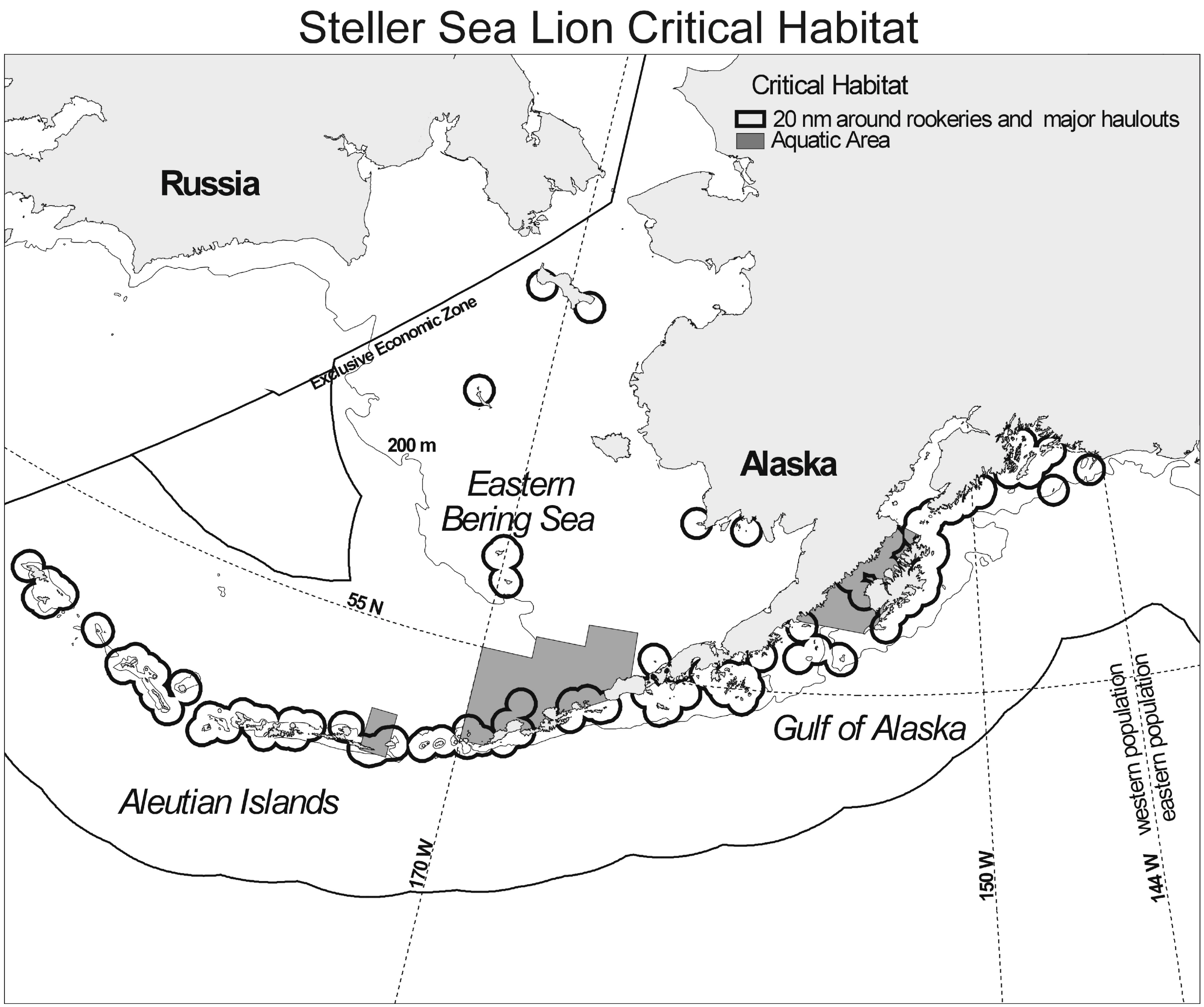


Figure 4.9. Critical habitat for the western population of Steller sea lions.

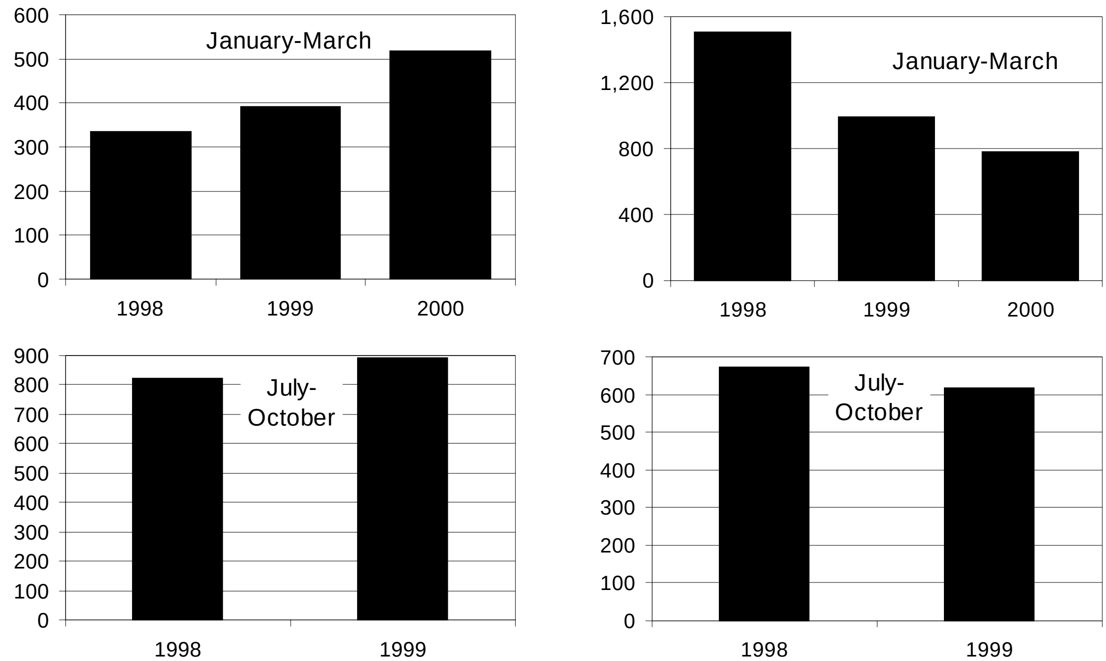


Figure 5.1. Number of 100 km^2 cells fished by the eastern Bering Sea pollock fishery (left panels), and average pollock catch per 100 km^2 cell in the eastern Bering Sea (right panels).

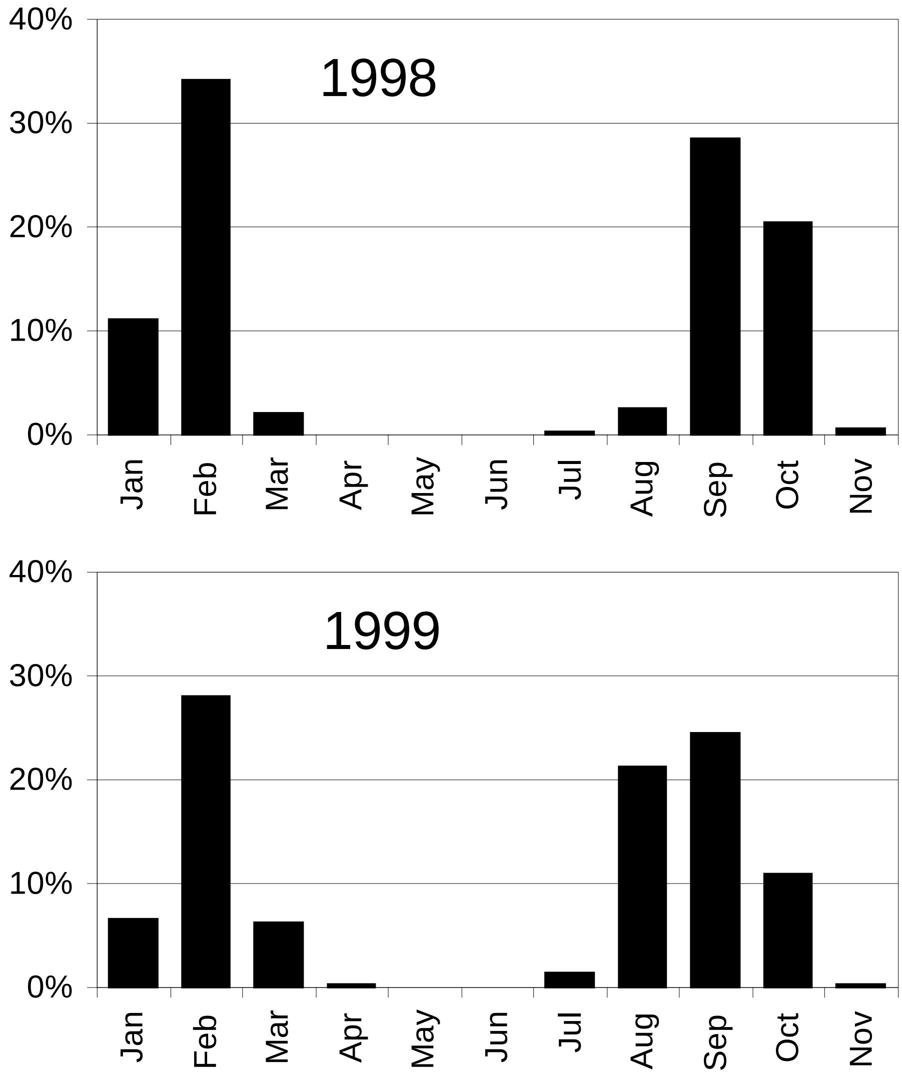


Figure 5.2. Percent of annual pollock catch in the eastern Bering Sea by month in 1998 and 1999.

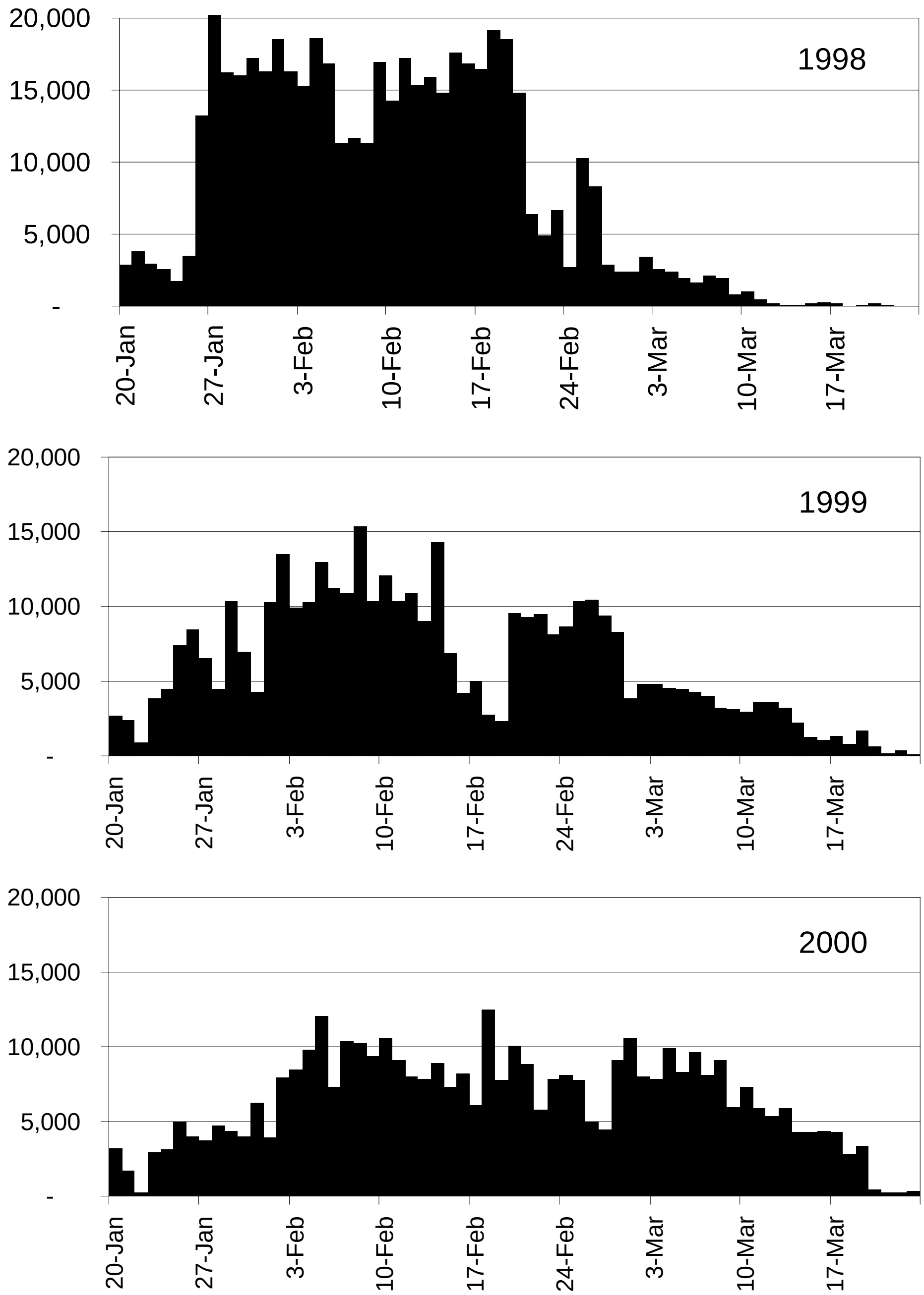


Figure 5.3. Estimated daily catch rates of pollock by the EBS pollock fishery in January-March 1998-2000.

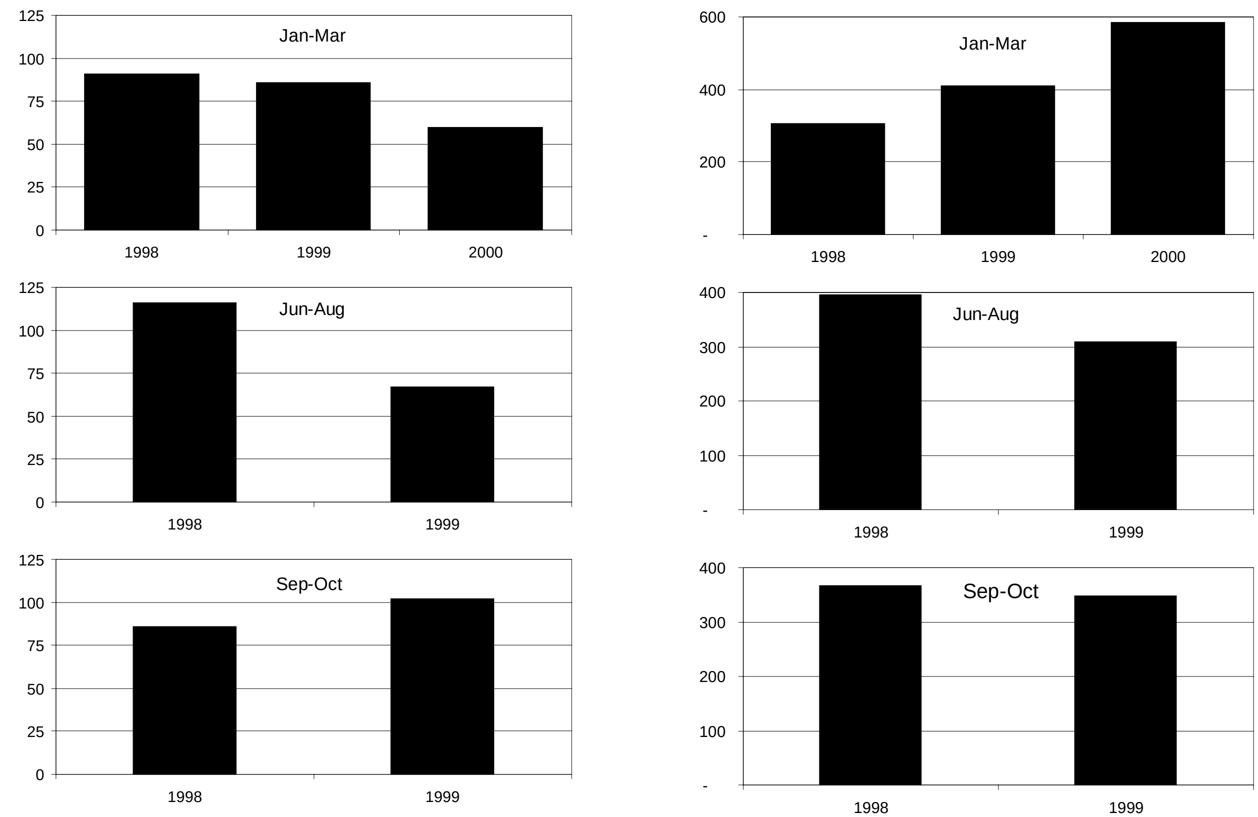


Figure 5.4. Number of 100-km^2 areas fished by the GOA pollock fishery from 1998 to 2000 (left panel), and average pollock catch per 100-km^2 area in the GOA (right panel). The data suggest that the fishery became increasing concentrated spatially in the period from January to March, with fewer areas fished and increasing mean catch per area. The opposite trend was observed for the September and October period, with mixed results in June to August.

