Endangered Species Act – Section 7 Consultation

Biological Opinion and Incidental Take Statement

October 2001

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 as modified by amendments 61 and 70; and

Authorization of Gulf of Alaska groundfish fisheries based on the Fishery Management Plan for Groundfish of the Gulf of Alaska as modified by amendments 61 and 70.

Parallel fisheries for pollock, Pacific cod, and Atka mackerel, as authorized by the State of Alaska within 3 nm of shore.

Consultation By: National Marine Fisheries Service
Protected Resources Division

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1 BACKGROUND INFORMATION AND CONSULTATION HISTORY

The Endangered Species Act (ESA) (16 U.S.C. 1531-1544), amended in 1988, establishes a national program for the conservation of threatened and endangered species for fish, wildlife, and plants and the habitat on which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitat.

This document is the product of a consultation pursuant to Section 7(a)(2) of the ESA and implementing regulations found at 50 Code of Federal Regulations (CFR) Part 402. It evaluates three actions:

- Implementation of amendments 70/70 to the Bering Sea and Aleutian Islands Area (BSAI) and Gulf of Alaska (GOA) Fishery Management Plans (FMPs); Steller sea lion conservation measures for the pollock, Pacific cod, and Atka mackerel fisheries of the BSAI and GOA; and

- Implementation of BSAI and GOA FMP amendments 61/61; final regulations to implement the American Fisheries Act of 1998

- Parallel fisheries in waters managed by the State of Alaska; fisheries for Pacific cod, pollock, and Atka mackerel that are considered part of the federal fishery yet occur in State waters (0-3 nm from shore)

Consultation was initiated on July 26, 2001, due to significant new information on the biology of Steller sea lions and subsequent proposed changes to the Federal action. This consultation considers whether the effects of these actions are likely to jeopardize the continued existence of two populations of Steller sea lions or cause the destruction or adverse modification of their designated critical habitat. For all other listed species in the action area, NMFS OSF has made a determination of either "no effect" or "not likely to adversely affect." For further information on other species not considered here, see the Biological Assessment prepared by OSF for these actions (NMFS 2001). The species of concern in this formal Section 7(a)(2) consultation are as follows:

- Western Population of Steller Sea Lions (*Eumetopias jubatus*; listed as threatened on November 26, 1990 [55 FR 40204]; listed as endangered on May 5, 1997 [62 FR 30772]; critical habitat designated on August 27, 1993 [58 FR 45269])

- Eastern Population of Steller Sea Lions (*Eumetopias jubatus*; listed as threatened on November 26, 1990 [55 FR 40204]; critical habitat designated on August 27, 1993 [58 FR 45269])

This opinion is based on an evaluation of both the direct and indirect effects of the action on Steller sea lions and their 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).[1]

State managed, so-called "parallel fisheries" are also included in this biological opinion in part because of their intricate connection with the federal fisheries being considered, and also due to the State of Alaska's request to formally include this fishery in the consultation. This was re-iterated by the State in a comment received dated September 12, 2001 (from Frank Rue, Commissioner, Alaska Department of Fish and Game).

1.1 Comments on the draft biological opinion of August 2001

In August 2001, NMFS issued a draft biological opinion for public comment through September 21, 2001 numerous comments were received, including an evaluation by Bowen *et al.* of the FMP biological opinion (November 2000) and the draft opinion (August 2001). NMFS has reviewed all of the comments and has made substantive changes in this final document in response to those comments.

Generally, the agency has found these comments to be insightful and useful in further developing this document and in determining the appropriate level of protection for Steller sea lions. The issue at the forefront of all of the comments received is the paucity of information and reliable data surrounding the decline of the species. It is likely that in 2-3 years from now significant new information will be available that may or may not re-shape our knowledge of the sea lion decline - yet the Agency is required to make certain determinations now based on the best available data and a reasonable approach which takes into account uncertainty and adequate protection for the species and its designated critical habitat. This document outlines the agency's current opinion, which in many cases requires the use of hypothetical relationships, opinion of agency scientists, and all of the published and unpublished data on Steller sea lions and their environment. In many cases these hypotheses are not proven to the satisfaction of many of the commentors. The agency recognizes these differing opinions and has explained its reasoning for accepting or rejecting various hypotheses for the decline of the Steller sea lion.

1.2 Relation to Other Biological Opinions

On November 30, 2000, NMFS issued an FMP level biological opinion (NMFS 2000; herein referred to as the FMP biological opinion) which evaluated all known impacts of authorizing the BSAI and GOA FMPs on listed species as required by Section 7(a)(2) of the ESA. That biological opinion was requested by the Court. However, that biological opinion found that the FMP jeopardized the species and adversely modified critical habitat, and thus that a reasonable and prudent alternative (RPA) must be implemented. The biological opinion provided an RPA which was partially implemented in 2001. In January 2001, an RPA committee was formed that is comprised of members of the fishing community, conservation community, NMFS, State agencies and the Council's Science and Statistical Committee

[1] 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.

(see section 1.4). The proposed action presented in this biological opinion reflects the results of this Committee's work. This biological opinion will remain as NMFS' coverage under Section 7(a)(2) at the plan level. The level of detail and type of actions required in the RPA were related more to the project level than to the plan level. In other words, the biological opinion found that the FMPs themselves did not result in jeopardy or adverse modification, yet the interpretation of them and the subsequent regulations allowed a fishery which did result in jeopardy and adverse modification.

On July 26, 2001, the Office of Sustainable Fisheries (OSF) initiated consultation with the Office of Protected Resources (OPR) for the western and eastern populations of Steller sea lions. In that memorandum, OSF determined that the proposed changes to the Federal action as requested by the North Pacific Fisheries Management Council (Council) would not affect listed species, other than Steller sea lions, in a manner not previously considered. OPR has concurred with that determination. Therefore, consultation for those species was not re-initiated[2].

For the two populations of Steller sea lions and their critical habitat, OSF determined, and OPR concurs, that the proposed action is likely to adversely affect Steller sea lions in a manner not previously considered in the FMP biological opinion. There are two main reasons to re-initiate consultation: (1) new analyses on the distribution of Steller sea lions have revealed a possible greater dependence on near shore waters than previously understood, and (2) the proposed action, although at the same scope as the RPA in the previous biological opinion, significantly deviates from the specific actions required in that opinion to avoid jeopardy and adverse modification. However, as mentioned above, the FMP level biological opinion will remain in effect as NMFS' coverage at the plan level, and this opinion will address the project level effects on listed species that would be likely to occur if the Council's preferred action were implemented. In this biological opinion we will describe how the new information on Steller sea lions is being evaluated by NMFS (see the description of the white papers above), and relate this back to an analysis of the likelihood of survival and recovery of the species.

The listed short-tailed albatross, spectacled eider, and Steller's eider are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). In a letter dated January 10, 2001, the USFWS extended a March 19, 1999 Biological Opinion and its accompanying Incidental Take Statement until superseded by a revised opinion due later in 2001.

1.3 Consultation History

NMFS has conducted multiple internal section 7 consultations on the BSAI and GOA groundfish fisheries. 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 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

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[2] For further detailed information on the decisions made by OSF on other listed species, see the Biological Assessment prepared by OSF and the letter initiating consultation for Steller sea lions.

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[3]; 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 (Green Peace 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.

