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

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[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

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[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 taking into account the protection of marine ecosystems;
> >
> > (B) is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and
> >
> > (C) in the case of an overfished fishery, provides for rebuilding to a level consistent with

> producing the 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 <u>and the marine environment</u>; and (B) which are designed <u>to assure that</u>–
>
> > (i) a supply of food and other products may be taken, and that recreational benefits may be obtained, on a continuing basis;
> >
> > (ii) <u>irreversible or long-term adverse effects on fishery resources and the marine environment are avoided</u>; 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 the 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: $B/B_{MSY} > 1$
    $F_{OFL} = F_{MSY}$
    $F_{ABC} \le F_{MSY} \times (F_{40\%} / F_{35\%})$
  2b) Stock status: $a < B/B_{MSY} \le 1$
    $F_{OFL} = F_{MSY} \times (B/B_{MSY} - a)/(1 - a)$
    $F_{ABC} \le F_{MSY} \times (F_{40\%} / F_{35\%}) \times (B/B_{MSY} - a)/(1 - a)$
  2c) Stock status: $B/B_{MSY} \le a$
    $F_{OFL} = 0$
    $F_{ABC} = 0$

Tier 3) Information available: Reliable point estimates of B, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$.
  3a) Stock status: $B/B_{40\%} > 1$
    $F_{OFL} = F_{35\%}$
    $F_{ABC} \le F_{40\%}$
  3b) Stock status: $a < B/B_{40\%} \le 1$
    $F_{OFL} = F_{35\%} \times (B/B_{40\%} - a)/(1 - a)$
    $F_{ABC} \le F_{40\%} \times (B/B_{40\%} - a)/(1 - a)$
  3c) Stock status: $B/B_{40\%} \le a$
    $F_{OFL} = 0$
    $F_{ABC} = 0$

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

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

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 ≤ 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

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[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, $47{,}579 \pm 26{,}704$ km^2 for adult females in winter, and $9{,}196 \pm 6799$ 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 20th 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 20th 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 144° 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 144° 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.

	Estimated Pollock Catches (mt) and Percent Caught in the Steller Sea Lion Critical Habitat in the Gulf of Alaska		
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 (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).

<table>
<tr><td colspan="2">3. Increase the Temporal Dispersion of the Catch to Minimize the Risk of Localized Depletion of Prey Species</td></tr>
<tr><td>Management Actions</td><td>Conservation Impacts of the Actions</td></tr>
<tr><td>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.</td><td>* 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.</td></tr>
<tr><td colspan="2">4. Spatial Distribution and Further Reduction of the Harvest of the Three Primary Prey Species Within Critical Habitat</td></tr>
<tr><td>Management Action</td><td>Conservation Impacts of the Action</td></tr>
<tr><td>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.</td><td>* 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.</td></tr>
<tr><td colspan="2">5. Provide a Basis for Developing Better Information on the Impacts of Area Closures and Other Measures</td></tr>
<tr><td>Management Action</td><td>Conservation Impacts of the Action</td></tr>
<tr><td>Select area closures to provide contrast between complete closures and restricting fishing areas within critical habitat.</td><td>*Provide a stronger experimental statistical basis for the evaluation of area closures on sea lion recovery.
*Provide a stronger monitoring capability through experimental design.</td></tr>
</table>

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