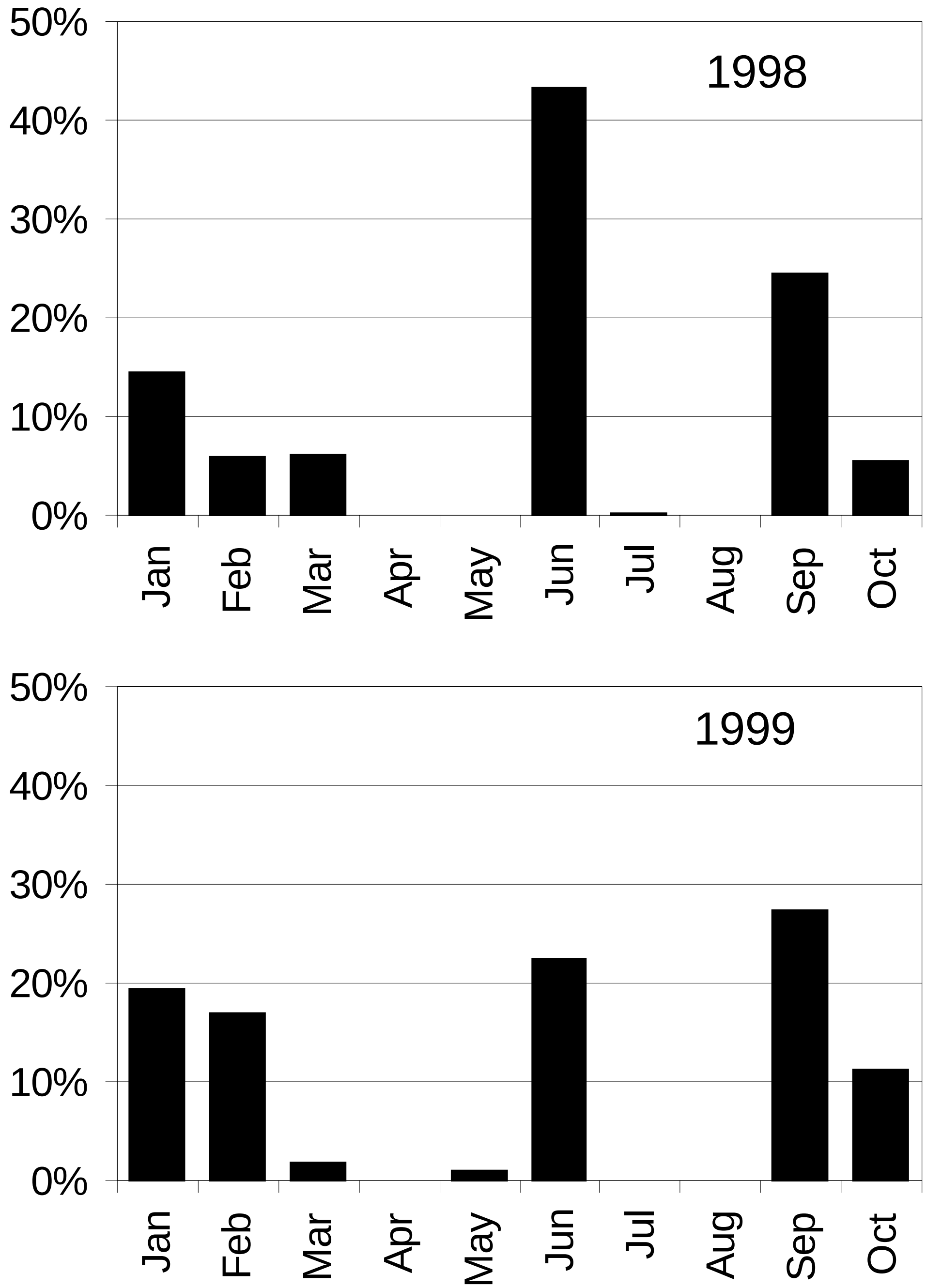


Figure 5.5. Percent of annual pollock catch caught each month in the GOA, 1998 and 1999.

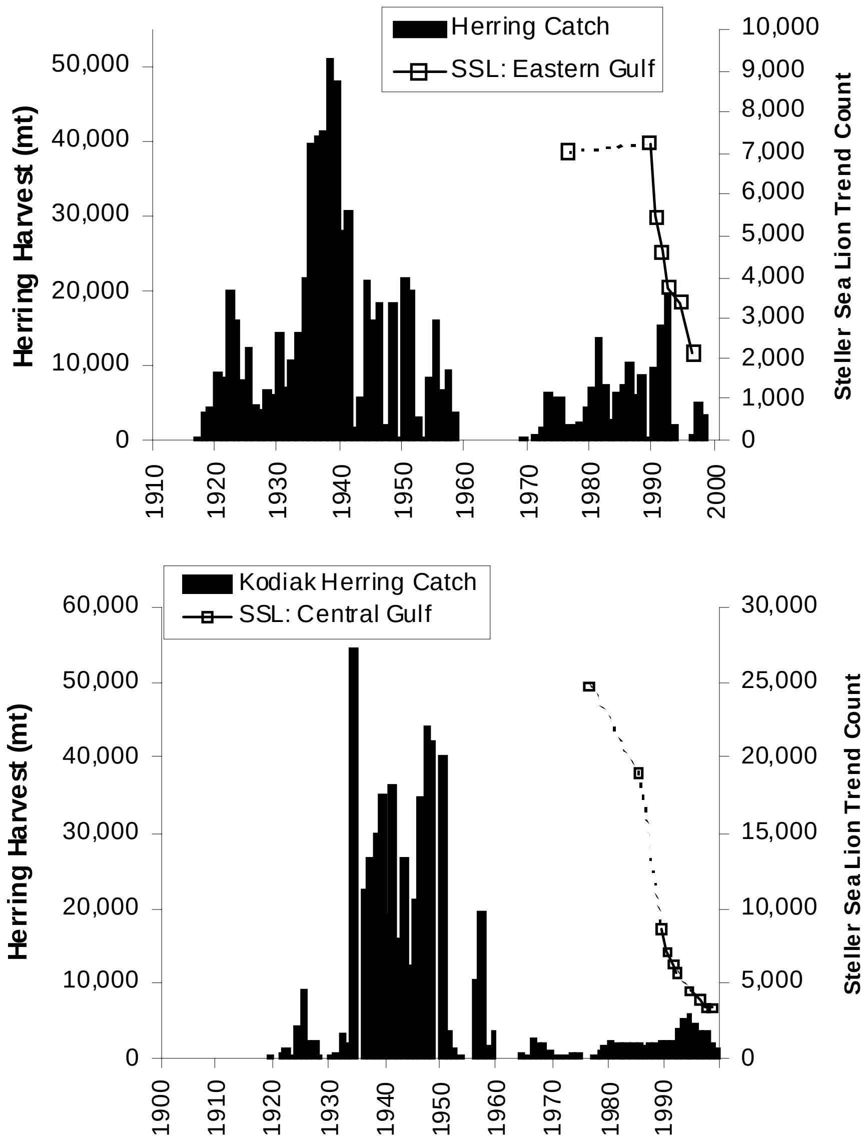


Figure 5.6. Historical harvest of herring in the central and eastern GOA and counts of Steller sea lions.

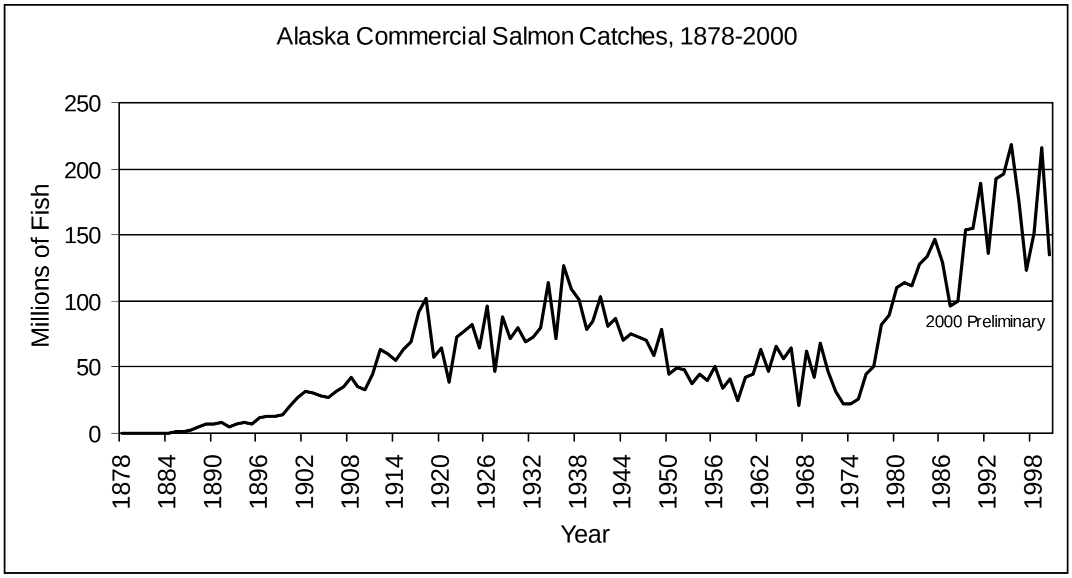


Figure 5.7. Historical salmon catches in Alaska from 1878-2000.

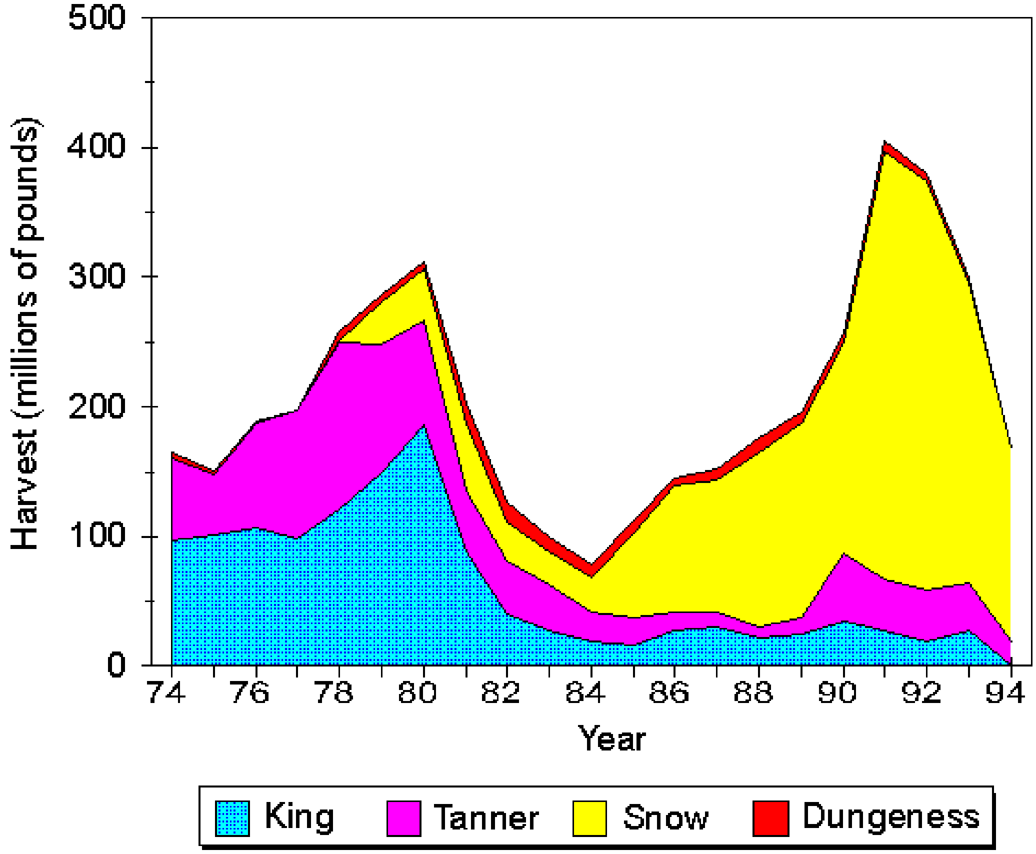


Figure 5.8. Landings of King, Tanner, snow, and Dungeness crabs in Alaska during 1974-1994. Since 1994, the catch of crab in Alaska has continued to decline due to depressed stocks.

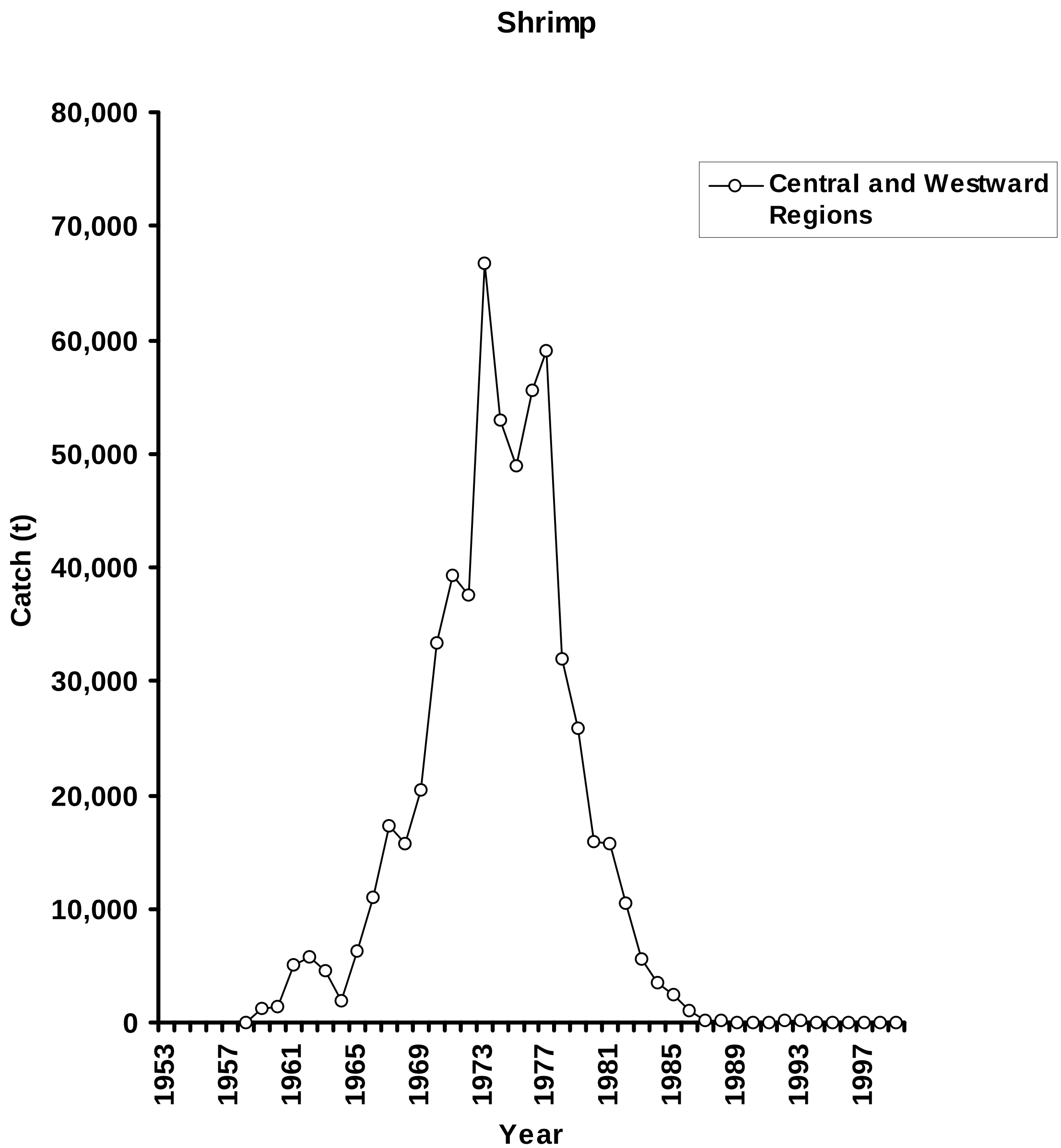


Figure 5.9. Historical annual shrimp catch (t) in the central and westward regions (west of 144^o W). Landings from PWS, Cook Inlet, Kodiak, Alaska Peninsula, Chignik, Aleutian Islands, and Bering Sea contributed to the total catch.

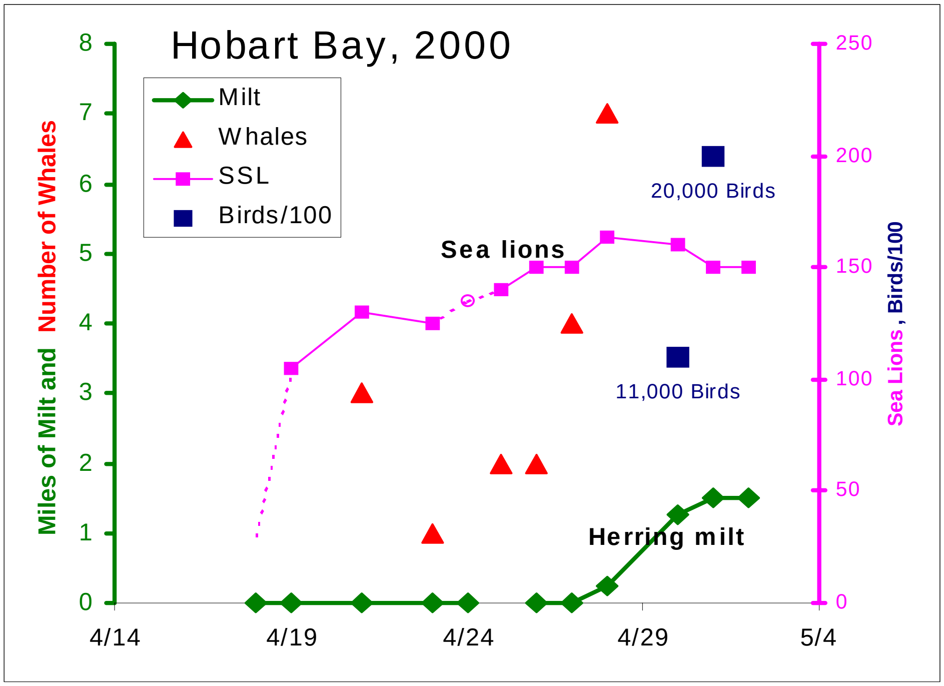


Figure 5.10. Timing of herring spawning and bird and mammal presence at Hobart Bay, southeast Alaska, in the spring of 2000.