- November 30, 2000 Biological Opinion (FMP biological opinion) on authorization of groundfish fisheries in the BSAI under the Fishery Management Plan (FMP) for the BSAI Groundfish, and the authorization of groundfish fisheries in the GOA under the FMP for Groundfish of the GOA. The opinion was comprehensive in scope and considered the fisheries and the overall management framework established by the respective FMPs to determine whether that framework contained necessary measures to ensure the protection of listed species and their critical habitat. The biological opinion determined that the BSAI or GOA groundfish fisheries, as implemented under the respective FMPs, jeopardized the continued existence of the western population of Steller sea lions and adversely modified their critical habitat. The biological opinion provided an RPA which was partially implemented in 2001. Full implementation of the RPA was scheduled for 2002; however, the action considered in this opinion will take the place of that RPA. The relationship between the November 30, 2000 opinion and this opinion is described above in Section 1.1.

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[3] 55 F. Supp. 2d 1248 (W.D. Wash. 1999)

1.4 Unpublished Papers

NMFS, in cooperation with the Alaska Department of Fish and Game, has prepared a series of white papers (unpublished or submitted for publication) intended to provide the most up-to-date information on the foraging ecology and population dynamics of Steller sea lions. These papers provide analyses of data not previously presented, and offer new insights into sea lion biology. This biological opinion was in large part re-initiated because of this new information, and therefore, this opinion relies heavily on the information presented in those papers. These papers are available on the NMFS Alaska Region web site at www.fakr.noaa.gov and are summarized briefly below:

- *An Accounting of the Sources of Steller Sea Lion Mortality*. Thomas R. Loughlin and Anne. E. York. [cited as Loughlin and York 2001]

  Loughlin and York estimated the magnitudes of natural and anthropogenic sources of Steller sea lion mortality to tabulate the number of animals lost each year to each of the possible sources. After accounting for losses due to known causes of mortality, they estimated that 936-1,279 Steller sea lions may die annually from unknown sources; an alternative way to state this is that an estimated 2.9-3.8% of the 5% overall decline (based on trend site counts of nonpups) in the western population is due to unknown sources. Mortalities from unknown sources may be attributable to environmental change, the indirect effects of fisheries, or other factors yet to be recognized.

- *Steller Sea Lion Diet Trends Among the Western Stock of Steller Sea Lions (Eumetopias Jubatus)*. E. H. Sinclair and T. K. Zeppelin. [cited as Sinclair and Zeppelin submitted]

  Steller sea lion scats collected from summer and winter island sites across the range of the western stock from 1990-1998 were analyzed to identify prey remains. Walleye pollock and Atka mackerel were the dominant prey species across all regions and seasons. Analyses also pointed to area-specific foraging strategies with significantly strong seasonal patterns. Regional diet patterns are presumed to reflect regional foraging strategies learned at or near the natal rookery site on seasonally dense prey patches characteristic to that area.

- *Immature Steller Sea Lion Foraging Behavior*. Thomas R. Loughlin, Jeremy T. Sterling, Richard L. Merrick, and John Sease. [cited as Loughlin *et al.* unpublished]

  This unpublished manuscript summarized information on dive depth and duration received from pup and yearling Steller sea lions equipped with satellite dive recorders in the GOA/AI and Washington from 1994-2000. This paper also summarized the use of designated critical habitat by foraging Steller sea lions based on all of the data in the satellite dive recorder data base. The results showed that 93.8% of all locations from pre-breeding and breeding-aged animals were within the 0-10nm zone, indicating that the 0-10nm zone is the most important habitat for Steller sea lion foraging. *Note: this is an incomplete manuscript expected to be submitted for publication in late 2001.*

- *Overview of Telemetry Studies*. Contributions from the Alaska Department of Fish and Game(ADF&G), the National Marine Mammal Lab (NMML), and the National Marine Fisheries Service (NMFS). [cited as ADF&G and NMFS 2001]

This paper is an overview of the use of satellite telemetry in research on Steller sea lion behavior by ADF&G and NMFS. ADF&G is focusing their satellite telemetry research on the juvenile stage of Steller sea lions to study the ontogeny of dive behavior, dispersal, movement patterns, and resource selection in relation to age, sex, and season. Other studies have combined satellite tags with stomach temperature transmitters and time-depth recorders to get a better picture of Steller sea lion foraging success among adult females. This paper also describes how critical habitat was designated based on interpretations of telemetry data from 1990-1993 and summarizes the research by Loughlin *et al.* (2001) on immature sea lion foraging behavior. Preliminary results are presented in this overview; however, most of the analyses from these studies are still being conducted.

- *Evaluating the Impact of Reasonable and Prudent Alternatives for the Management of the BSAI and GOA Groundfish Fisheries on the Western Stock of Steller Sea Lion*. Douglas P. DeMaster. [cited as DeMaster 2001]

  DeMaster applied the population trajectory model used to evaluate the efficacy of the RPA in the FMP biological opinion to the proposed action in order to evaluate the response of the Steller sea lion population. The action proposed by the Council is likely to be equal to or more conservative in terms of impacts to the western stock of Steller sea lions when compared to the worst case scenario from the FMP biological opinion, according to the approach described in this paper.

- *Summary Report from the Is It Food II Workshop May 30-31, 2001.* Douglas P. DeMaster, Shannon Atkinson, and Ron Dearborn. [cited as DeMaster *et al.* 2001]

  Twenty-four scientists participated in a workshop to share information and discuss contributing factors to the current decline of the western population of Steller sea lion. This paper summarized the conclusions that resulted from the workshop. Among other conclusions, the participants agreed that the causes of the steep decline in the 1980s are likely to be different from the causes of the moderate decline in the 1990s and that at present, data are inadequate to evaluate the importance of the nutritional stress hypothesis. The majority of the participants rejected both competition with fisheries and predation by killer whales as current leading hypotheses for the decline.

- *Review of the November 2000 Biological Opinion and Incidental Take Statement with Respect to the Western Stock of the Steller Sea Lion, with Comments on the Draft August 2001 Biological Opinion*. W.D. Bowen, J. Harwood, D. Goodman, and G.L. Swartzman. [cited as Bowen *et al.* 2001]

  This paper is a final report prepared by a panel of reviewers tasked by the NPFMC to review and assess the science, assumptions, and hypotheses presented in the FMP biological opinion and the August 2001 draft biological opinion. In general, this report supports the conclusions in the draft opinion as being plausible, yet points out the lack of direct scientific evidence available to adequately determine the validity of competing hypotheses. The report states that NMFS approach is reasonable, but that certain aspects (i.e., telemetry data and food habits) will certainly need to be re-visited as new information becomes available over the next few years. They also point out needed research areas, which in large part have already been initiated.

1.5 The Council's RPA Committee

The RPA committee was established by the Council in January 2001 to review scientific and commercial data and provide the Council with recommendations for Steller sea lion protection measures for the second half of 2001 and develop an alternative approach to the RPA (from the FMP biological opinion) to be implemented by January 1, 2002. The RPA Committee was composed of twenty-one members from fishing groups, processor groups, Alaska communities, environmental advocacy groups, and NMFS representatives.