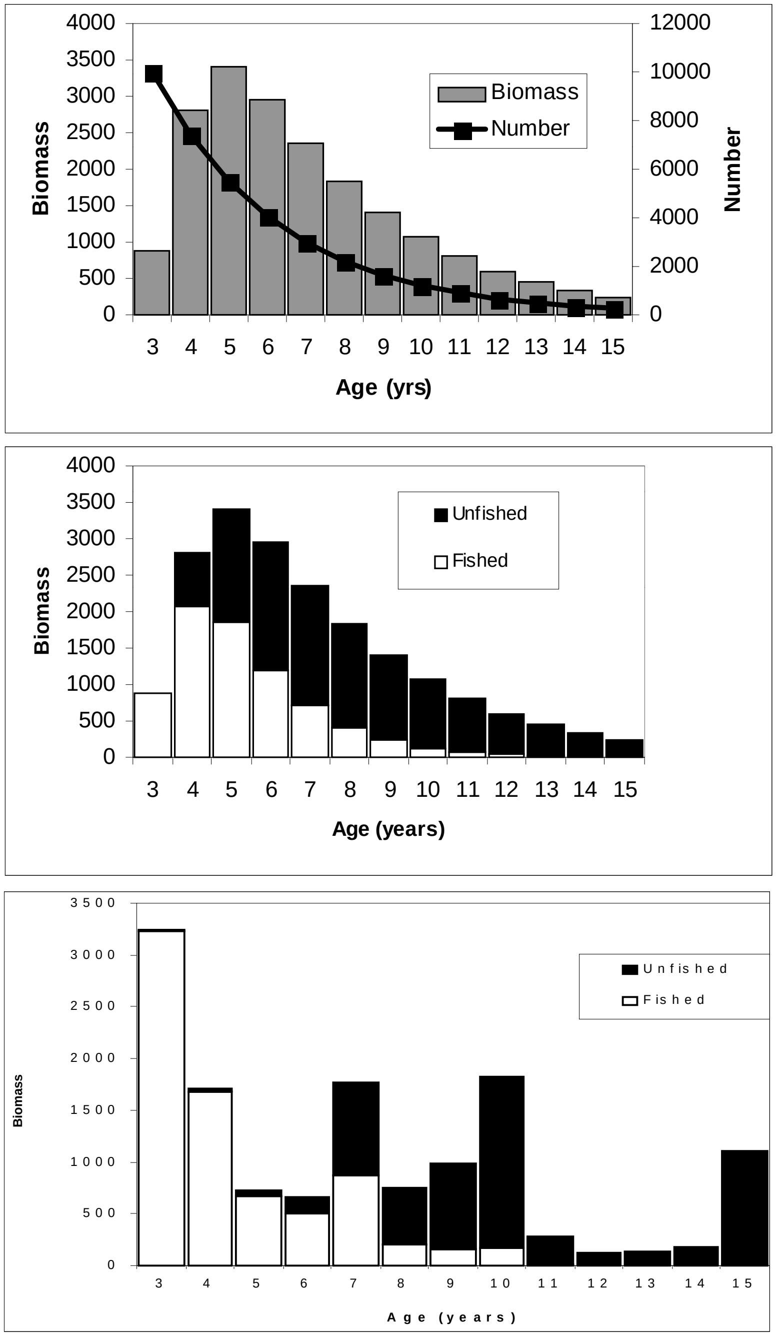
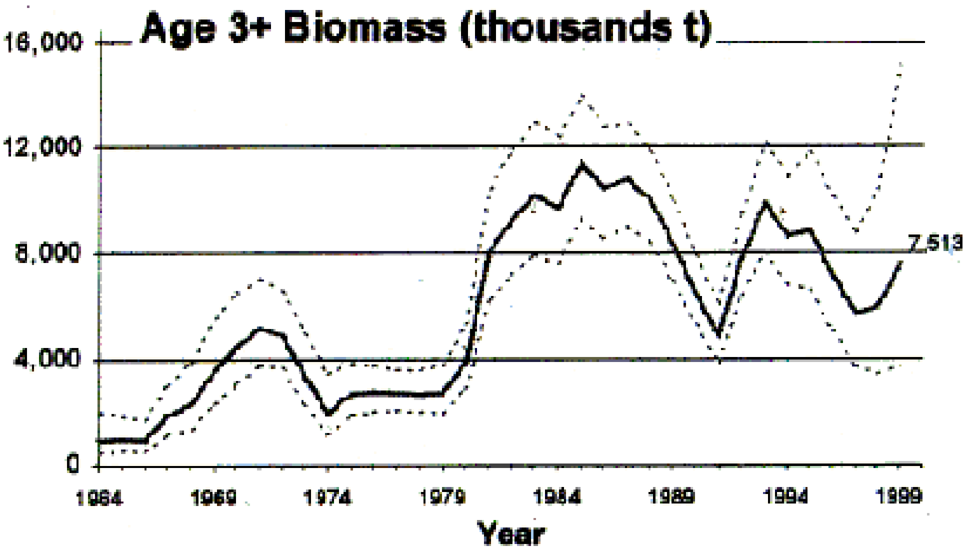


Figure 6.1. Figure 6.1a (top panel) represents a theoretical unfished population showing female spawning biomass and numbers at age from age 3. Figure 6.1b (middle panel), shows a theoretical female spawning stock biomass by age in a population fished at $F_{40\%}$ (white portion of each bar) and in an unfished population (black and white portions combined). Figure 6.1c (bottom panel) illustrates the biomass at age for the eastern Bering Sea pollock stock in 1999. Again, the white portion of each bar indicates the biomass available in the fished portion of the population, and the black portion represents the portion that was removed in previous years and would have been available if the stock had not been fished.



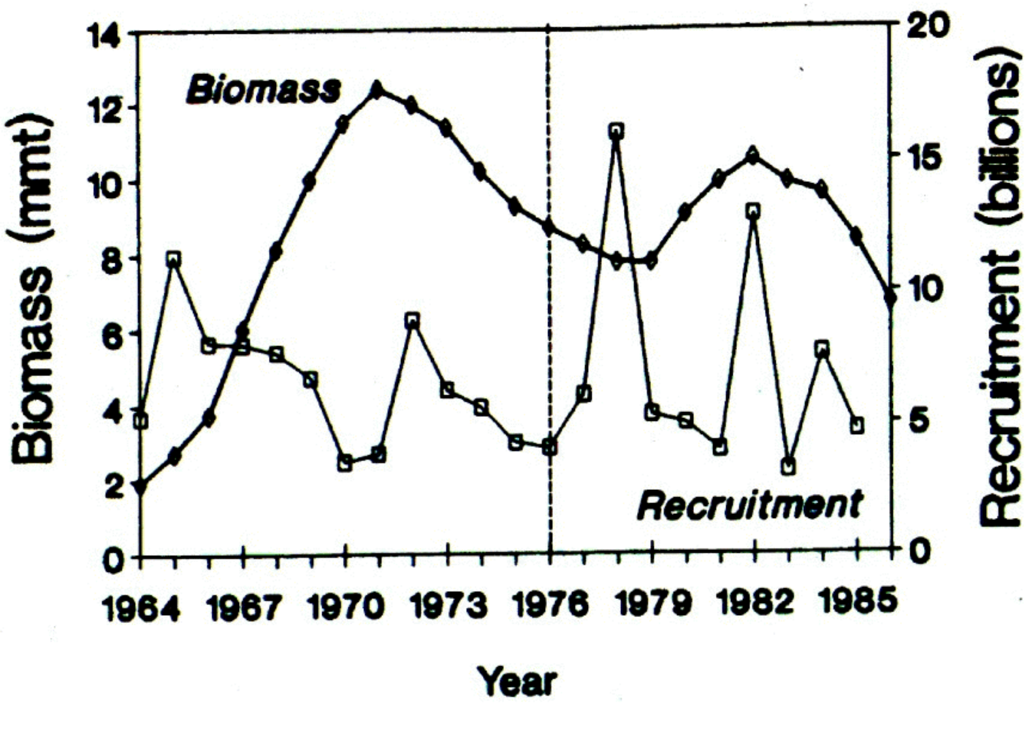


Figure 6.2. (6.2a Top) Estimated biomass of eastern Bering Sea pollock (age 3+) as described in Ianelli et. al. (1999). (6.2b Bottom) Estimated biomass of eastern Bering Sea pollock (age 3+) for the period from 1964-1985 as presented in Megrey and Wespestad, 1990.

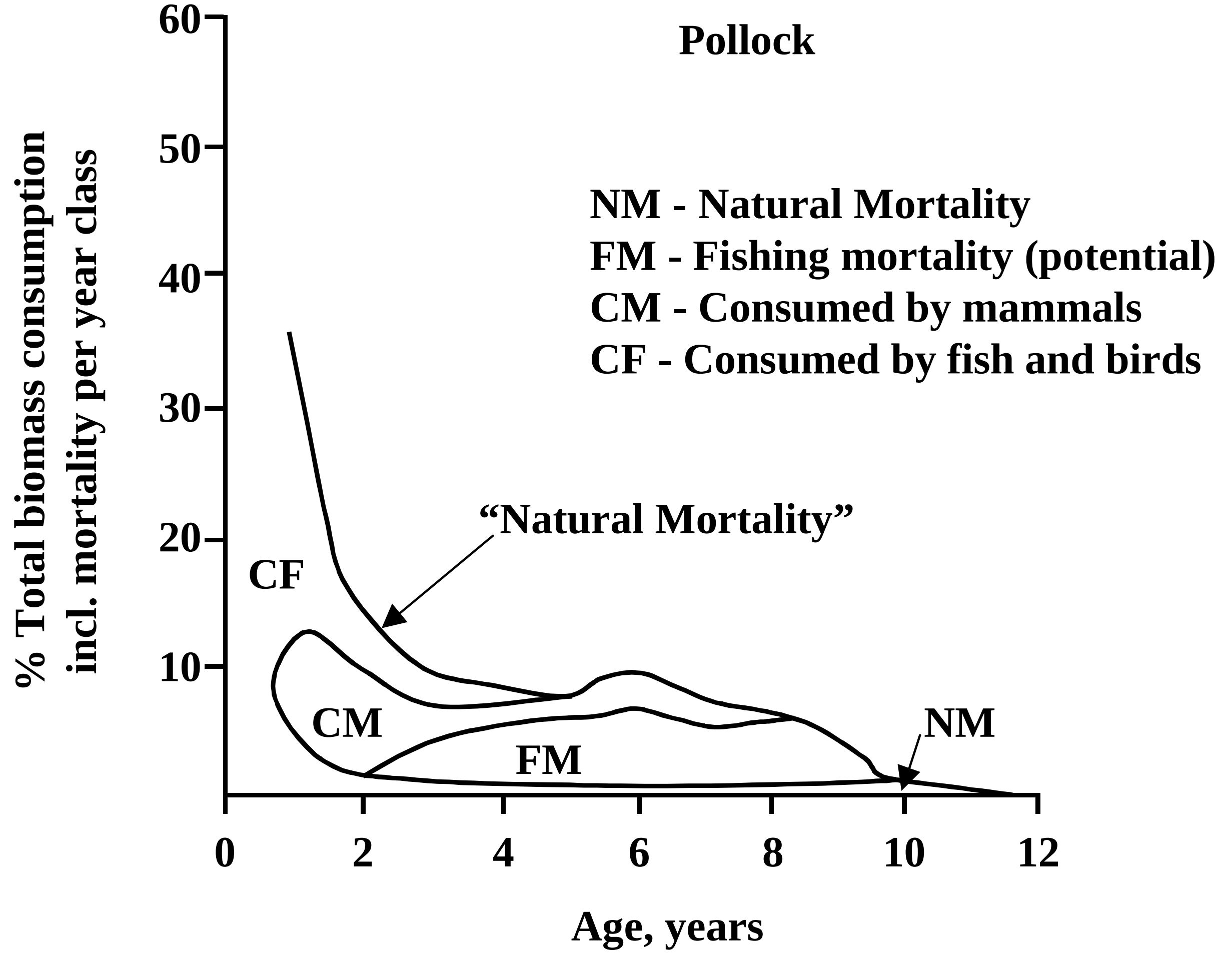


Figure 6.3. Distribution of "consumption" with age of walleye pollock, as percent of total biomass. (From BSAI FMP, p. 179.)

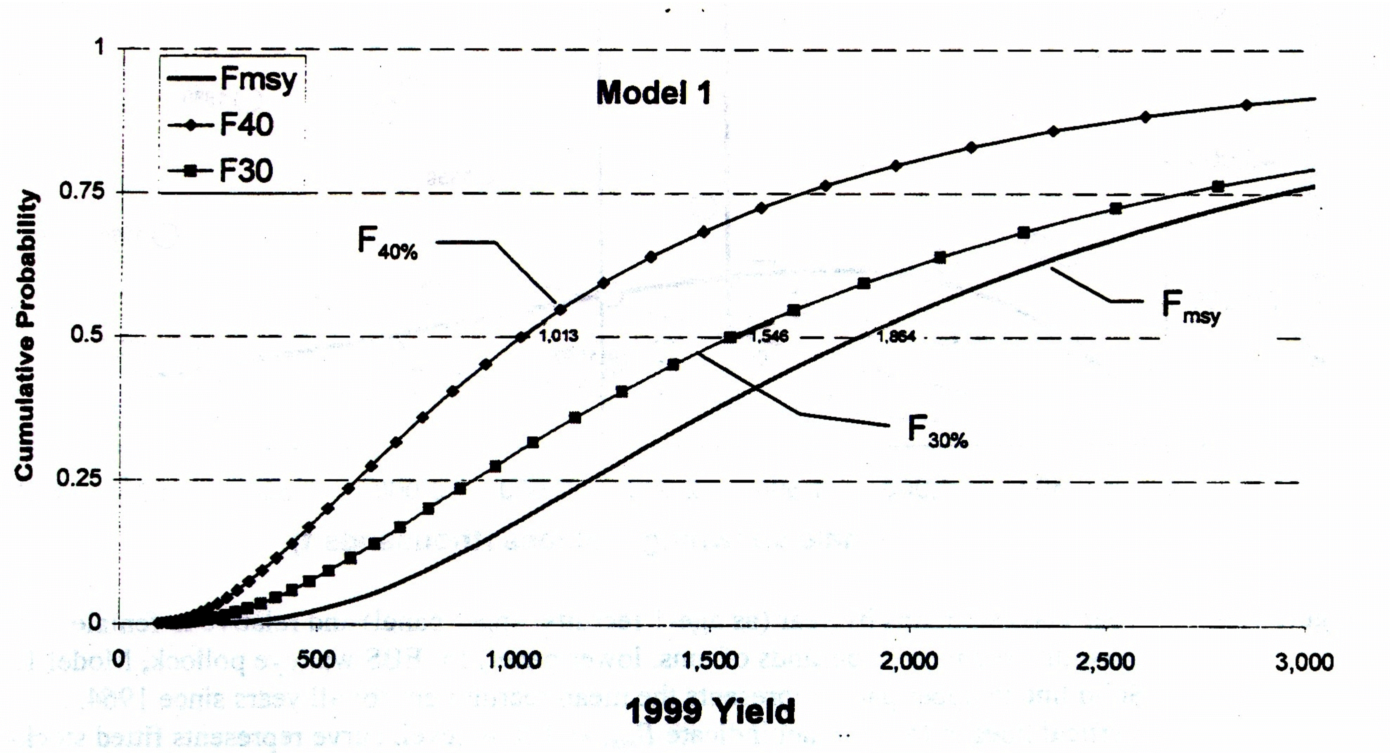


Figure 6.4. Measures of uncertainty in 1999 (unadjusted) yield for EBS pollock as a cumulative distribution. Values along the curve represent the estimated probability (vertical axis) that the 1999 yield will be lower than the corresponding value on the horizontal axis (reprinted from Ianelli et. al., 1998).

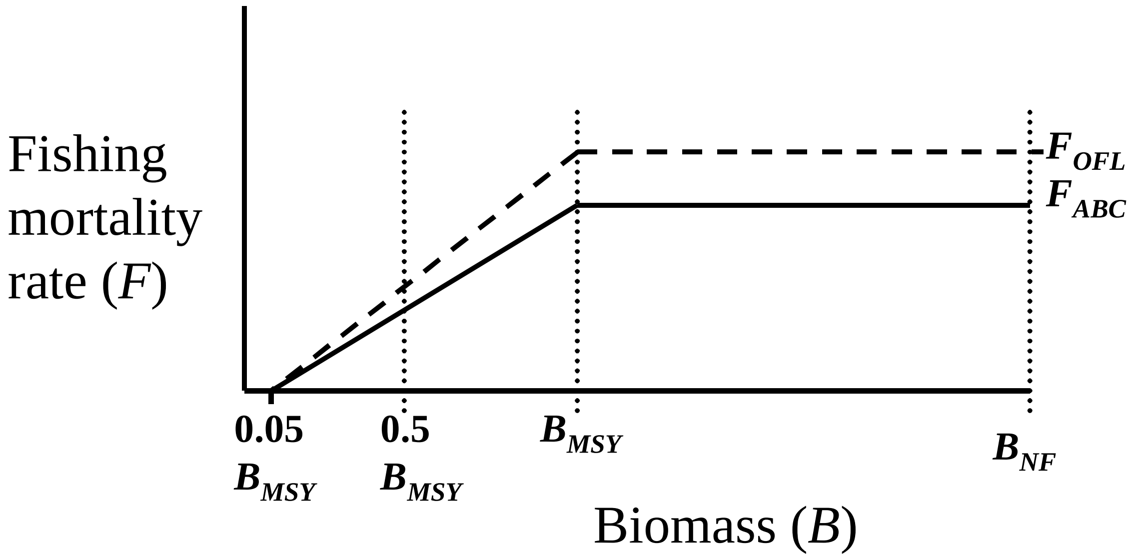


Figure 6.5. Theoretical framework for setting fishery mortality rates to achieve ABC (and avoid OFL) based on stock biomass as determined relative to the estimated size of the stock if it had not been fished (B_{NF}).

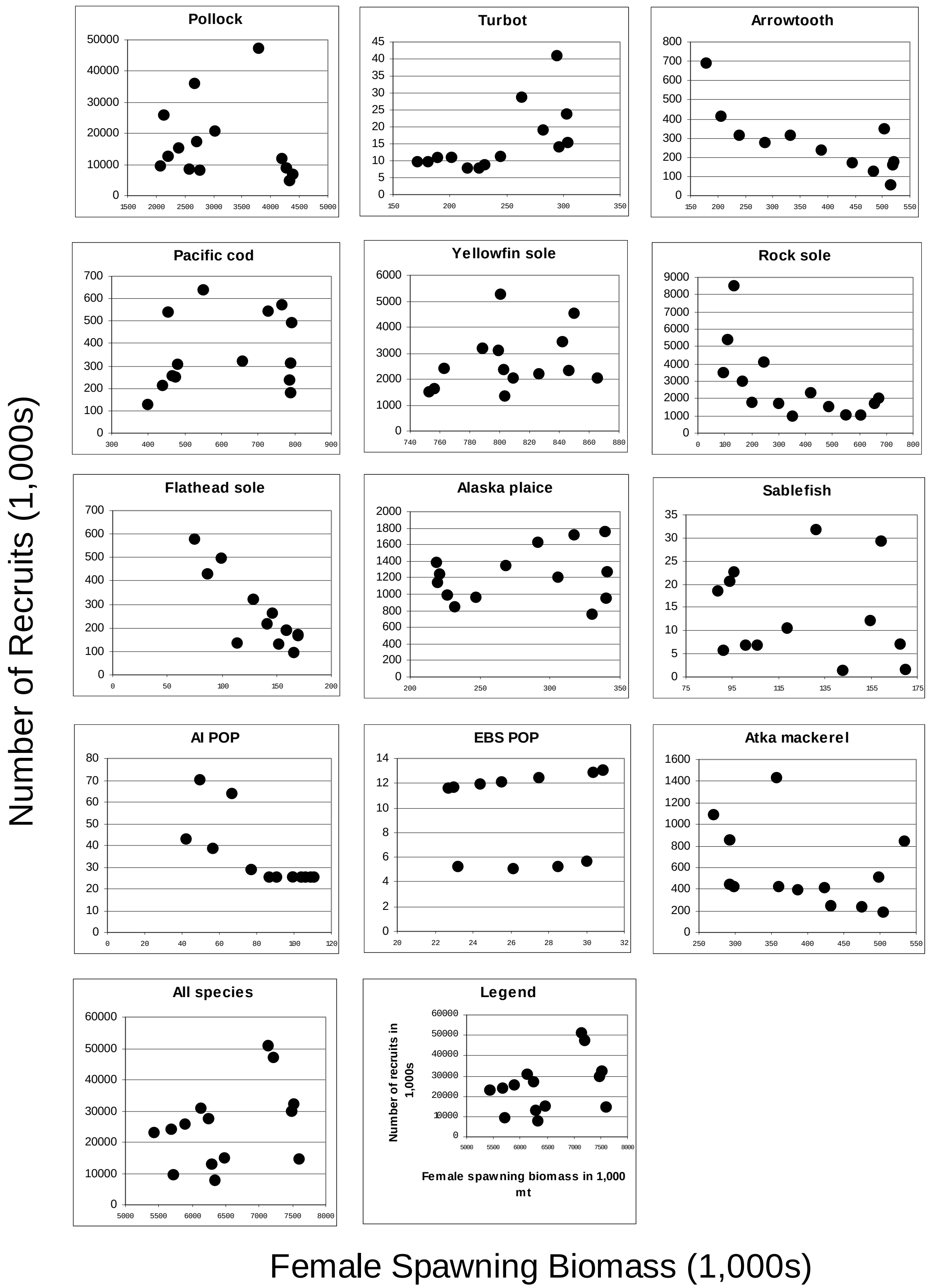


Figure 6.6. Number of recruits as a function of female spawning biomass in the EBS, 1985-1999.

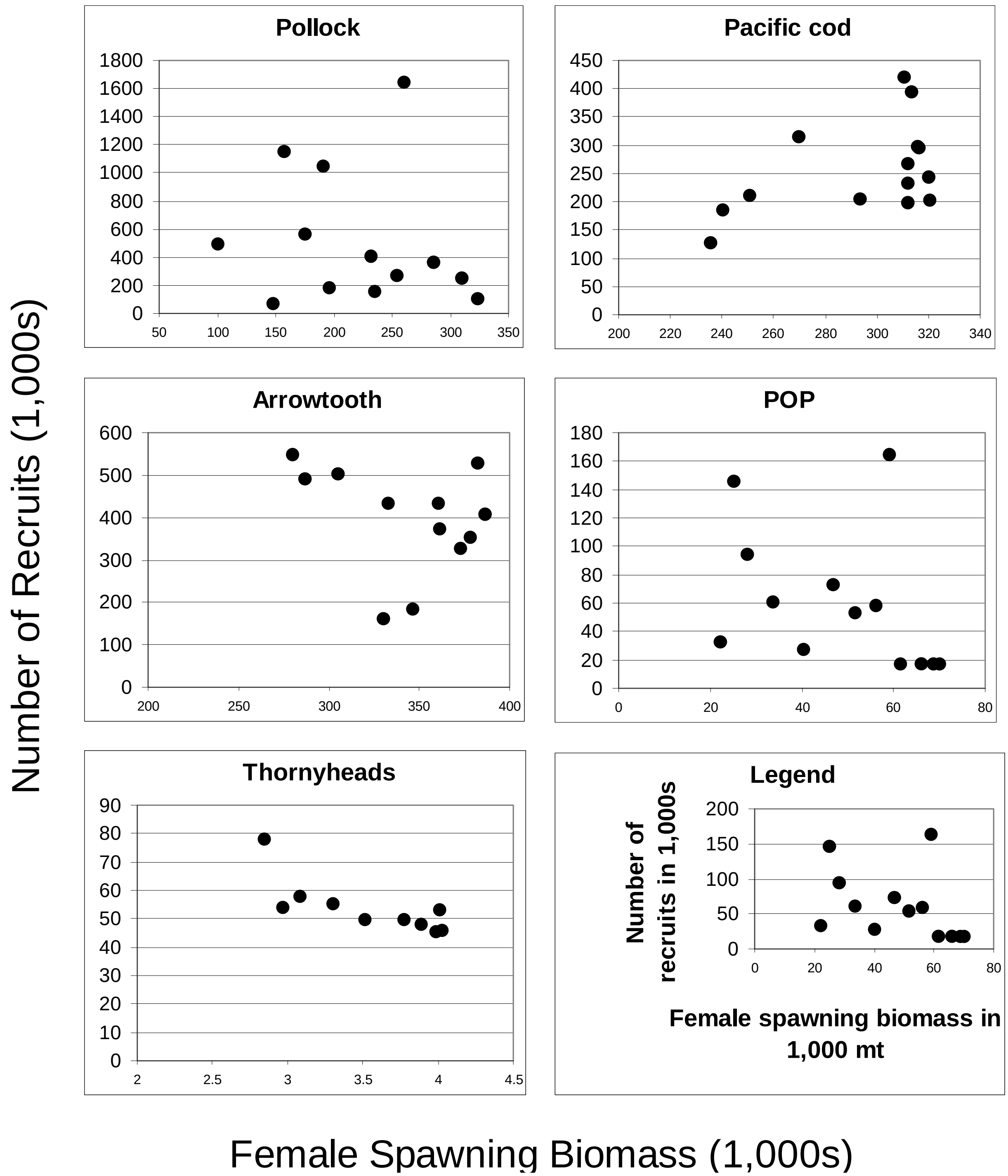


Figure 6.7. Number of recruits as a function of female spawning biomass in the GOA, 1985-1999.

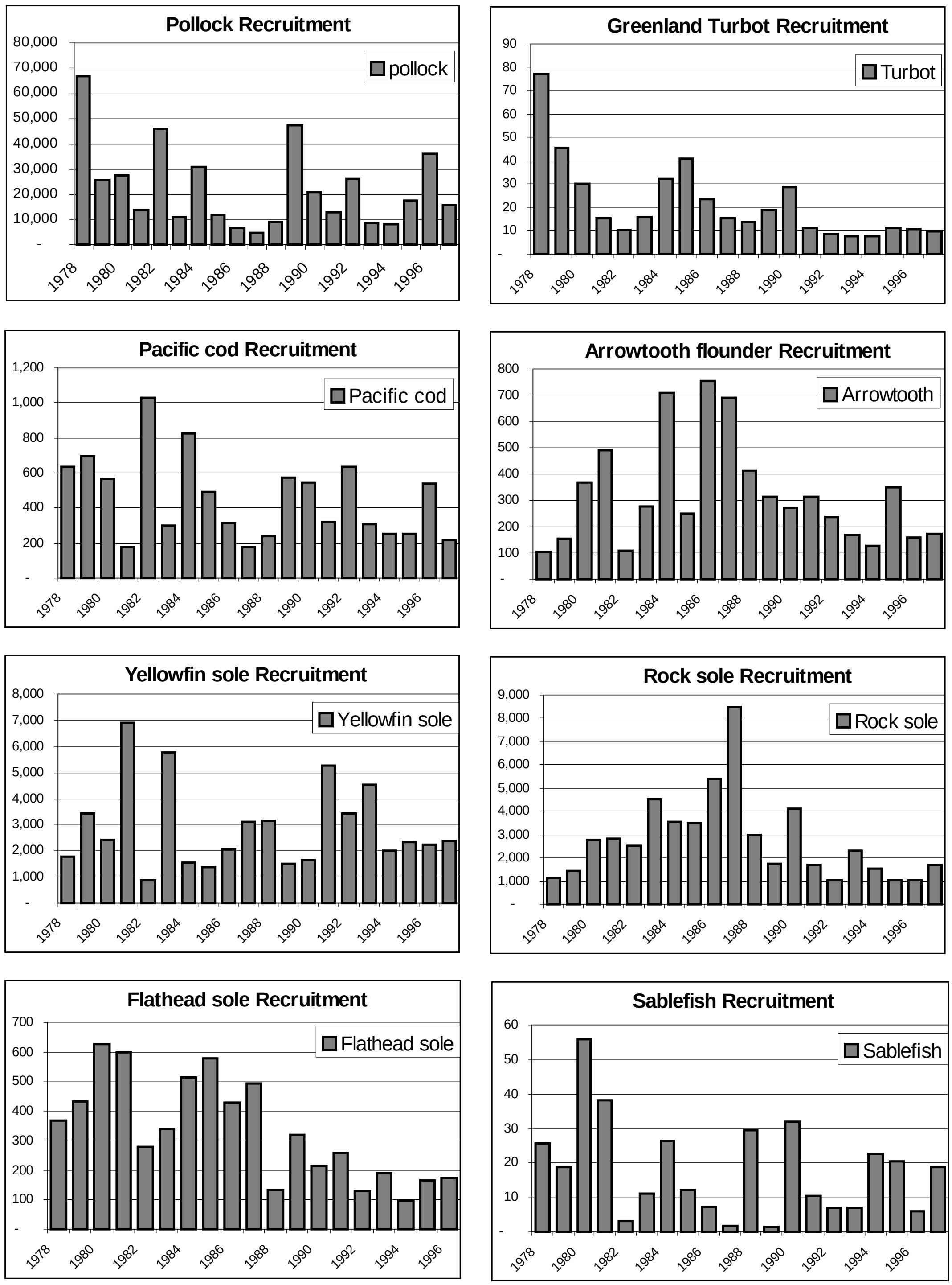


Figure 6.8. Number of recruits (by 1,000) of each species in the BSAI (age of recruitment to the fishery varies by species).

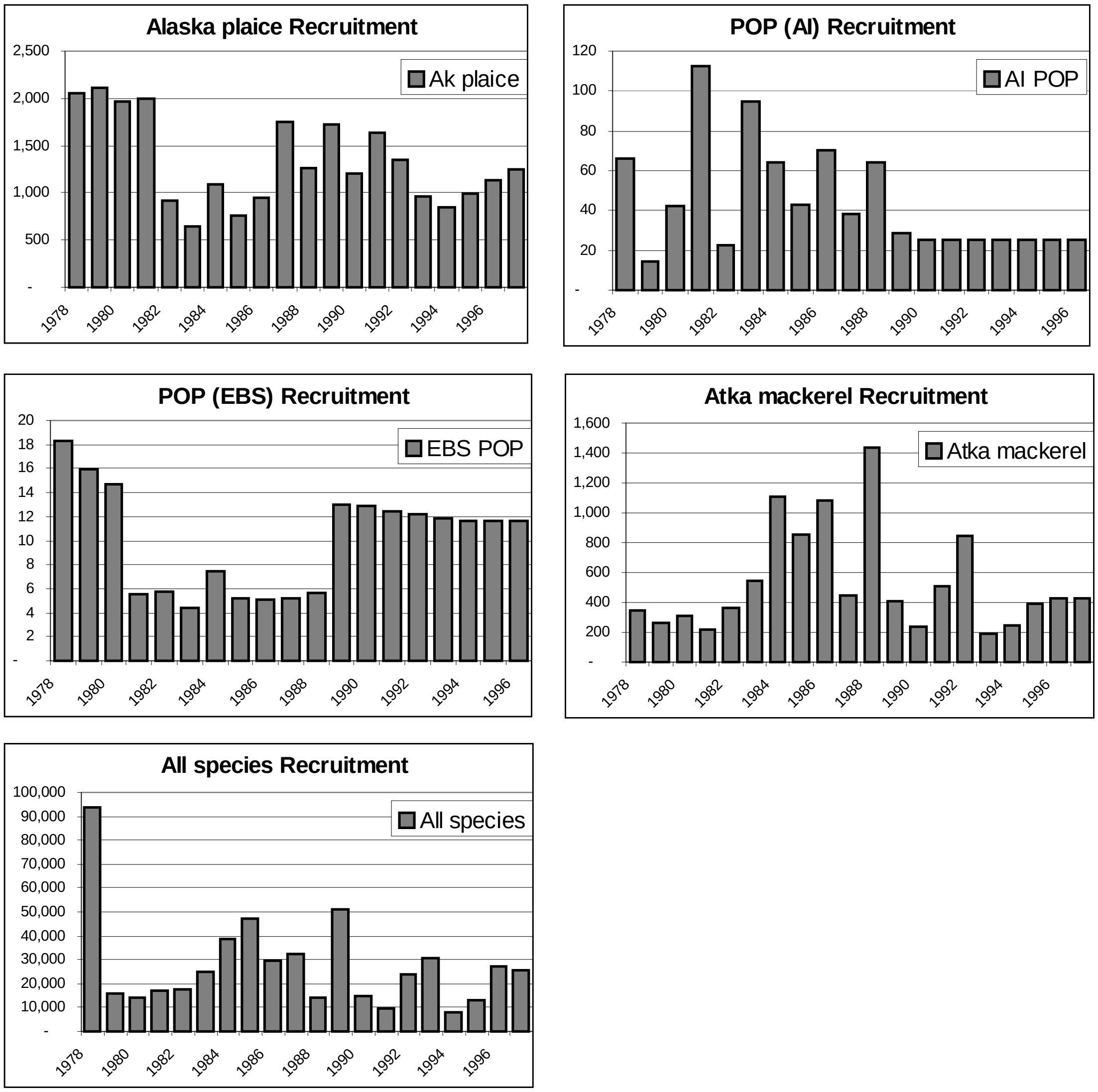


Figure 6.8. Continued.

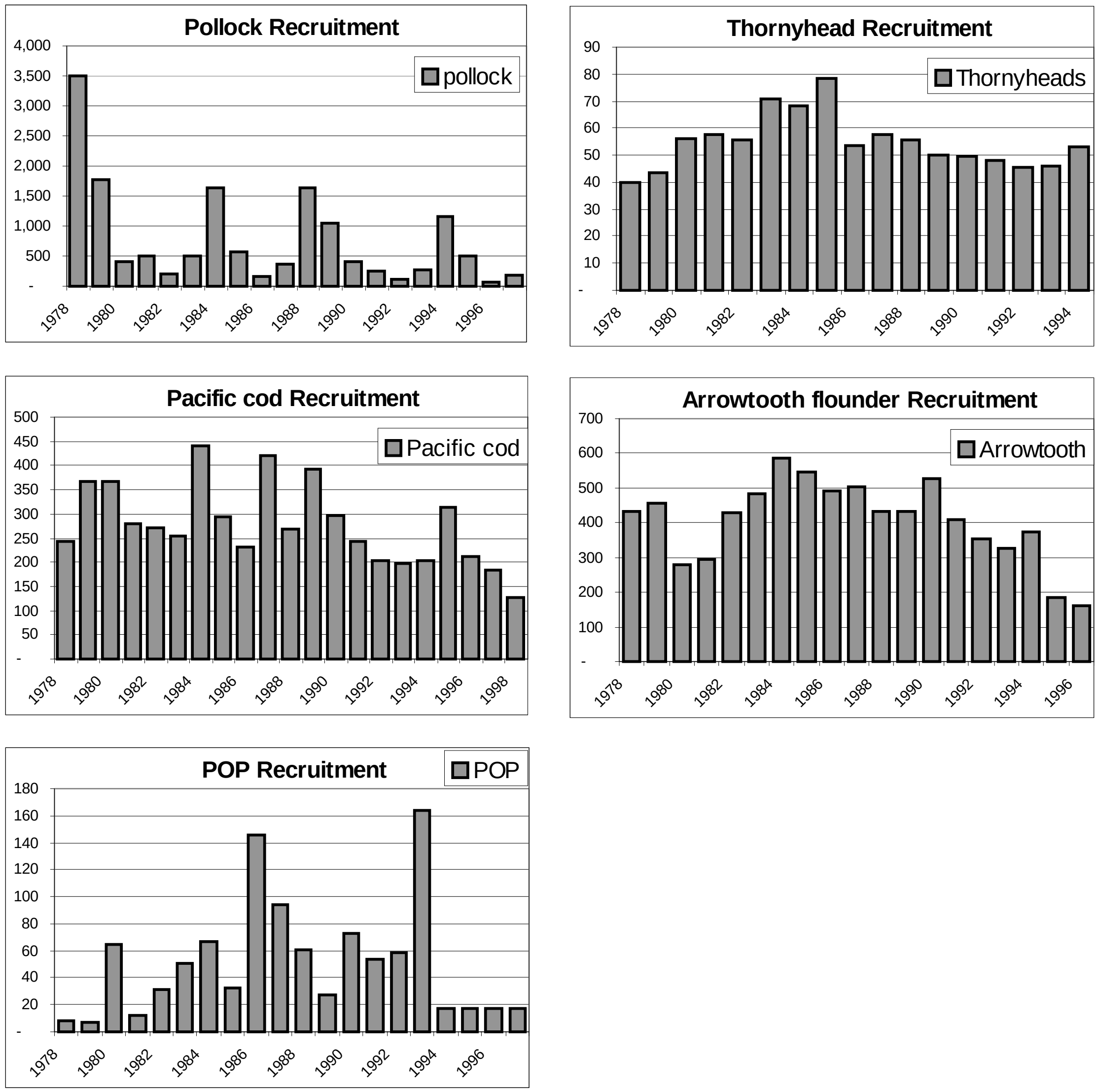


Figure 6.9. Number of recruits (by 1,000) of each species in the GOA (age of recruitment to the fishery varies by species).