The RPA Committee met numerous times to review Steller sea lion biology, new information gathered on telemetry and food habits, and fishery and survey information. Meetings were held on February 10, February 20, March 6-7, March 26-29, April 9, May 9-11, May 21-24, and August 23-24. The RPA Committee reported to the Council in April with recommendations for 2001 fishery management measures. Then in June, the Committee provided recommendations to the Council for a draft proposed action to be analyzed as one alternative in a Supplemental Environmental Impact Statement (SEIS). Following the release of the draft SEIS and draft biological opinion in August 2001, the RPA committee met again to discuss the proposed action, and made changes based on Steller sea lion concerns raised in the draft opinion, which were then presented to the Council in September. Minutes from all meetings have been distributed at Council meetings and are available on the Council's web site at *http://www.fakr.noaa.gov/npfmc/default.htm*. During its October meeting, the Council further reviewed changes to the SEIS, and had extensive debate on the issues which included reports from the RPA committee, NMFS, and the public. The Council then moved to adopt Alternative 4 from the SEIS with a few technical refinements and 3 substantive changes.

1.6 Environmental Impact Statement

Since the issuance of the FMP biological opinion, which determined that fisheries as conducted under the existing BSAI and GOA FMPs for pollock, Pacific cod, and Atka mackerel were likely to jeopardize the continued existence of the endangered stock of Steller sea lions and adversely modify their critical habitat, several alternative fisheries management proposals have been developed in addition to the RPA proposed in the FMP biological opinion. The proposed management alternatives were developed to provide protection measures for Steller sea lions so that these fisheries would not jeopardize the continued existence of Steller sea lions or adversely modify their critical habitat. Each of the proposed alternatives would substantially modify the FMPs and have various impacts on components of the natural ecosystem such as marine mammals, seabirds, fishes, the marine habitat, and on fishers, processors, and coastal communities. A draft SEIS has been prepared as a parallel project with this biological opinion. The purpose of the SEIS is to evaluate each of the alternatives and determine the significance of the impacts on each of the listed components. The primary objective of this process is to identify the alternative(s) that minimizes potential adverse effects of the BSAI and GOA pollock, Pacific cod, and Atka mackerel fisheries on Steller sea lions. This process also determines the environmental and socio-economic impacts of the proposed Steller sea lion conservation measures on all of the components affected by the action. If more than one alternative minimizes the negative impacts to Steller sea lions, the SEIS describes which alternative is expected to have the least negative socio-economic impacts.

This opinion relies heavily on the draft SEIS, and due to timing issues was finalized before the completion of the final SEIS. OSF and OPR concur that the changes to the proposed action as a result of the October Council meeting and subsequent changes to the SEIS are not substantial, and will remain well within the scope of the draft SEIS.

1.7 Meetings with State and Tribal Representatives

Executive Order 13084 requires that, to the extent practicable, NMFS consult with Alaska tribal governments on a government-to-government basis prior to the promulgation of any regulation that may have tribal implications. In previous consultations on the effects of the groundfish fisheries in the Bering Sea and Aleutian Islands, and the Gulf of Alaska (NMFS 1998; 1999), NMFS found that the action as recommended by the NPFMC may have jeopardized the continued existence of Steller sea lions and may adversely modified their critical habitat. As such, NMFS required that reasonable and prudent alternatives to the fishery be implemented that would remove the possibility of jeopardy to sea lions and that, also, might have had tribal implications. As the RPAs resulted in the promulgation of regulations to implement the actions required under the RPAs, it was considered necessary to consult with tribal governments on those biological opinions. Under such circumstances NMFS is required to consult with affected Alaska tribal governments early in the process of proposing regulations and indicate any tribal implications that might occur as a result of the action.

NMFS has determined and reported in this biological opinion that the action, as recommended by the Council at its June 2001 meeting, will not result in jeopardy or adverse modification to Steller sea lions. Therefore, RPAs are not required to reduce takes of listed species to acceptable levels. Consequently, it is not considered necessary to consult with Alaska tribal governments on this biological opinion. However, a letter was sent out to over 120 tribal organizations requesting their comments on the draft biological opinion; no comments were received by September 21.

1.8 The Steller Sea Lion Recovery Team

On April 5, 1990, NMFS published an emergency rule listing the Steller sea lion as a threatened species under the ESA. Section 4(f) of the ESA requires that recovery plans be developed for endangered and threatened species unless the appropriate Secretary finds that such a plan will not promote conservation of the species. Each plan must incorporate: (1) a description of site-specific management actions that may be necessary to achieve goals for conservation and survival of the species; (2) objective measurable criteria that can be used to determine whether a species can be removed from a list; and (3) estimates of the time and costs for carrying out actions needed to achieve that plan's goal. NMFS determined that a recovery plan would promote the conservation of the Steller sea lion. The Final Recovery Plan for the Steller sea lion was written by the Steller Sea Lion Recovery Team at the request of the Assistant Administrator for Fisheries, NMFS, and was published in December 1992.

A Recovery plan identifies the specific management actions that must be taken to ensure that the species of concern recovers to the point that it can be removed from ESA listing. Unlike the situation with many other species where the problems and necessary remedial actions can be clearly identified, the factors that have caused the decline in Steller sea lion abundance have never been fully understood. Although the amount of research and number of management actions taken to understand and protect Steller sea lions are increasing, it may still be a long time before we understand the role of all the factors that may be influencing the population. Because of these uncertainties, the Recovery Plan identified actions that the Recovery Team, and NMFS, consider to be the most likely to stop the decline of the sea lion population. Actions that may have such an effect are given the highest priority in the Recovery Plan. The goal of any recovery plan is met when the species of concern is considered recovered to the extent that it can be removed from ESA listings.

The Final Recovery Plan identified as priorities the following actions: (1) to identify habitat requirements and protect areas of special biological significance, (2) to identify management units or stocks of Steller sea lions, (3) to monitor status and trends of Steller sea lions, (4) to monitor the health and vital biological parameters of individual Steller sea lions recognizing that the condition of individual sea lions may be one of the most important factors to monitor in relation to the population decline, (5) to assess and minimize known causes of mortality, (6) to investigate the feeding ecology of Steller sea lions and factors affecting energetic status, and (7) to implement all aspects of the Recovery Plan to the extent possible.

Since the Final Recovery Plan was published in 1992, there have been many significant actions that were identified in the Recovery Plan taken by NMFS to protect Steller sea lions. On April 1, 1993, NMFS published a final rule designating critical habitat for Steller sea lions. In Alaska, all major rookeries and haulouts and three special foraging areas were designated as habitat that contains those elements necessary to recover and conserve the species. At the time of the November 26, 1990 listing of Steller sea lions as threatened under the ESA, and at the time of the drafting of the 1992 Recovery Plan, Steller sea lions were considered one population. In 1997, based on demographic and genetic dissimilarities, the species was split into two separate population segments. The ESA status of the western population was changed to endangered, and the status of the eastern population remained as threatened. Also, there has been a significant increase in the number of researchers and studies regarding Steller sea lions since the Recovery Plan was first drafted. As a result, NMFS has concluded that the Recovery Plan is dated. The research and management actions taken during the past decade need to be incorporated into a revised Recovery Plan. Further, the much expanded research program needs to be reviewed and incorporated into an overall recovery effort. The management and conservation sections of the Recovery Plan also need to be updated and changed to both incorporate actions that have been taken to protect and manage sea lions since 1992, and to recommend new actions that may be required.

On April 18, 2001, the Administrator, Alaska Region, NMFS, sent out a letter thanking the members of the original Recovery Team for all their efforts to protect sea lions. In that letter, the Regional Administrator also recognized that a new Recovery Team, consisting of a blend of original and new members, was necessary to address the issues of the day. A follow-up letter on June 25, 2001, was sent inviting members of the public, research community, academia, state and Federal agencies, the fishing industry, and Native Alaskan organizations, to participate as members of the newly developed Recovery Team.

This Recovery Team will be larger than the previous team with up to 19 members consisting of researchers, conservation group representatives, the fishing industry, state and Federal agencies, and academia. The larger group is considered necessary as it reflects both the increased significance and visibility of this issue within NMFS, and the increased breadth of the research and management programs that need to be incorporated into a recovery effort. The State of Alaska will Chair the Recovery Team as they have in the past. Meeting dates and times will be announced once a final membership has been established.

1.9 Background on Jeopardy and Adverse Modification of Critical Habitat

In this section, we discuss the statutory requirements of ESA section 7(a)(2), and its implementing regulations, and their relation to the actions considered in this consultation. Whereas the statutory standards, and the regulations that interpret them, are the ultimate determinants for this biological opinion, it is necessary for NMFS to develop a methodology for applying those standards that uses the best scientific and commercial data available. Both the USFWS and NMFS are currently revising regulations pertaining to jeopardy and adverse modification of critical habitat. However, they will not be available for this biological opinion, and therefore, cannot be incorporated. In this opinion we will use the legal standards currently available.

Section 7(a)(2) of the ESA states:

> *"Each federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded or carried out by such agency is not likely to jeopardize the continued existence of any endangered species and threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with affected States, to be critical, unless such agency has been granted an exemption for such action by the Committee pursuant to subsection (h) of this chapter."*

Definitions of "jeopardize the continued existence of" and "adverse modification of habitat" are not defined further in the statute. However, these definitions are further refined in the regulations implementing the ESA in 50 CFR §402.02.

- ***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).

- ***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 survival and recovery of a listed species in the wild by reducing the reproduction, numbers or distribution of that species (50 CFR §402.02).

The consulting agency is required to consider both of these standards to insure that the proposed action does not result in jeopardy or adverse modification of critical habitat as intended by the Act. The Act does intend that the consulting agency look at these two standards in a different way. The jeopardy standard is intended to provide for the conservation of the species based on any impacts that might occur to that species no matter where they might occur, whereas the adverse modification standard is intended to look more closely at the effects to the core habitat essential for the species' long term survival.

Regulations that implement section 7(a)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of federal actions to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (50 CFR §402.02). Biological opinions must also determine if federal actions would appreciably diminish the value of critical habitat for the survival and recovery of listed species (50 CFR §402.02).

Human activities can reduce a species' reproduction by reducing the number of adults that reproduce in a population, reducing the number of young an adult will produce in a time interval or a lifetime, increasing the time it takes for an adult to reproduce, increasing the number of years that pass before an adult female returns to breed, reducing the survival of young, or decreasing the number of young that recruit into the adult population (Andrewartha and Birch 1954, Caughley and Gunn 1996). Human activities can reduce a species' distribution by reducing its population size or density in ways that cause the species to abandon parts of its range (Fowler and Baker 1991). A species' reproduction, numbers, and distribution are interdependent: (1) reducing a species' reproduction will reduce its population size, (2) reducing a species' population size will usually reduce its reproduction, particularly if those reductions decrease the number of adult females or the number of young that recruit into the breeding population, and (3) reductions in a species' reproduction and population size normally precede reductions in a species' distribution.

We will approach a jeopardy analyses in three steps:

- First, we identify the probable direct and indirect effects of the action on the physical, chemical, and biotic environment of the action area,

- Second, given the environmental baseline, we will determine if we would reasonably expect the western or eastern populations of Steller sea lions to experience reductions in reproduction, numbers, or distribution in response to these effects and the cumulative effects of future anticipated non-Federal actions, and

- Third, we determine if any reductions in a species' reproduction, numbers, or distribution (identified in the second step of our analysis) can be expected to appreciably reduce a listed species' likelihood of surviving and recovering in the wild.

The final step in our analysis — relating reductions in a species' reproduction, numbers, or distribution to reductions in the species' likelihood of surviving and recovering in the wild — is the most difficult step because (a) the relationship is not linear; (b) to persist over geologic time, most species' have evolved to withstand some level of variation in their birth and death rates without a corresponding change in the species' likelihood of surviving and recovering in the wild; and (c) we have imperfect knowledge of the population dynamics of other species and their response to human perturbation. Nevertheless, our analysis must attempt to distinguish between anthropogenic reductions in a species' reproduction, numbers, and distribution that can reasonably be expected to affect the species' likelihood of survival and recovery in the wild and other (natural) declines, given the best scientific and commercial information available at the time of the analysis.

We will approach an analysis for the adverse modification of critical habitat through a more qualitative analysis using all available scientific and commercial information.

For both the determination of jeopardy and adverse modification of critical habitat NMFS must make a determination on whether an action is likely to appreciably reduce the likelihood of survival and recovery of a species in the wild. The following are the definitions of survival and recovery from the ESA Section 7 Handbook:

- ***Survival*** is defined as the species' persistence, as a listed or recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for recovery from endangerment (ESA Handbook).

- ***Recovery*** is the process by which species' ecosystems are restored and/or threats to the species are removed so self-sustaining and self-regulating populations of listed species can be supported as persistent members of native biotic communities (ESA Handbook).

Recovery is also defined in the implementing regulations (however survival is not):

- ***Recovery*** means improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the Act (50 CFR 402.02).

In this biological opinion, both analyses (jeopardy and adverse modification) will involve both quantitative and qualitative information. For jeopardy, we will rely more heavily on the predicted effects on the sea lion population and its probability for survival and recovery, using a combination of qualitative information, new analyses on sea lion habits, and a population trajectory model (DeMaster 2001). For adverse modification, NMFS must rely more on a qualitative assessment based on a risk averse approach to maintaining an adequate prey field for Steller sea lions (i.e., avoiding type II error). The final determinations will be made by combining the expected population trajectories, risk of extinction, and other quantitative and qualitative information currently available.

There is no clear guidance either in regulation or through NMFS policy on the specific criteria to determine whether a species is likely to survive. In some cases, NMFS and USFWS have attempted to project population trajectories into the future (such as 100 years) and account for some level of variability around that trend, such as environmental disturbance, threats of disease, and other unknown factors. Then, a probability of extinction has been calculated for some species. In some cases, this probability of extinction is related to a bright line definition of what risk is acceptable for that particular species. For this type of an analysis, considerable information on the life history of a species is needed in order to have confidence in the predictions of the model.

Since the listing of Steller sea lions in 1990, NMFS scientists have prepared a number of different Population Viability Analyses (PVA) (Merrick and York 1994, York 1994, and York *et al.* 1996). In a draft document prepared by Merrick and York (1994), they looked at a number of different models using both the 1985-94 and the 1989-94 population trends and determined that it was highly likely that the population would reach extinction between 53 and 86 years respectively. These analyses were further refined in York (1994) and York *et. al.* (1996), however, they have relied heavily on using a population trend since the mid-1970s. At the current decline, Loughlin and York (2001) estimated that the western population would be reduced to only 11,430 animals by 2020.