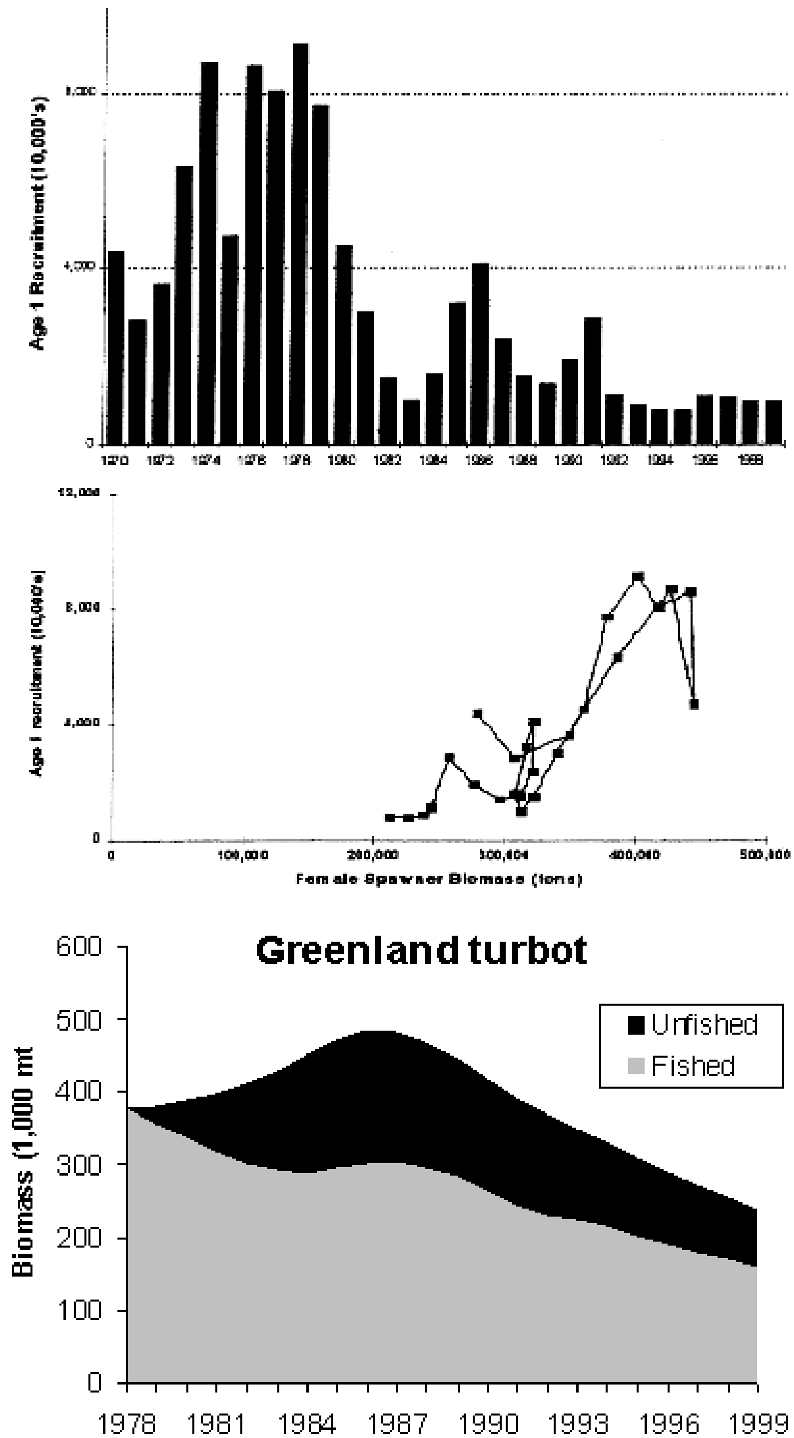
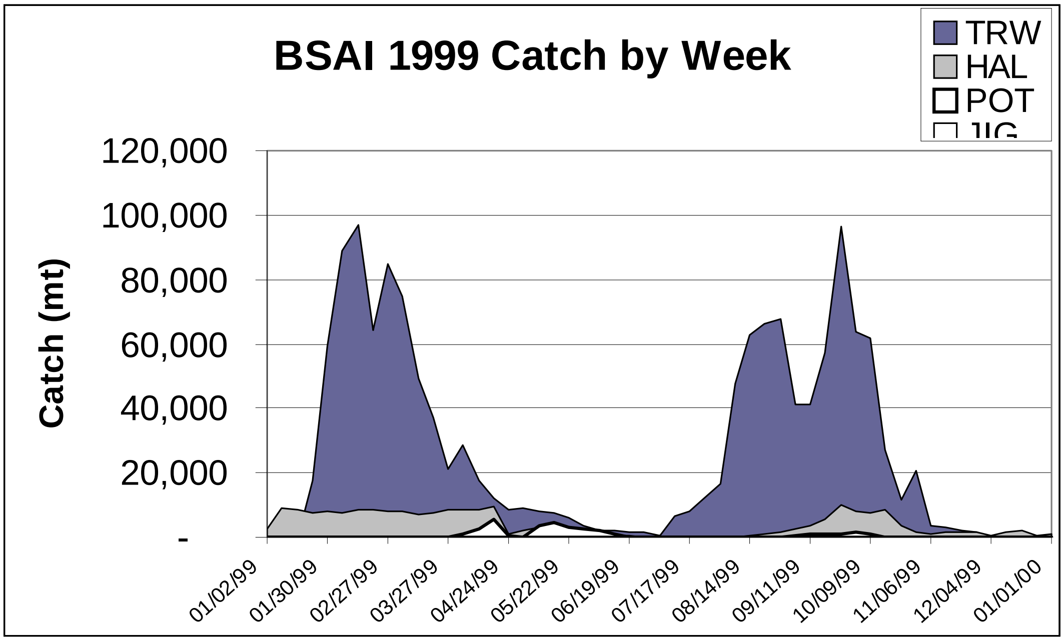


Figure 6.10. Estimated recruitment to age 1 (6.10a upper panel) and the observed sock-recruitment pattern (6.10b middle panel) of Greenland turbot in the EBS/AI region, 1970-1999 (reprinted from Ianelli et. al., 1999; their Figure 4.9), and estimated Greenland turbot biomass at fished and theoretical unfished levels (6.10c bottom panel).



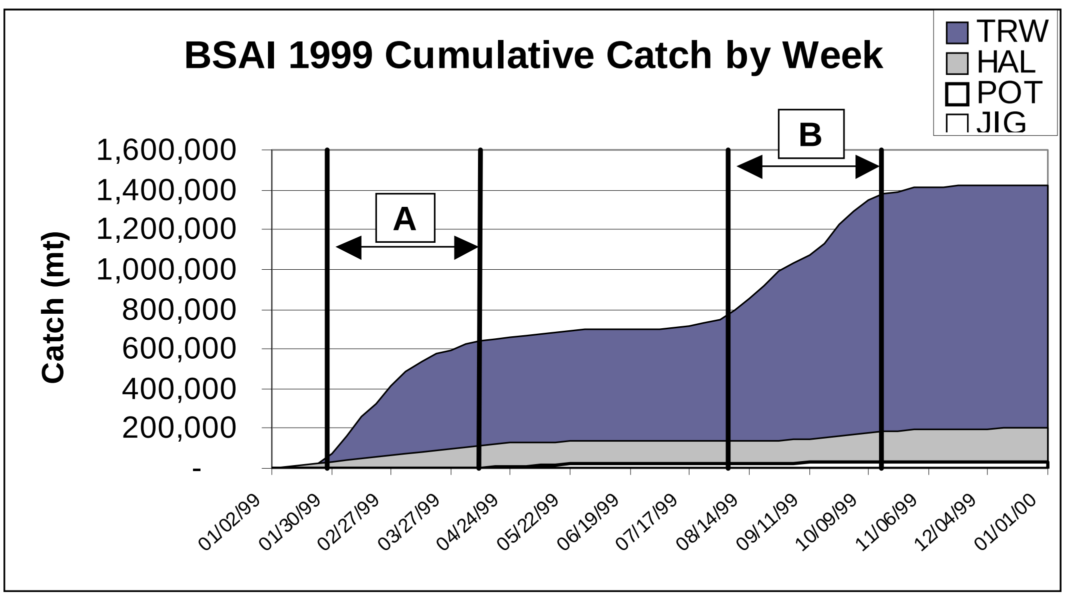
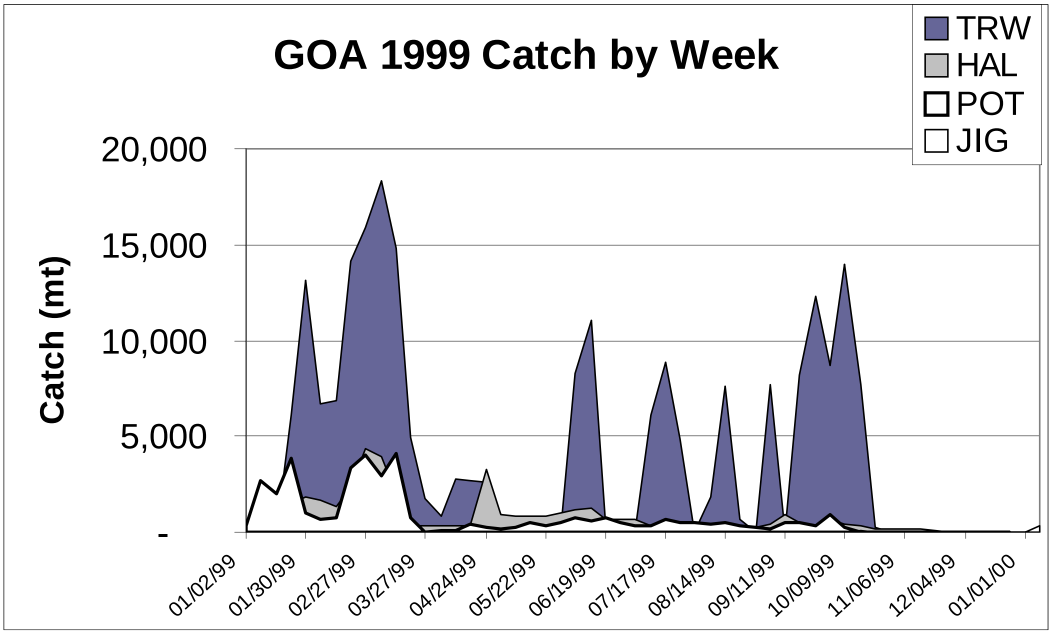


Figure 6.11. Figure 6.11a (top panel) displays the weekly catch rates in the BSAI by gear type for all groundfish species. Figure 6.11b (bottom panel) displays the cumulative catch by week. This figure reveals the two time periods (A and B) in which the majority of groundfish are harvested.



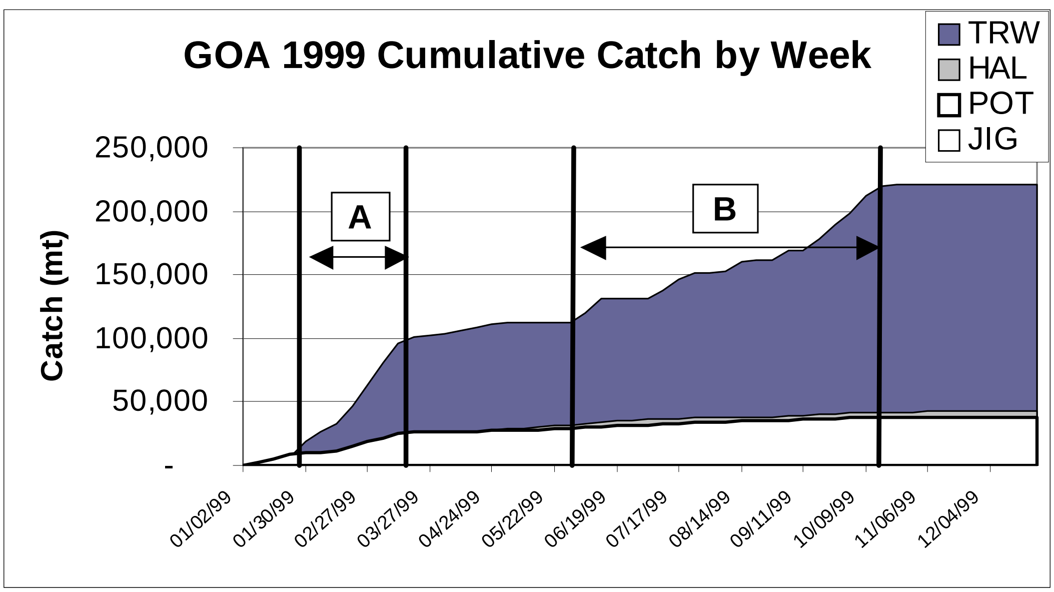


Figure 6.12. Figure 6.12a (top panel) displays the weekly catch rates in the GOA by gear type for all groundfish species. Figure 6.12b (bottom panel) displays the cumulative catch by week. This figure reveals the two time periods (A and B) in which the majority of groundfish are harvested.

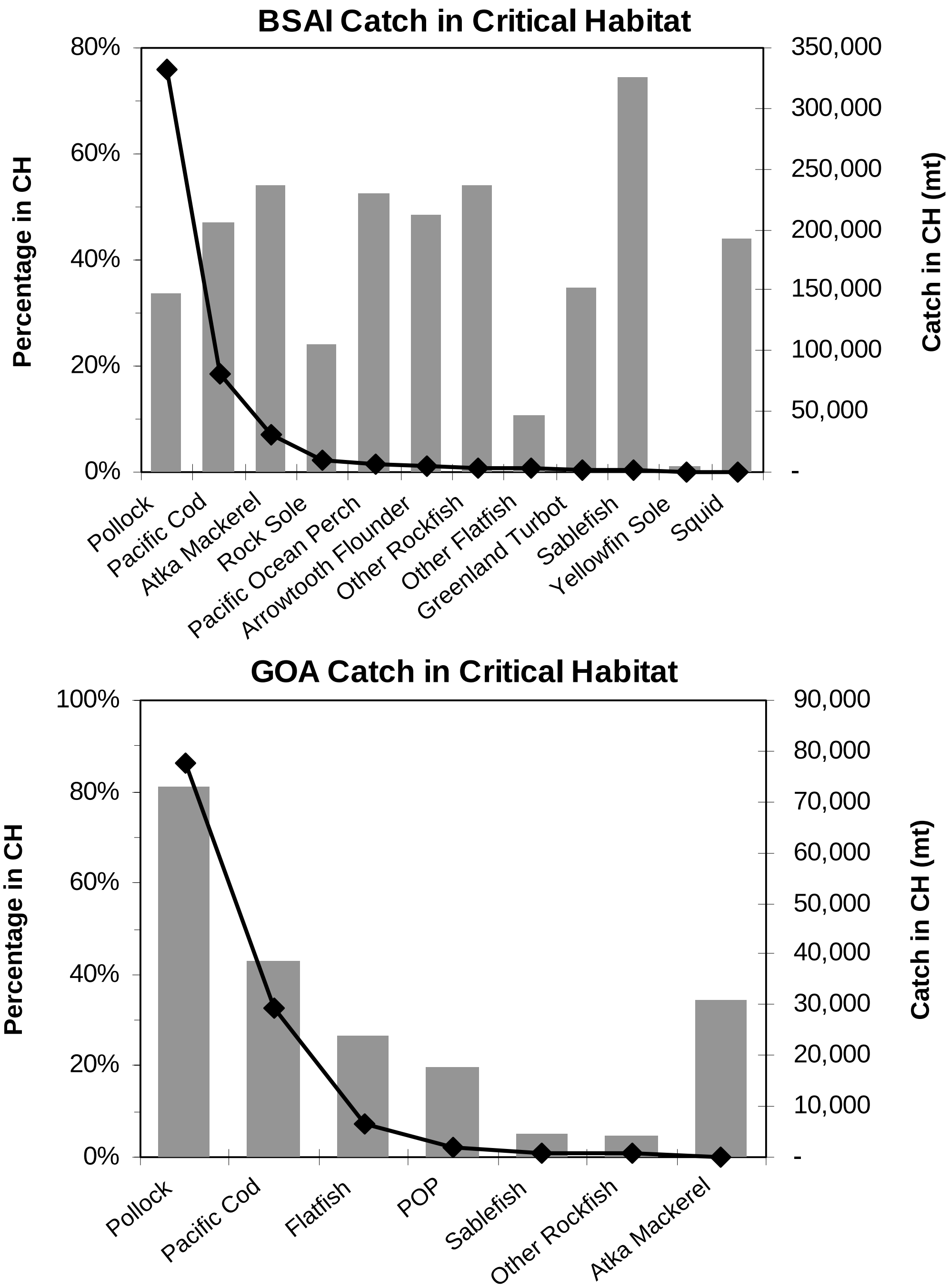
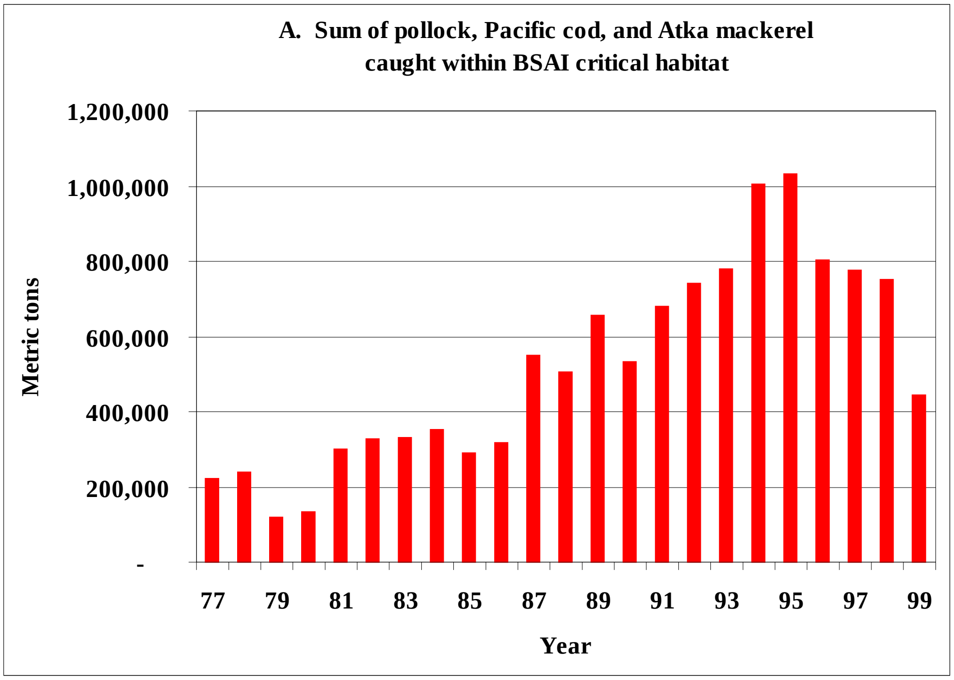


Figure 6.13. BSAI (top panel) and GOA (bottom panel) catch in critical habitat in percent (bars, left Y axis) and amount (line graph in mt, right Y axis).