In a NMFS white paper (DeMaster 2001), the author estimated the expected impacts of the proposed action to the Steller sea lion population through a simple model. This analysis was intended to serve as an index of the conservation measures considered by the RPA committee relative to the conservation measures required in the FMP biological opinion. The next logical step might be to submit this to a PVA analysis. However, although this might appear to be a quantitative assessment, it is largely qualitative and serves as a general guide to NMFS and the public on the possible trajectory of this theoretical scenario. NMFS scientists recommend that submitting this to any more rigorous testing would be inappropriate. Therefore, we will make a qualitative determination on the likelihood for survival of the species based on the analysis and all other pertinent information available.

In the Steller sea lion recovery plan (NMFS 1992), a set of criteria was developed for delisting Steller sea lions. However, the criteria were never adopted by the agency and only stand as general guidance. Development of delisting criteria will be a central mission for the new Steller sea lion recovery team which will begin meeting this fall, but until that time, no specific recovery guidelines exist for Steller sea lions. In this biological opinion NMFS must determine whether the proposed action is likely to appreciably reduce the likelihood that Steller sea lions will recover in the wild.

Recovery criteria are a complex issue that will not be decided in this opinion. In the scientific community opinions on this subject cover a wide range of possibilities. This question will be addressed by the Steller sea lion recovery team (SSLRT) when it begins meetings of the reconstituted team late in 2001. As a guideline for this opinion, NMFS will make a qualitative determination whether the proposed action is likely to affect the reproduction or numbers of each population of Steller sea lions.

2 DESCRIPTION OF THE PROPOSED ACTION

NMFS OSF, under the authority of the MSA, proposes to (1) implement amendments 61/61, and (2) amendments 70/70 to the FMPs for the BSAI and GOA groundfish fisheries. As stated in Section 1, this biological opinion is project level, specifically evaluating the effects on Steller sea lions of implementing the above amendments to the pollock, Pacific cod, and Atka mackerel fisheries.

A detailed description of the FMPs and their management measures are described in the FMP biological opinion and the Draft SEIS for the BSAI and GOA FMPs. After review of the RPA contained in the FMP biological opinion, and the subsequent release of new scientific information on the foraging ecology of Steller sea lions, the Council and NMFS OSF have proposed modifications to the FMPs and their implementing regulations that are designed to adequately protect Steller sea lions as required by the ESA and all other applicable law.

The modifications have a minor impact on the FMPs themselves, and generally make changes to the spatial and temporal patterns of fishing for Pacific cod, Atka mackerel, and pollock in the BSAI and GOA. The details of the proposed action are described below. The scope of changes to the fishery are similar to those proposed by the RPA from the FMP biological opinion, and are intended by the Council and NMFS to be at least as protective as the RPA, and be implemented in order to avoid jeopardizing the continued existence of Steller sea lions or destroy or adversely modify their critical habitat.

2.1 Objectives of the Proposed Action

The overall objective of the proposed action is to meet the mandates of the MSFCMA to promote healthy and prosperous fisheries while conserving our natural resources. This includes avoiding adverse impacts to ESA listed species, conserving marine biodiversity, and sustaining viability of the diverse fishing communities dependent upon the Alaska fishery resources. The proposed action, authorization of the BSAI and GOA FMPs, includes modifications to the pollock, Atka mackerel, and Pacific cod fisheries in order to avoid jeopardy and adverse modification of Steller sea lions and their critical habitat.
The modifications to the FMPs described in this action were developed through the Council's RPA committee described in Section 1.4 and slightly altered by the Council. This opinion focuses on the modifications to the FMP because they were developed to be in lieu of the previous RPA required in the FMP biological opinion. Generally, the Council and NMFS concluded, given the new biological information on Steller sea lions, that there were other possible ways to avoid jeopardy and adverse modification for sea lions and their habitat. This proposed action represents the collective work of

numerous agencies and representatives of commercial fishing organizations and environmental organizations, in their attempt to accomplish these competing goals:

- Avoid jeopardy and adverse modification
- Develop a sound experimental design for monitoring
- Minimize social and economic impacts
- Minimize bycatch of PSC and other groundfish
- Promote safety at sea.

This opinion focuses only on the first bullet, whether or not this proposed action is likely to result in jeopardy or adverse modification to Steller sea lions or their critical habitat.

2.2 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 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 ...". 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. 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 and Gulf of Alaska. Of those fisheries identified in the FMPs within the action area fisheries likely to adversely affect Steller sea lions are the Atka mackerel, pollock, and the Pacific cod fisheries.

2.2.1 Atka Mackerel Fishery Area

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. However, recent evidence (Fritz unpublished data) indicates that Atka mackerel may be more highly tied to specific locations than previously considered, and that migrations may be limited to very short distances. This could make local areas even more susceptible to depletions which may affect sea lions, especially if the fishery occurs in areas and times that sea lions are foraging. In other words, replenishment from an outside stock may be slow or non-existent.

Figure 2.3-6 of the SEIS displays the closure areas and fishery description for the proposed Atka mackerel fishery.

2.2.2 Pollock Fishery Area

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 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 pollock fishery region (50 CFR, Tables 1 and 2 for part 226.12). Steller sea lions that may be affected by the pollock fishery occur 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) suggested a 1996 western Steller sea lion population of 39,500 animals, of which about 56%, or just over 22,000 animals, 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 pollock fishing zones, the distribution of the pollock 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.

Figure 2.3-6 of the SEIS displays the closure areas and fishery description for the proposed pollock fishery.

2.2.3 Pacific Cod Fishery Area

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.

Figure 2.3-4 and 2.3-5of the SEIS display the closure areas and fishery descriptions for the proposed Pacific cod trawl and fixed gear fisheries, respectively.

2.3 Description of the Proposed Action

A detailed description of the proposed action is provided in Section 2.0 (their Figures 2.3-4 through 2.3-6) of the SEIS which is scheduled to be released November 30, 2001. The proposed action is not described in complete detail in this document, as this document will be appended to the SEIS. The final SEIS will incorporate all elements of the proposed action, including modifications adopted by the Council on October 5, 2001. The following is a description of the action as taken from the biological assessment provided by OSF as part of the consultation package submitted to OPR. It has been amended to reflect changes adopted by the Council during meetings held September 4-8 and October 1-8, 2001. Further detailed descriptions of the action are contained in the SEIS Sections 2-4 and the SEIS for the AFA.

2.3.1 Amendment 61/61: The American Fisheries Act (AFA)

Background on the AFA

On October 21, 1998, the President signed into law the AFA (Div. C, Title II, Pub. L. No. 105-277, 112 Stat. 2681 (1998)). The AFA is divided into two subtitles addressing the requirements for fishery endorsements for all U.S. fishing vessels, and providing for the reorganization and rationalization of the BSAI pollock fishery, respectively.

Subtitle I--Fisheries Endorsements established a 25 percent foreign ownership and control limit for all

U.S. documented fishing vessels over 100 ft registered length. Subtitle I also limits new U.S. documented fishing vessels to no more than 165 ft registered length, no more than 3,000 lbs shaft horsepower, and no more than 750 gross registered tons. The provisions of this subtitle apply to all U.S. documented fishing vessels fishing anywhere in the U.S. EEZ and are being implemented by the Maritime Administration (MARAD) and the U.S. Coast Guard.

Subtitle II–Bering Sea Pollock Fishery mandated sweeping changes to the BSAI pollock fishery and to a lesser extent, affected the management of the other groundfish, crab, and scallop fisheries off Alaska. The purpose of Amendments 61/61/13/8 is to implement the management program required by Subtitle II of the AFA.

Congress identified two primary objectives in passing the AFA. The first objective was to complete the process begun in 1976 to give U.S. interests a priority in the harvest of U.S. fishery resources. This objective was accomplished through the restrictions on foreign ownership and control that are set out in Subtitle I of the AFA. The second objective addressed by Subtitle II of the AFA was to significantly decapitalize the Bering Sea pollock fishery. Under the council system established by the Magnuson-Stevens Act, Congressional action is generally not needed to address fishery conservation and management issues in specific fisheries. However, Congress concluded that the overcapacity in the BSAI pollock fishery prior to the AFA was due, in part, to mistakes in, and misinterpretations of, the 1987 Commercial Fishery Industry Vessel Anti-Reflagging Act (Anti-Reflagging Act). In passing the AFA, Congress noted that the Anti-Reflagging Act had allowed a flood of foreign-rebuilt catcher/processors into the BSAI pollock fishery and did not limit foreign control of such vessels in the manner in which Congress had intended. Without an Act of Congress, the Council and NMFS did not have authority to provide funds under the Federal Credit Reform Act to buyout and retire vessels from the BSAI pollock fishery, to strengthen U.S. controlling interest standards for fishing vessels, or to implement the inshore cooperative program contained in the AFA.

Subtitle 2 of the AFA contains numerous provisions that affect the management of the groundfish and crab fisheries off Alaska. Key provisions include:

- The buyout of nine pollock catcher/processors and the subsequent scrapping of eight of these vessels through a combination of $20 million in Federal appropriations and $75 million in direct loan obligations;
- A new allocation scheme for BSAI pollock that allocates 10 percent of the BSAI pollock total allowable catch (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;
- 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.
- A prohibition on entry of new vessels and processors into the BSAI pollock fishery. The AFA lists by name vessels and processors and/or provides qualifying criteria for those vessels and processors eligible to participate in the non-CDQ portion of the BSAI pollock fishery;
- New observer coverage and scale requirements for AFA catcher/processors;
- New standards and limitations to guide the creation and operation of fishery cooperatives in the BSAI pollock fishery;

- An individual fishing quota program for inshore catcher vessel cooperatives under which NMFS grants individual allocations of the inshore BSAI pollock TAC to inshore catcher vessel cooperatives that form around a specific inshore processor and agree to deliver at least 90 percent of their pollock catch to that processor;
- The establishment of harvesting and processing limits known as "sideboards" on AFA pollock vessels and processors to protect the interests of fishermen and processors in other fisheries from spillover effects resulting from the rationalization of the BSAI pollock fishery,
- A 17.5 percent excessive share harvesting cap for BSAI pollock and a requirement that the Council develop excessive share caps for BSAI pollock processing and for the harvesting and processing of other groundfish.

Some of the above provisions of the AFA already have been implemented by NMFS and other agencies. The buyout and scrapping of the nine ineligible factory trawlers were completed by NMFS in 1999 under the schedule mandated by the AFA. This action was accomplished by contract with the vessel owners rather than regulation. The inshore pollock fee program required by the AFA was implemented by NMFS through final regulations published February 3, 2000 (65 FR 5278). MARAD has implemented the new U.S. ownership requirements and size restrictions for U.S. fishing vessels through final regulations published July 19, 2000 (65 FR 44860). MARAD's regulations also set out procedures for review of compliance with excessive share harvesting limits contained in this proposed rule.

Council Development of Amendments 61/61/13/8

Since the passage of the AFA in October 1998, NMFS and the Council have undertaken an extensive public process to incorporate the AFA into the FMPs and their implementing regulations. This management program has been submitted under proposed under Amendments 61/61/13/8 to the FMPs for the groundfish fisheries of the BSAI and GOA FMPs for the crab and scallop fisheries off Alaska. Amendments 61/61/13/8 were developed and revised during the course of twelve Council meetings over the past two years and have been the subject of numerous additional public meetings held by the Council and NMFS to address specific aspects of the AFA. While the permanent management program proposed under Amendments 61/61/13/8 was under analysis and development by the Council and NMFS, the statutory deadlines in the AFA were met on an interim basis through several emergency interim rules, and was extended through the end of 2001 by Pub. L. No. 106-554 which mandated that all management measures in effect as of July 2000 would be extended through the end of 2001.

The proposed rule to implement Amendments 61/61/13/8 is one of the most complex regulations ever produced by the Alaska Region and is not summarized in its entirety here. However, the proposed measures are specifically described in the draft environmental impact statement prepared for this action and fall into four general categories:

- Regulations limiting access to the BSAI pollock fishery. Participants in all fishing and processing sectors of the BSAI pollock fishery are limited to those vessels and processors specifically named in the AFA or that meet qualifying criteria set out in the AFA. The BSAI pollock TAC would be allocated among these industry sectors according to the formula set out in the AFA which allocates 10 percent of the TAC to the Community Development Quota program and, after subtraction of the projected incidental catch of pollock in other fisheries, allocates the remaining TAC 50 percent to the inshore sector, 40 percent to the catcher/processor sector, and 10 percent to the mothership sector.

- Regulations governing the formation and operation of fishery cooperatives in the BSAI pollock fishery. The AFA specifically authorizes the formation of fishery cooperatives in the BSAI pollock fishery. The proposed rule contains guidelines and requirements for the formation of fishery cooperatives in different sectors of the BSAI pollock fishery and contains regulations governing their operation. These regulations include such measures as restrictions on membership in inshore sector cooperatives, recordkeeping and reporting requirements, requirements that cooperatives constrain the activities of member vessels in other fisheries, and annual reporting requirements.

- Regulations to protect other fisheries from spillover effects from the AFA (Sideboards). The AFA requires that the Council and NMFS develop protection measures to prevent negative effects of the AFA from affecting participants in other groundfish, crab, and scallop fisheries. Under Amendments 61/61/13/8 the Council has developed a complex suite of sideboard measures designed to protect vessels and processors from spillover effects of the AFA. These sideboard measures generally take two forms: (1) restrictions on the entry of AFA vessels into other fisheries, and (2) harvest restrictions on AFA vessels that do participate in other fisheries.

- Regulations governing catch measurement and monitoring in the BSAI pollock fishery. The AFA also contains new catch measurement and observer coverage requirements for AFA vessels and processors. Under the proposed rule, all AFA catcher/processors and motherships would be required to weigh all groundfish on NMFS certified flow scales and would be required to carry 2 NMFS-certified observers at all times. AFA inshore processors would have new catch monitoring requirements and would be required to have 2 observers as well whenever BSAI pollock is being received or processed. Finally, all AFA catcher vessels and catcher/processors would be required to deploy NMFS-approved vessel monitoring system (VMS) units so that vessel locations may be tracked via satellite.