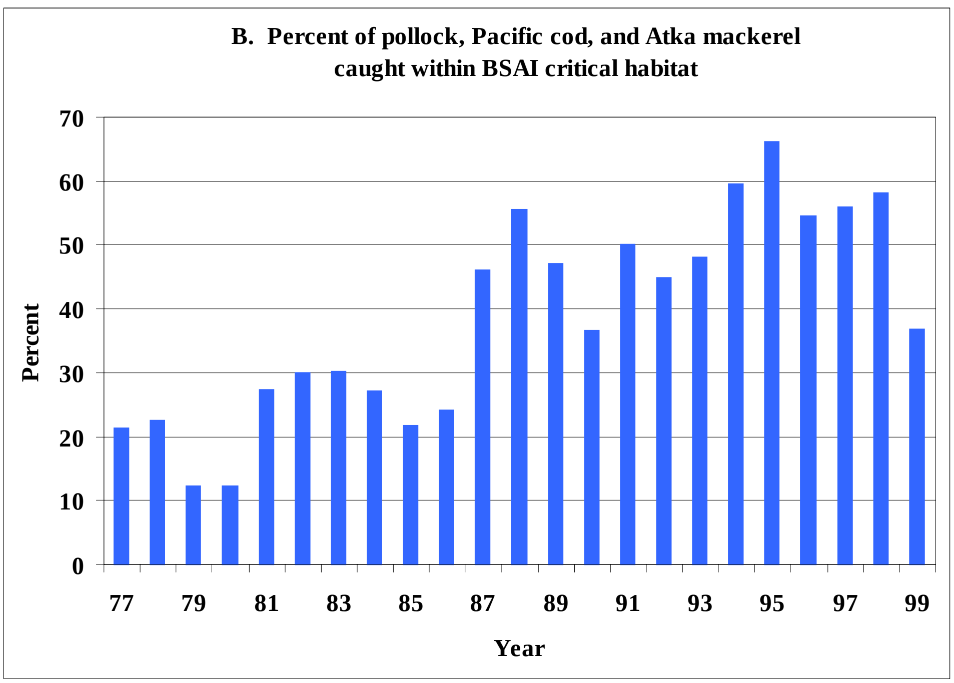
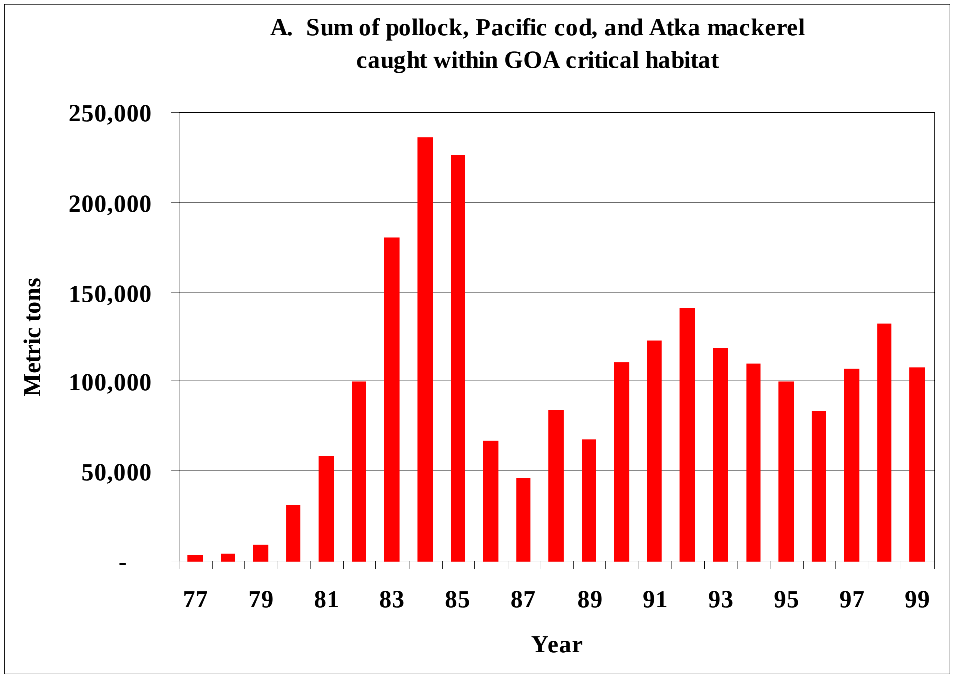


Figure 6.14a. Total catch of pollock, Pacific cod, and Atka mackerel in critical habitat (top panel, in mt) and as a percent of the annual catch (bottom panel) for the BSAI and GOA.



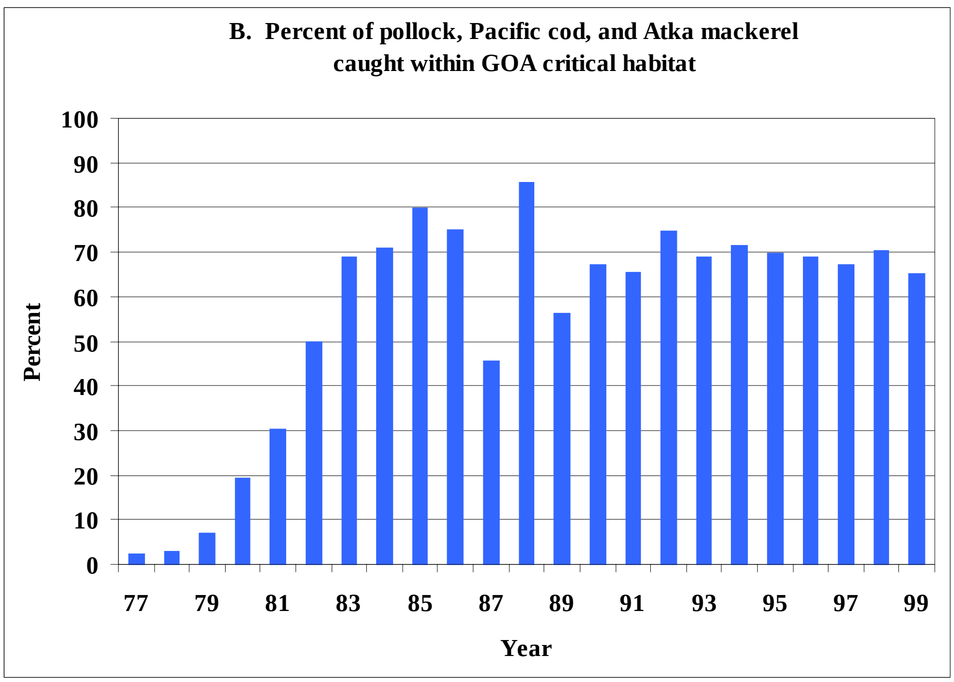


Figure 6.14b. Total catch of pollock, Pacific cod, and Atka mackerel in critical habitat (top panel, in mt) and as a percent of the annual catch (bottom panel) for the BSAI and GOA.

Figure 6.15a. Weekly catch rates of Atka mackerel, Pacific cod, pollock, and all other groundfish species in the BSAI from 1995-1999, both inside and outside of critical habitat.

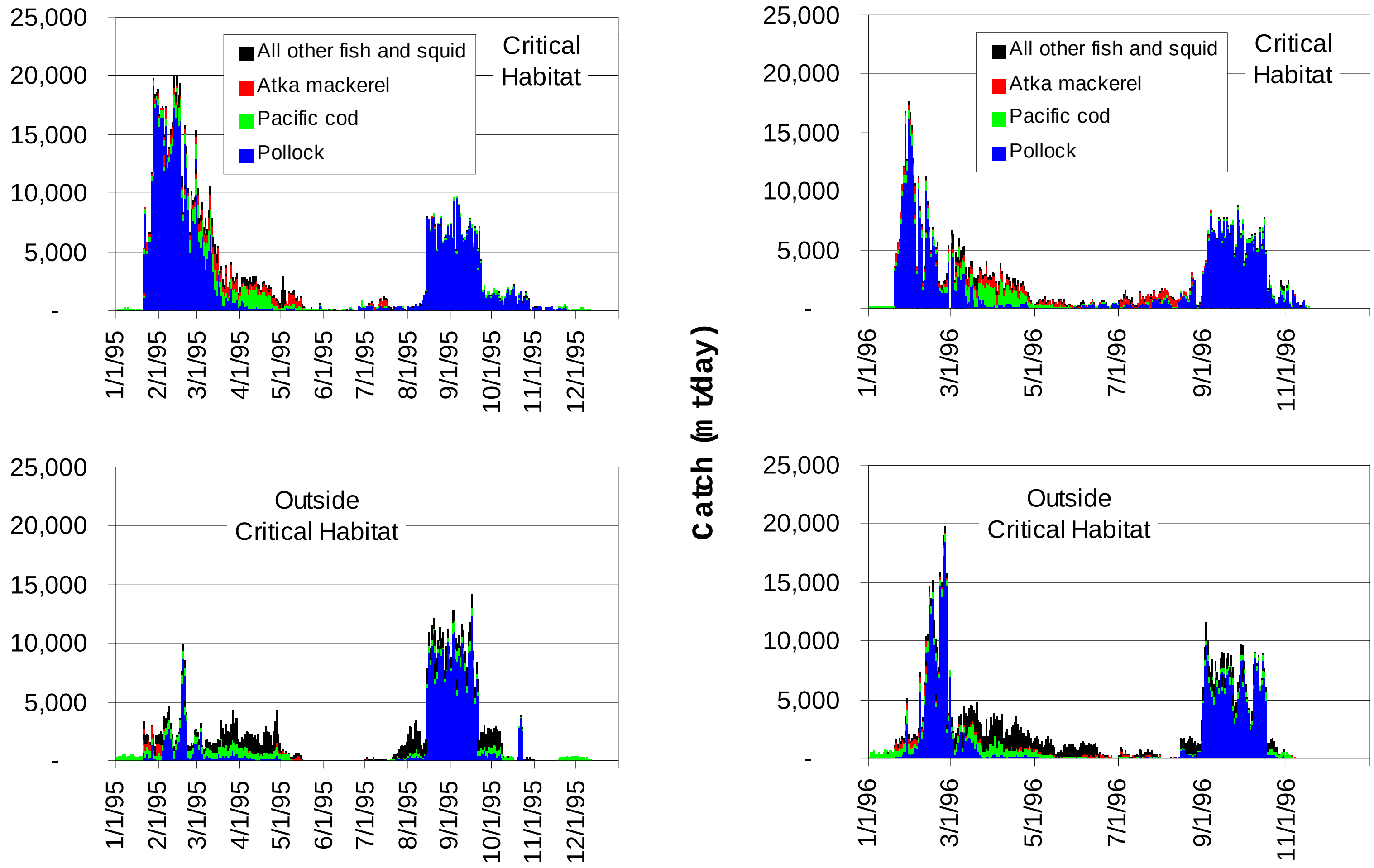


Figure 6.15a. BSAI continued.

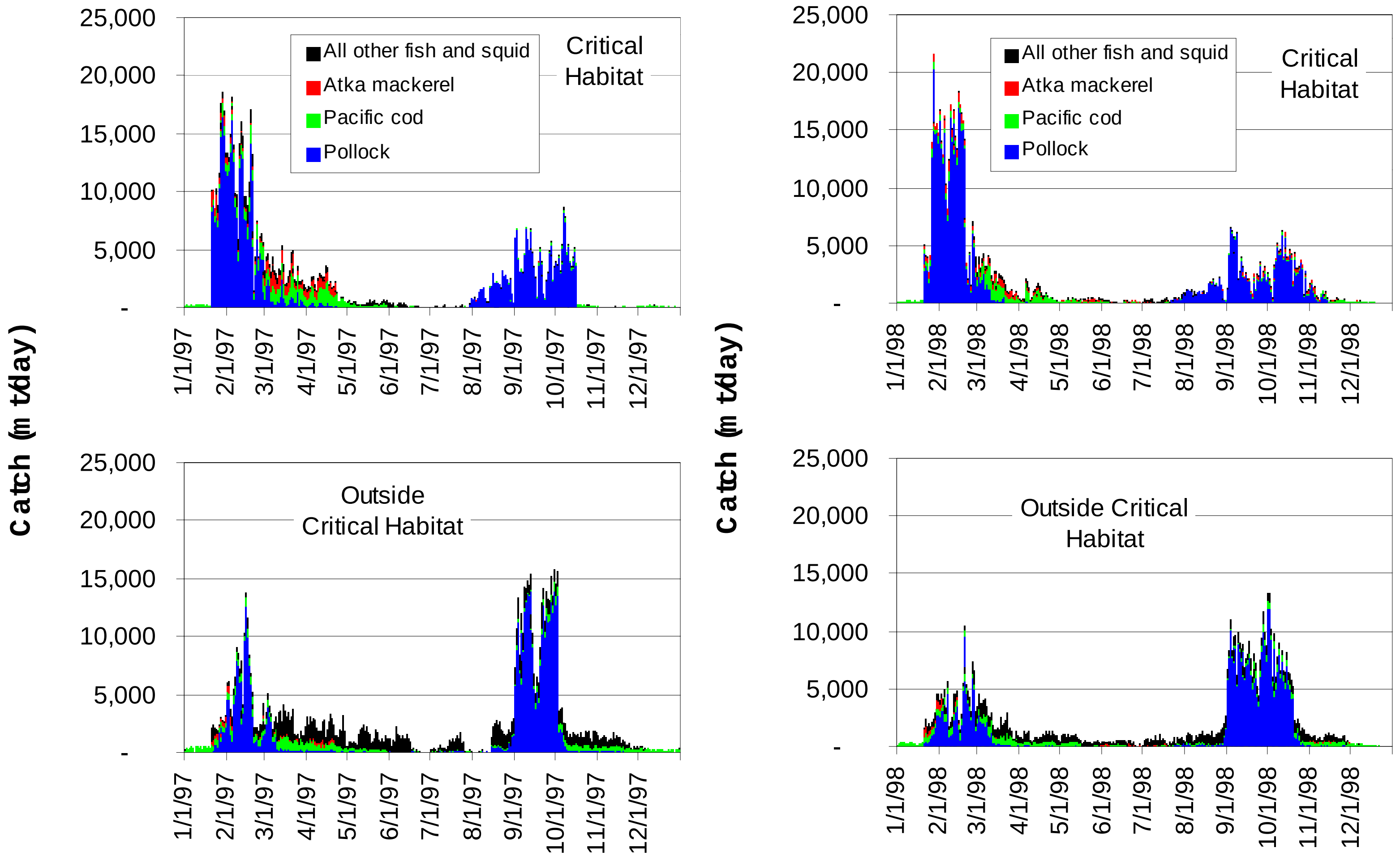


Figure 6.15a. BSAI continued.

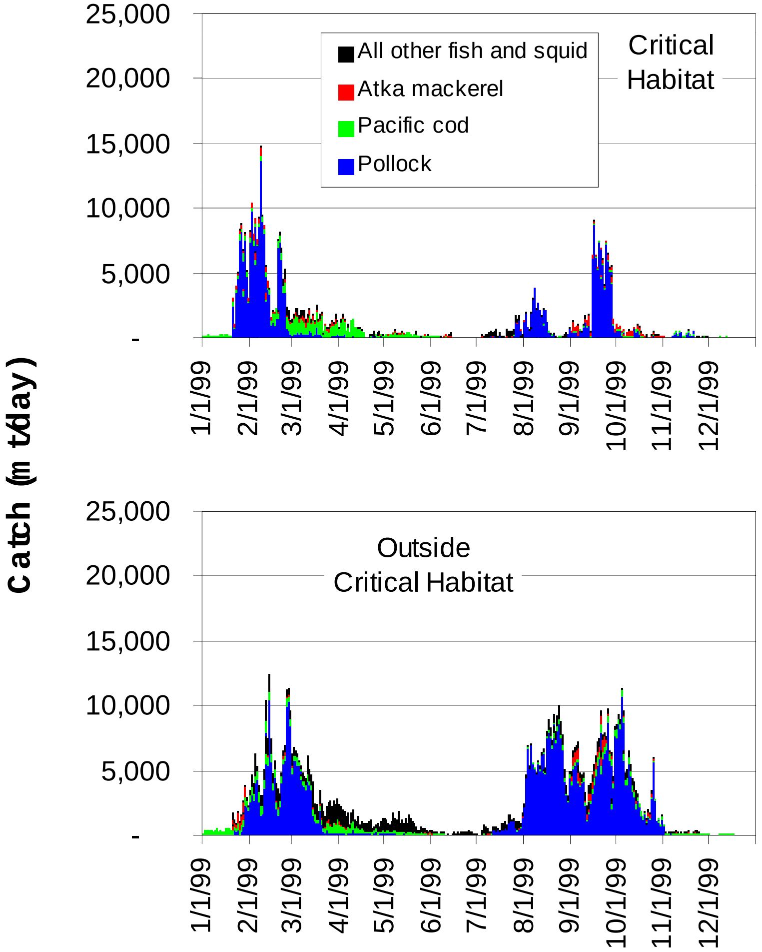


Figure 6.15b. Weekly catch rates of Pacific cod, pollock, and all other groundfish species in the GOA from 1995-1999, both inside and outside of critical habitat.