2.3.2 Amendments 70/70: Steller Sea Lion Protection Measures

In June 2001, the Council reviewed and adopted for analysis the RPA Committee recommendations on Steller sea lion protection measures for 2002 and beyond. These measures included temporal and spatial allocation of pollock, Pacific cod and Atka mackerel fishing, protection of rookeries and haulout areas used by Steller sea lions, and critical habitat harvest limits. The RPA Committee developed their recommendations based on the FMP biological opinion and information contained in the white papers described in Section 1 of this document. The proposed Steller sea lion protection measures for purposes of reinitiating consultation are the RPA committee's recommendations with seasonal and allocation changes to the GOA pollock fishery in the Western and Central Regulatory Areas as recommended by the Council in June 2001. Pending approval by NMFS, the Steller sea lion protection measures would be Amendments 70/70 to the BSAI and GOA FMPs. The proposed actions are summarized below for the Aleutian Islands subarea, the Bering sea subarea, and the Gulf of Alaska and are described in detail in Chapter 2 of the SEIS prepared for this action. In all areas, all rookeries are surrounded by a 3 nm no transit/no groundfish fishing zone and haulouts are surrounded by a 3 nm no groundfish fishing zone with some exceptions. Table 21 of 50 CFR Part 679 lists rookeries and haulouts subject to fishing restrictions.

The setting of TAC for the pollock, Pacific cod and Atka mackerel fisheries would be based on a global control rule which is modified from the one detailed in the FMP biological opinion. The allowable biological catch (ABC) for pollock, Pacific cod, and Atka mackerel in the BSAI and GOA would be reduced when the spawning biomass is estimated to be less than 40% of the projected unfished biomass. The reduction would continue at the present rate established under the tiers described in the groundfish FMPs, but when the spawning biomass is estimated to be less than 20% of the projected unfished biomass, directed fishing for a species would be prohibited.

Aleutian Islands Fisheries

Atka Mackerel:

The Atka Mackerel fishery will be prosecuted in the A and B seasons with half the TAC allocated to each season. The A season starts January 20 and ends April 15, and the B season begins September 1 and ends November 1.

The Atka mackerel fishery will be managed as platoons in Areas 542 and 543. Vessels fishing in the A or B season fishery would be required to register with NMFS to be randomly assigned to one of two teams. The teams are assigned to start fishing in either 542 or 543 and may not switch to the other area until the other team has harvested the critical habitat harvest allocation assigned to their area. Once registered for an opening, vessels would be required to participate, otherwise they would be prohibited from fishing in any other fishery during the 14 day period following the Atka mackerel season opening date. The seasonal apportionment would be divided equally between platoons, except if an odd number of vessels register to fish a seasonal apportionment. In that case, the seasonal apportionment would be divided proportional to the number of vessels in each platoon.

No Atka mackerel fishing is allowed in the Seguam foraging area. All critical habitat areas east of 178°W longitude are closed to Atka mackerel fishing. All rookeries west of 178°W longitude are closed to Atka mackerel fishing to10 nm, except Buldir is closed to 15 nm. All haulouts are closed to 3nm to Atka mackerel fishing.

Harvest of Atka mackerel will be limited to 60 percent of the seasonal TAC inside critical habitat and 40 percent outside.

Pacific cod

The Pacific cod TAC would continue to be established as a single TAC for the BSAI management area. In both the Aleutian Islands and Bering Sea subareas, the Pacific cod fishery would be divided into two and three seasons for fixed and trawl gear, respectively. See Table 2.1 for the seasons and TAC allocations.

Table 2.1. Bering Sea and Aleutian Islands Subarea Pacific Cod Seasons and TAC Allocations.

Gear	A season and allocation	B season and allocation	C season and allocation
Trawl	January 20 - March 31 (60%)	April 1 - June 10 (20%)	June 10 - October 31 (20%)
Hook-and-line and jig	January 1 - June 10 (60%)	June 10 - December 31 (40%)	NA
Pot	January 1 - June 10 (60%)	September 1 - December 31 (40%)	NA
CDQ* pot	January 1 - December 31	NA	

*Community Development Quota program. CDQ vessels fishing with non-pot gear are governed by the gear specific seasonal restrictions listed in Table 2.1.

The harvest of Pacific cod by vessels less than 60 feet LOA using pot gear would account towards the 1.4% quota for vessels less than 60 feet LOA using pot gear when fishing by vessels equal to or greater than 60 feet LOA using pot gear is closed. 50 CFR part 679.20(a)(7) lists the nontrawl sector allocations of BSAI Pacific cod. When fishing by the pot vessels greater than or equal to 60 feet LOA is open, the harvest from the pot vessels less than 60 feet LOA using pot gear would be counted towards the 18.3 % quota for the larger pot vessels.

The Pacific cod fishery area restrictions would be dependent on the location and gear. The Seguam foraging area would be closed to all gear types fishing for Pacific cod. Pacific cod fishery area restrictions are describe in Tables 2.2 and 2.3.

Table 2.2. Aleutian Islands Subarea Pacific Cod Fisheries Area Restrictions.

Gear	Restriction
Trawl	**East of 178° west longitude** Rookeries closed to 0-10 nm, except 0-20 nm around Agligadak, Haulouts are closed 0-3 nm. **West of 178° west longitude** Haulouts and rookeries are closed 0-20 nm until the Atka mackerel fishery inside critical habitat in the A or B season, respectively, is completed, at which time trawling for cod is prohibited 0-3 nm of haulouts and 0-10 nm of rookeries. Seguam foraging area is closed.
Pot and Hook-and-line	No fishing in critical habitat east of 173° West long. to the western boundary of Area 9 (170°W long.), Buldir rookery is closed 0-10 nm, Agligadak rookery is closed 0-20 nm. Seguam foraging area is closed

Pollock

The Aleutian Islands pollock fishery is restricted to one season, January 20 through November 1, with fishing prohibited inside critical habitat. The allocations of pollock will be done according to the AFA requirements, similar to the Bering Sea. The proposed action includes a provision to close the area west of 170° W longitude to directed fishing for pollock in the Aleutian Islands in 2002. Directed pollock fishing would open in the Aleutian Islands in 2003 with the TAC split 40/60 between the A and B seasons.

Bering Sea Fisheries

Pacific cod

As stated previously, Pacific cod fisheries are managed under a single TAC for the BSAI management area. Therefore, Table 2.2 describes the seasonal and gear allocations for Pacific cod fisheries in the Bering Sea as well as in the Aleutian Islands. Gear and area restrictions that are specific to the Bering Sea Subarea are described in table 2.3.

The harvest of Pacific cod by vessels less than 60 feet LOA using pot gear will continue to account towards the 1.4% quota for vessels less than 60 feet LOA using pot gear when fishing by vessels equal to or greater than 60 feet LOA using pot gear is closed. When fishing by the vessels greater than or equal to 60 feet LOA using pot gear is open, the harvest from vessels less than 60 feet LOA using pot gear is counted towards the 18.3 % quota for the larger pot vessels.

Catcher vessels less than 60 feet LOA directed fishing for Pacific cod with hook-&-line and jig gear may fish in a portion of Area 9 (see table 2.3) and are limited to an annual harvest cap of 250,000 lbs.

Pollock

Area restrictions and fishing seasons for Bering Sea pollock fisheries are shown in Tables 2.3 and 2.4. In addition to the restrictions shown in Table 2.3, a critical habitat harvest limit would exist for the Steller sea lion conservation area (SCA) in the A season for pollock. No more than 30 percent of the annual TAC can be harvested in the SCA prior to April 1 each year. An additional 10% of the annual TAC may be harvested outside of the SCA before April 1 or inside SCA after April 1. If the 30 percent was not taken in the SCA prior to April 1, the remainder can be rolled over to be taken inside after April 1.