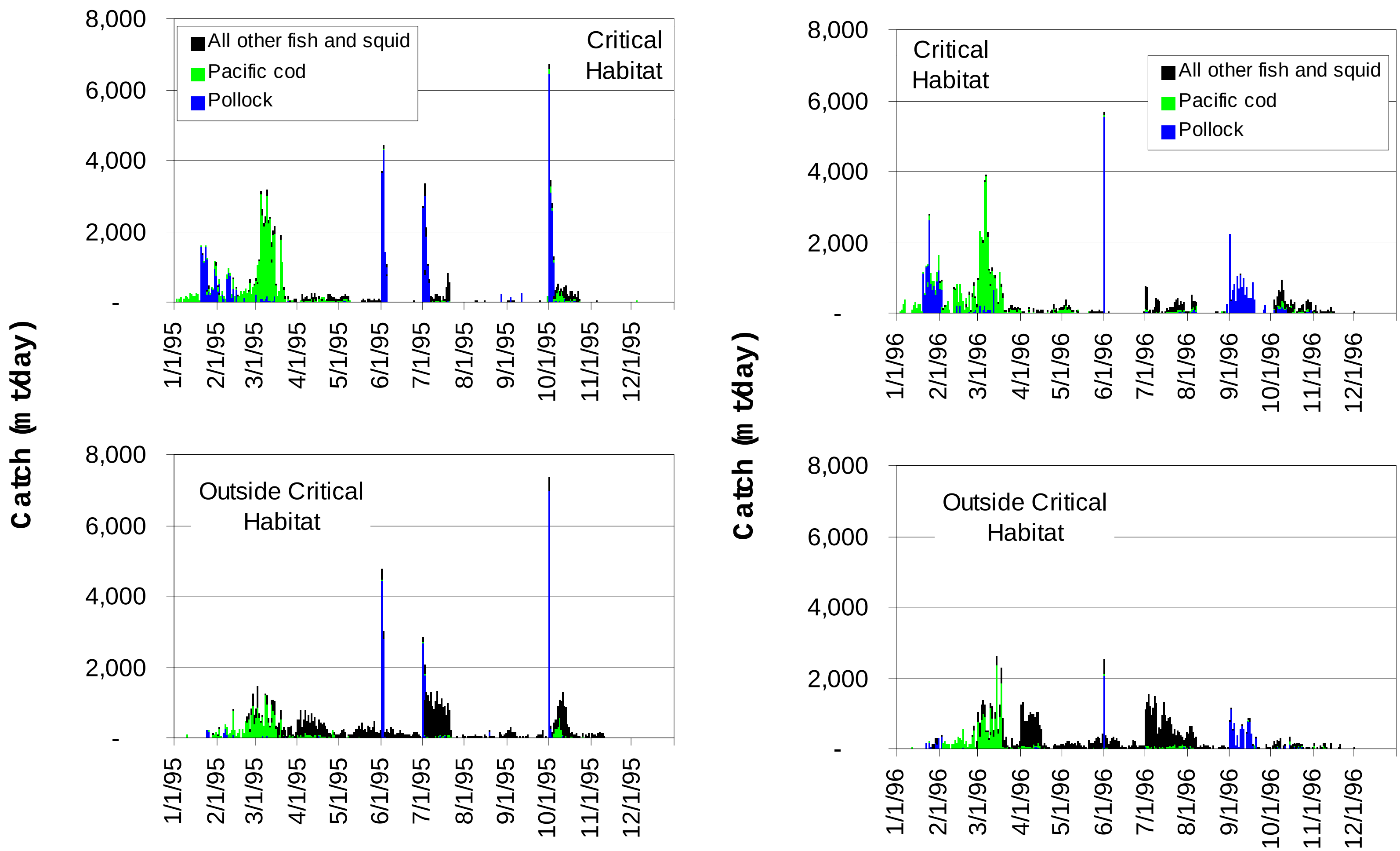


Figure 6.15b. GOA continued.

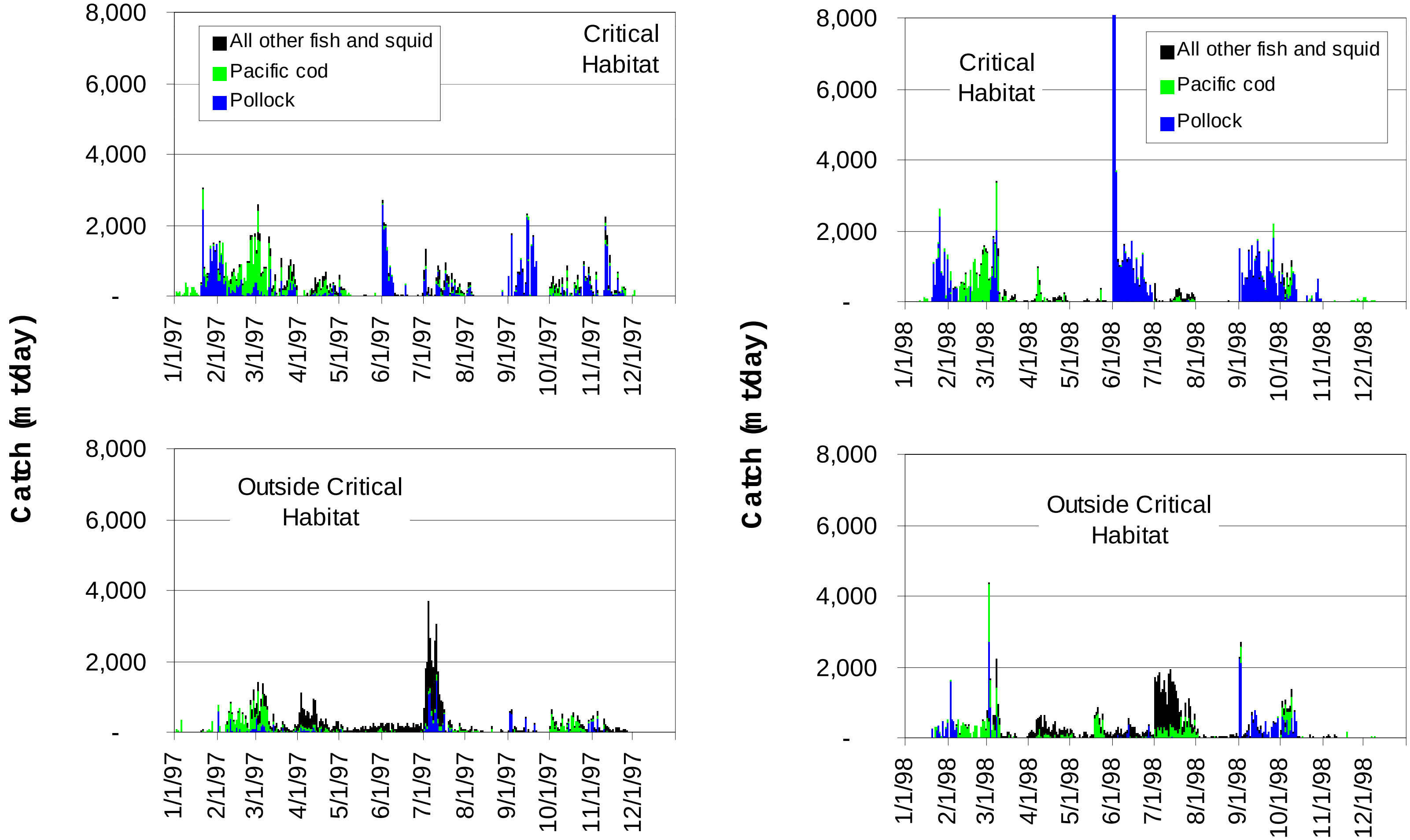
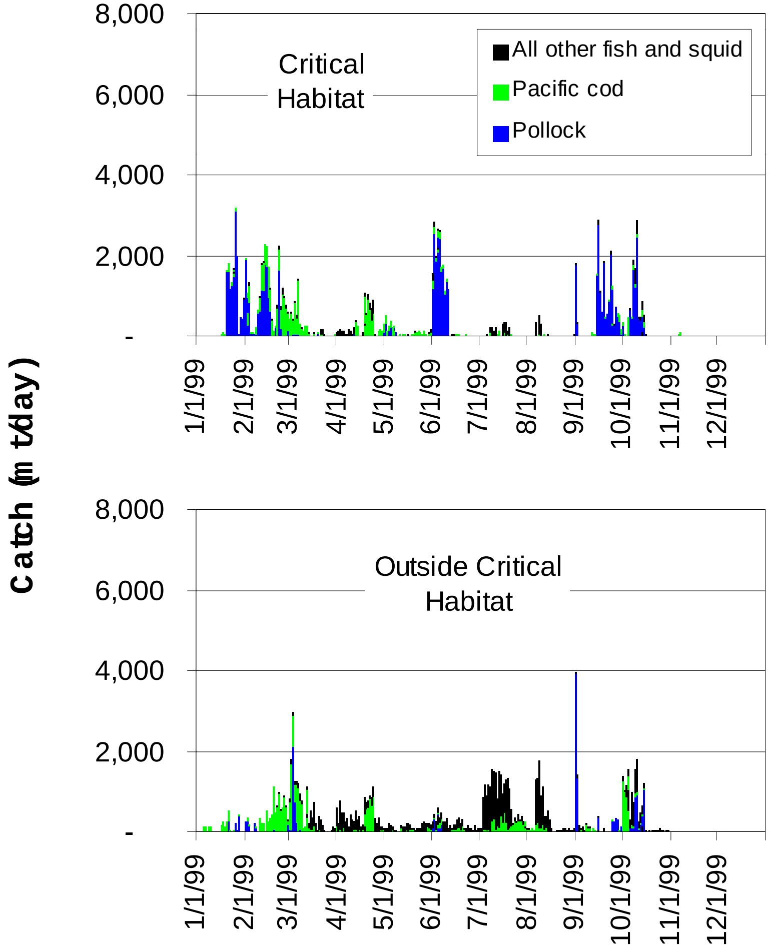


Figure 6.15b. GOA continued.



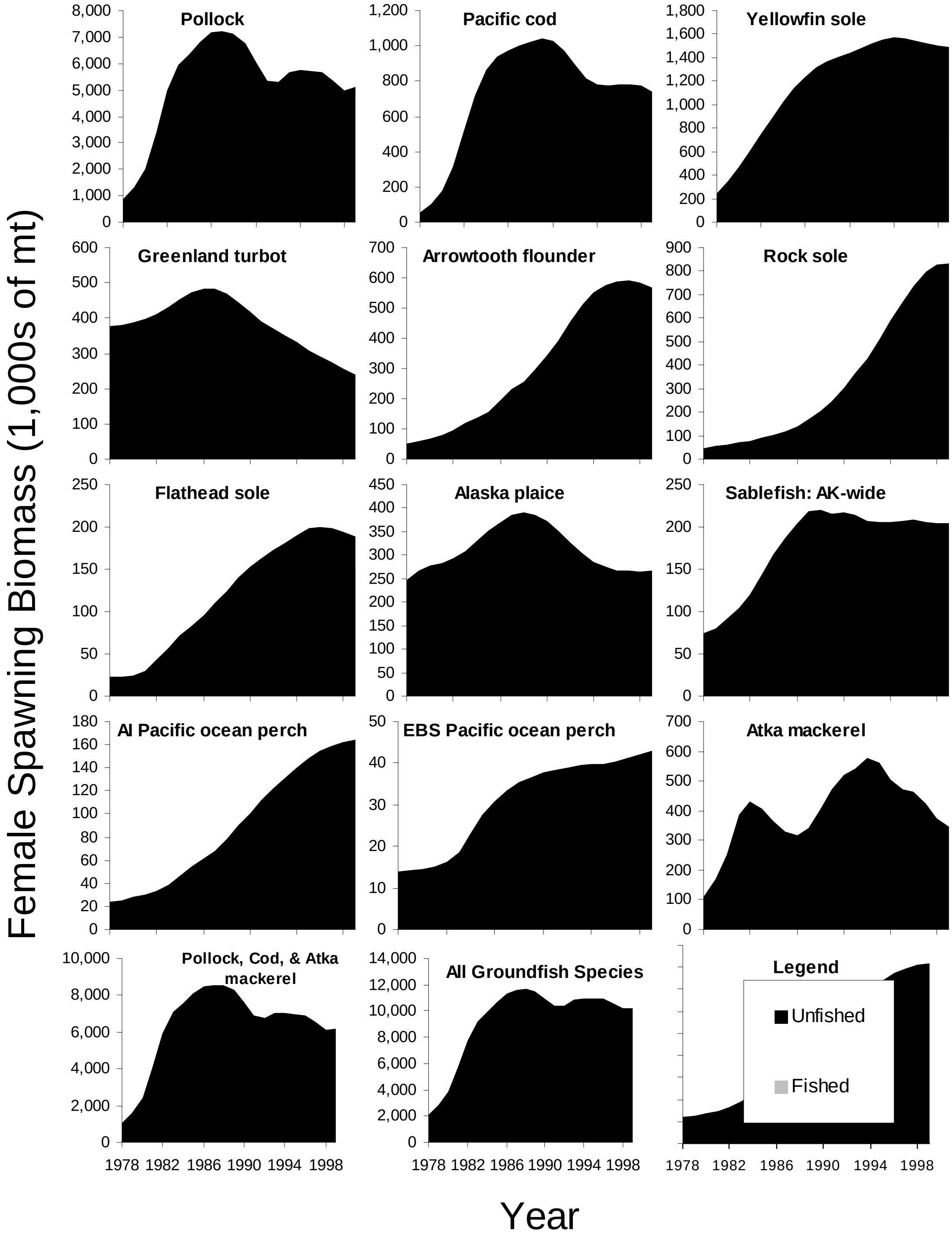


Figure 6.16. Reduction in fish biomass due to cumulative fishing effort on BSAI groundfish.

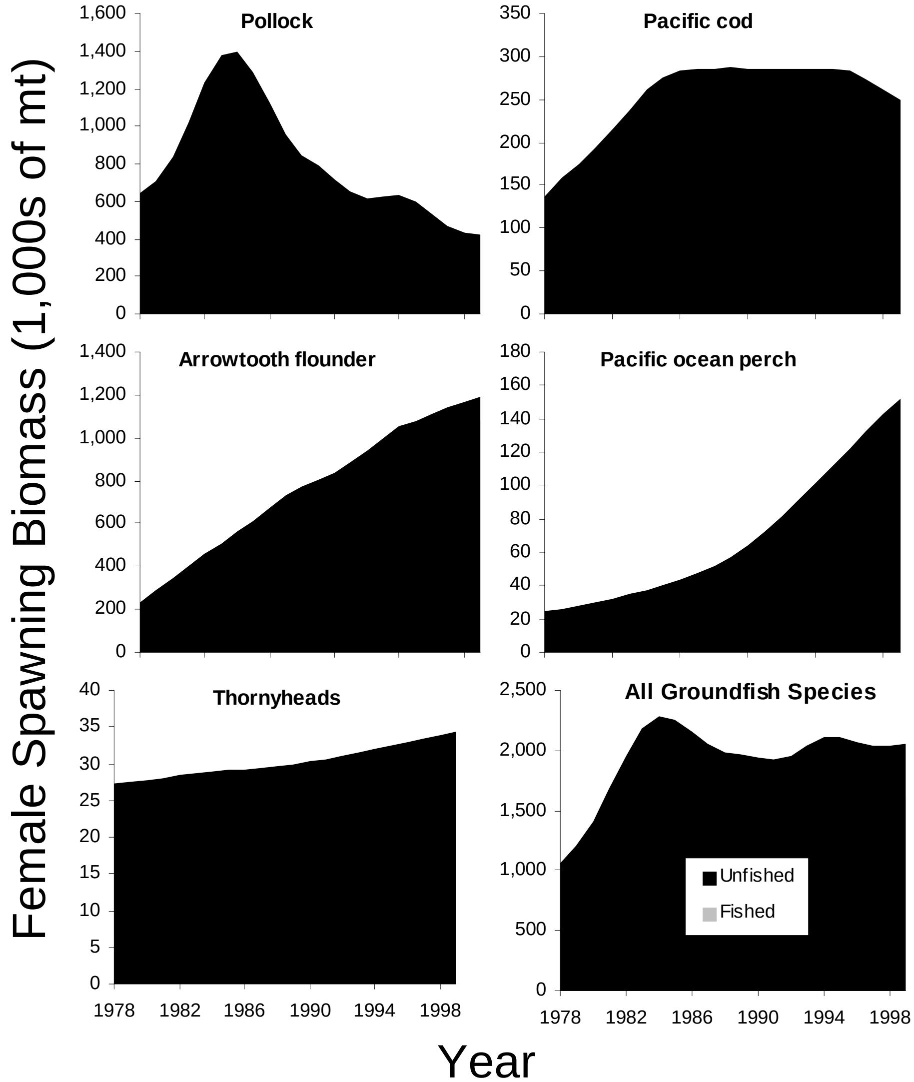


Figure 6.17. Reduction in fish biomass due to cumulative fishing effort on GOA groundfish.

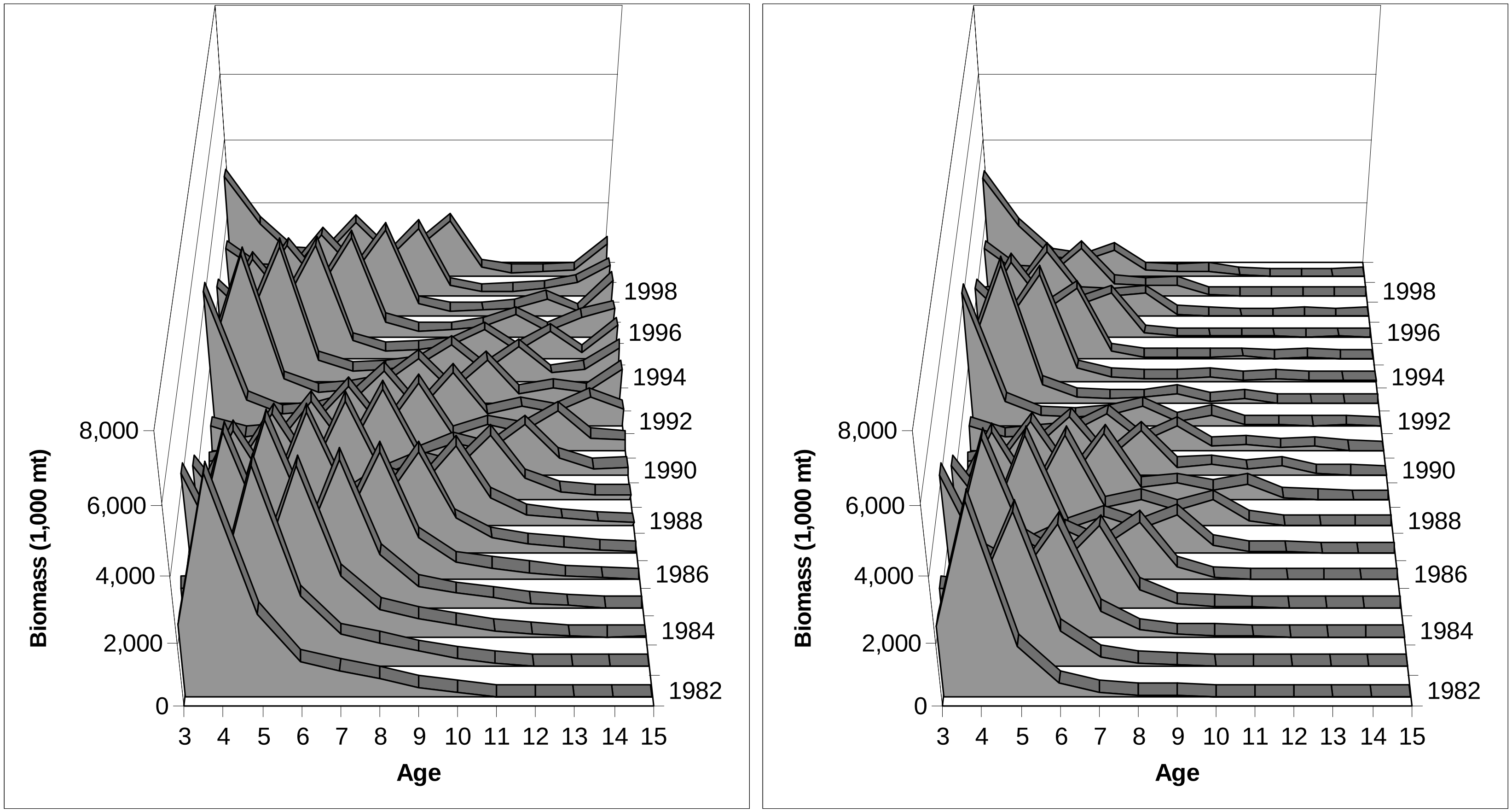


Figure 6.18. Eastern Bering Sea pollock biomass displayed by cohort without fishing (left panel) and with fishing (right panel) applied over the period from 1982 to 1998.

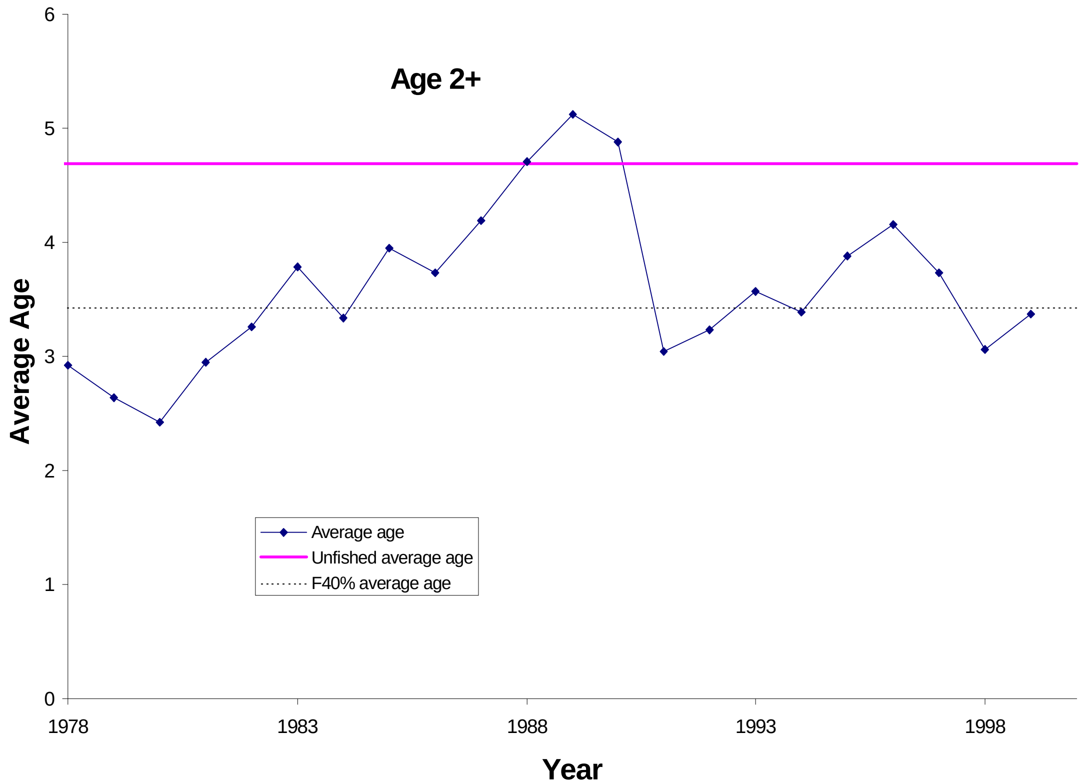


Figure 6.19. Mean age for EBS pollock (1978-1999) from Ianelli et al. (1999) compared to the expected mean age under no fishing and under fishing at a constant F40% harvest rate.

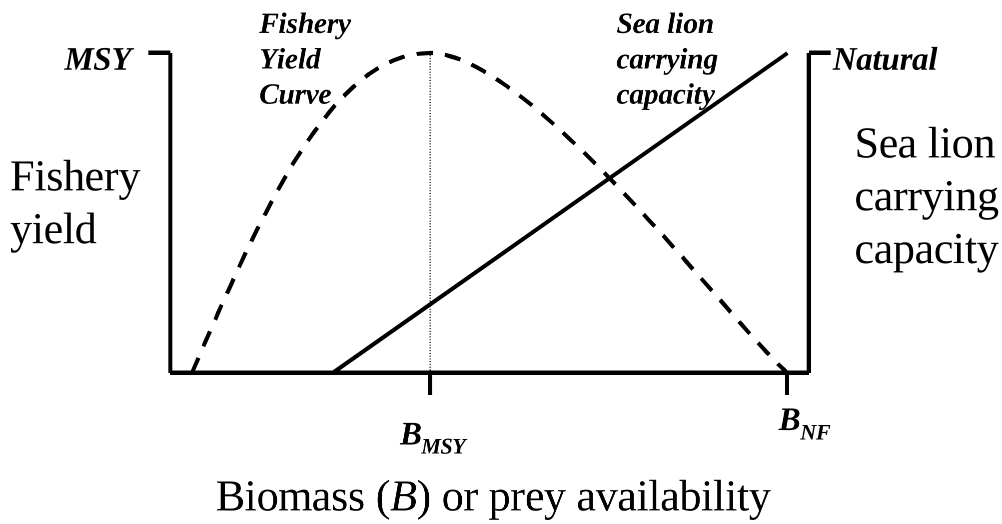


Figure 6.20. Schematic illustration of the relation between 1) the biomass of prey stocks and the yield curve that serves as the basis for the yield-based fishery paradigm, and 2) the simplest approximation of the relation of biomass of the prey stock to the environmental carrying capacity for Steller sea lions.

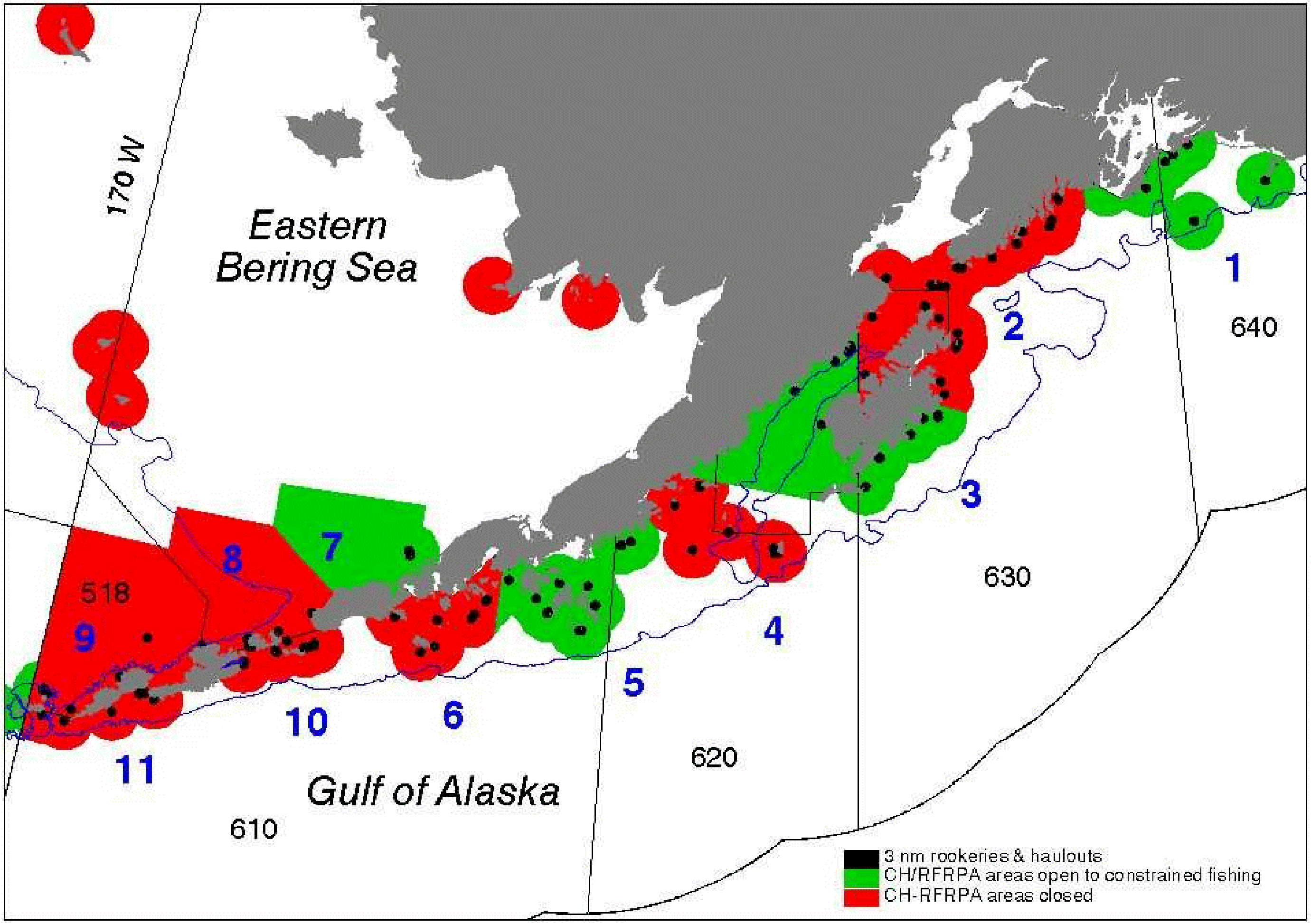


Figure 9.1a. CH-RFRPA areas closed and open to constrained fishing for pollock and Pacific cod fisheries in the Gulf of Alaska. Areas 1-6, 10 and 11 are in the Gulf of Alaska groundfish fishery management region (areas 610-640).

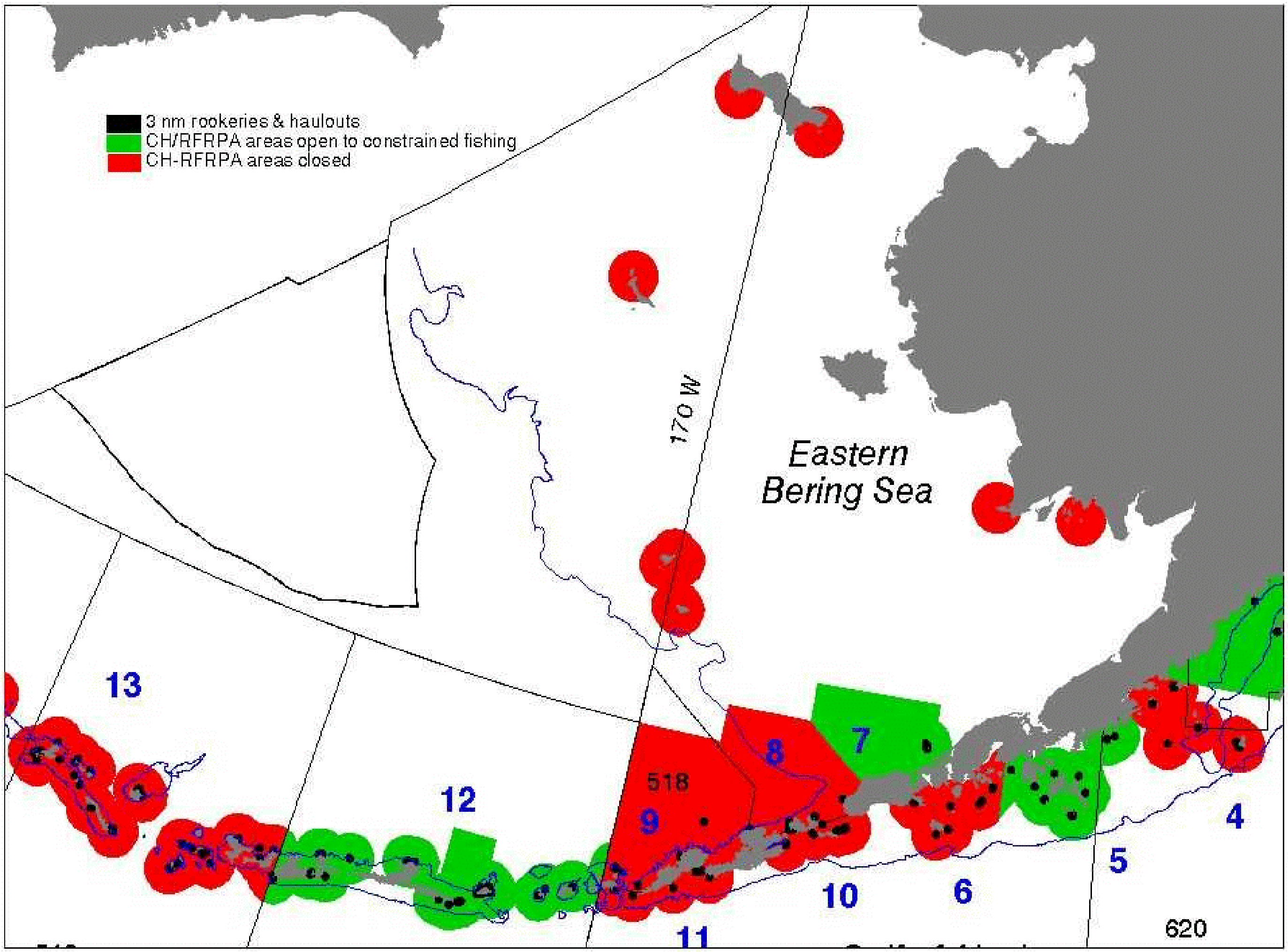


Figure 9.1a. CH-RFRPA areas closed and open to constrained fishing for pollock, Pacific cod, and Atka mackerel fisheries in the eastern Bering Sea. Areas 7-9 are in the eastern Bering Sea groundfish fishery management region.

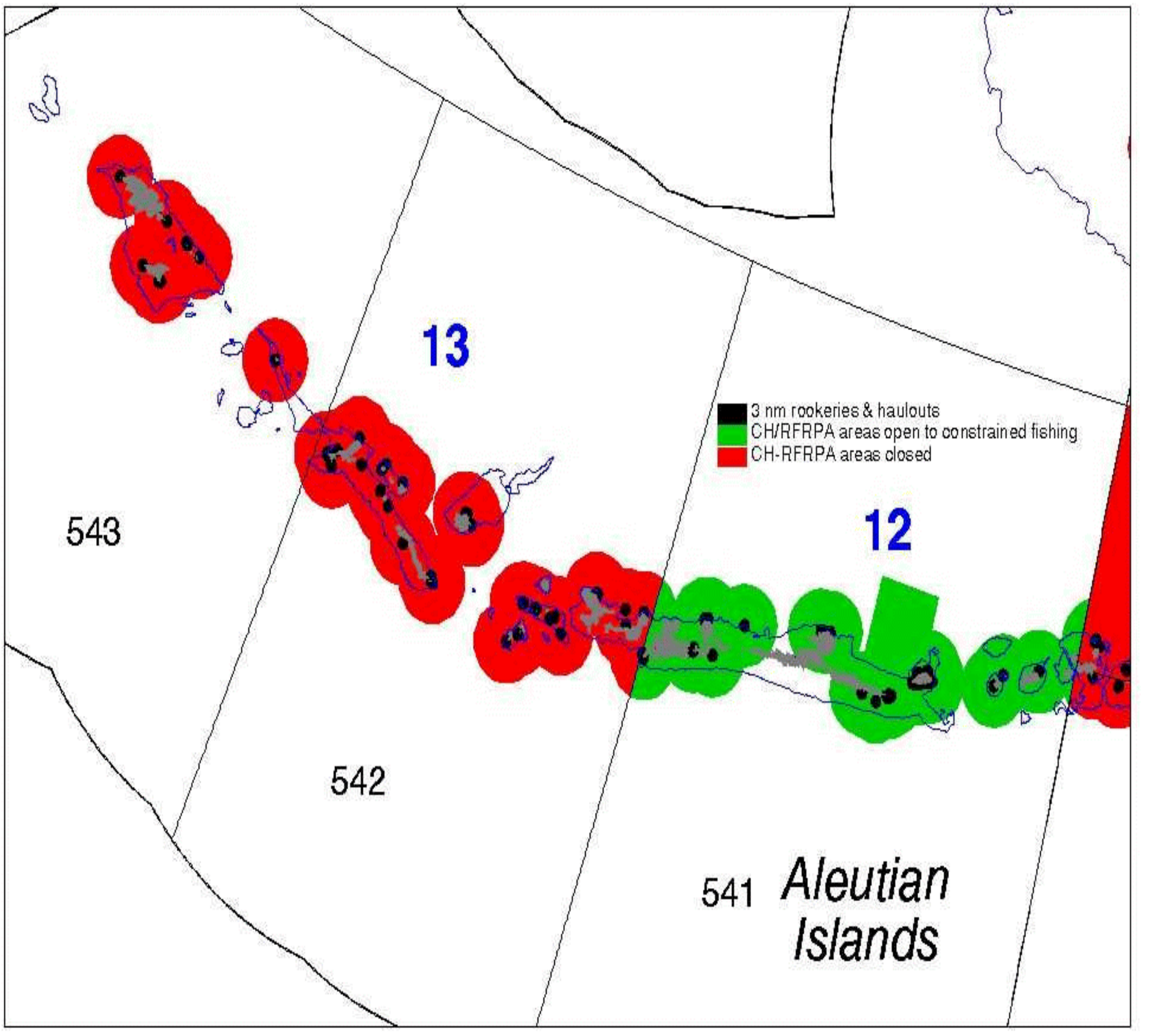


Figure 9.1c. CH-RFRPA areas closed and open to constrained fishing for pollock, Pacific cod, and Atka mackerel fisheries in the Aleutian Islands. Areas 12 and 13 are in the Aleutian Islands groundfish fishery management region (areas 541-543).