Table 2.3. Bering Sea Steller Sea Lion Protection Area Closures.

Area	restriction	Season	Exceptions
Rookeries	No groundfish fishing 0-3 nm *	All year	None
Haulouts	No directed fishing for pollock or P. cod 0-3 nm	All year	Jig vessels
St. Lawrence, Hall Island, Cape Newenham, and Round Island haulouts	No groundfish fishing 0-20 nm	All year	None
Rookeries and Haulouts	No directed fishing for pollock or P. cod by trawl vessels 0-10 nm	All year	Jig vessels, Pribilofs Islands haulouts, see below
Pribilof Islands Haulouts	No directed fishing for pollock or P. cod trawling 0-3 nm	All year	None
Bishop Point and Reef Lava Haulouts	No directed fishing for P. cod 0-10 nm by Hook and Line Catcher Processors	All year	Vessels <60 feet
Amak Rookery	No directed fishing for Pacific cod with hook-and-line or pot gear 0- 7 nm	All year	None
Area 9 Bogoslof	No directed fishing for pollock, Atka mackerel, or P. cod in area	All year	Hook-&-line and jig vessels < 60' targeting P. cod allowed south of a line extending from a point 3 nm north of Bishop Pt. to Cape Tanak in Area 9 (10 nm closures around Bishop Pt. and Emerald Island haulouts).
South Bering Sea Pollock Restriction Area (See fig. 1)	No directed fishing for pollock within area	A season	None
Catcher Vessel Operational Area (See fig. 2)	No directed fishing for pollock by Trawl Catcher Processors	June 10-Nov. 1 (B season)	None

*0-3 nm no transit restrictions around rookeries are implemented under ESA regulations at 50 CFR 223.202 and are not modified under the proposed action.

The fishing seasons for Bering Sea pollock and Pacific cod and TAC allocations are shown in Table 2.4.

Table 2.4. Pollock and Pacific Cod Fishing Seasons and Allocations in the Bering Sea.

Target Species	Gear	A season	B Season
Pollock	Trawl	January 20 - June 10 (40%)	June 10 - October 31 (60%).
Pacific Cod	Trawl	January 20 - June 10 (80%),	June 10 - October 31 (20%)
	Hook-and-line and jig	January 1 - June 10 (60%)	June 10 - December 31 (40%)
	Pot	January 1 - June 10 (60%)	September 1 - December 31 (40%)
	Pot CDQ*	January 1-December 31	

*Community Development Quota program. CDQ vessels fishing with non-pot gear are governed by the gear specific seasonal restrictions listed in Table 2.4.

GOA Fisheries

Steller sea lion protection measures for the GOA include area closures as shown in Table 2.5. The geographic location of the areas referred to in Table 2.5 are shown in Figure 9.1 of the FMP biological opinion. Vessels using jig gear are exempt from all GOA area closures, except the 0-3 nm no transit closures around rookeries under 50 CFR 223.202 and 0-3 nm no groundfish fishing zones around rookeries.

Table 2.5. GOA Steller Sea Lion Area Restrictions.

Area	Restriction	Exceptions
1	Directed fishing for Pacific cod and pollock with trawl gear is prohibited 0-20 nm of rookeries and haulouts. (Does not include State waters in Prince William Sound)	Directed fishing for Pacific cod and pollock using trawl gear is prohibited 0-10 nm of Middleton Island.
2	Pacific cod and pollock using trawl gear is prohibited 0-10 nm of haulouts and 0-20 nm of rookeries Directed fishing for Pacific cod using pot and hook-and-line gear is prohibited 0-10 nm around rookeries.	Marmot Island rookery is closed to directed fishing for Pacific cod and pollock using trawl gear 0-15 nm during January 20 through June 10
Table 2.5 (cont.)		
3	Directed fishing for Pacific cod and pollock using trawl gear is prohibited 0-10 nm of haulouts. Directed fishing for Pacific cod using pot and hook-and-line gear is prohibited 0-3 nm at Cape Barnabus and Cape Ikolik.	Directed fishing for Pollock and P. cod using trawl gear is prohibited 0-3 nm at Cape Barnabus and Cape Ikolik. During the pollock C&D season and the Pacific cod B season, directed fishing for Pacific cod and pollock using trawl gear at Gull Point and Ugak Island is prohibited 0-3nm.
4	Directed fishing for Pacific cod and pollock using trawl gear is prohibited 0-20 nm of haulouts and rookeries. Directed fishing for Pacific cod using pot and hook-and-line gear is prohibited 0-3 nm at all rookeries and Mitrofania/Spitz, Whaleback, Sea Lion Rocks, Mountain Point and Castle Rock,	Directed fishing for Pacific cod and pollock using trawl gear is prohibited 0-3 nm of Mitrofania/Spitz, Whaleback, Sea Lion Rocks, Mountain Point, and Castle Rock .
5	Directed fishing for Pacific cod and pollock using trawl gear is prohibited 0-10 nm of rookeries and haulouts. Pacific cod pot and hook-and-line fishing prohibited 0-3 nm at Caton and the Pinnacles.	Directed fishing for Pacific cod and pollock using trawl gear is prohibited 0-3 nm of Caton and the Pinnacles.
10 and 11	Pollock and Pacific cod trawling and pot fishing prohibited 0-20 nm of haulouts and rookeries. Hook-and-line fishing for Pacific cod prohibited 0-10 nm of all haulouts and rookeries.	

Pacific cod and pollock fisheries in the GOA are seasonally allocated as shown in Table 2.6.

Table 2.6. GOA Pollock and Pacific Cod Fishing Seasons and TAC apportionments.

Target Species	Season and apportionment	Date
Pacific Cod	A-season = 60% of TAC	January 1-June 10-- nontrawl January 20-June 10-- trawl
	B-season = 40% of TAC	September 1 -Nov. 1 -- trawl September 1-Dec. 31– nontrawl
Pollock	A season = 25 % of TAC	January 20 - February 25
	B season = 25 % of TAC.	March 10 - May 31
	C season = 25% of TAC	September 1- September 15
	D season = 25% of TAC	October 1 - November 1

Pertinent to GOA pollock: Rollovers of a seasonal pollock allocation from one quarter to the next may be done provided that no rollover is more than 30% of the annual TAC.

Pertinent to GOA Pacific cod: The start date for the GOA cod B season would be June 10, but directed fishing would be prohibited for all gear until September 1.

3 STATUS OF SPECIES AND CRITICAL HABITAT

NMFS has determined that the actions being considered in this biological opinion may adversely affect the western and eastern populations of Steller sea lions[4] and their critical habitat. Consultation was not re-initiated by OSF for other listed species within NMFS jurisdiction which may occur in the action area (see Section 1.1). OSF has provided a significant amount of material on the status of the species in Section 3.1.1 of the SEIS. Some of the following summarizes the information found in the SEIS while other sections provide additional information particular to biological opinions and the requirements under the ESA. Much of this information was previously described in the FMP biological opinion.

3.1 Species Description and Listing Status

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

[4] 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).

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).

On November 26, 1990, the Steller sea lion was listed as threatened under the ESA (55 FR 40204), and on August 27, 1993 (58 FR 45269) critical habitat was designated based on observed movement patterns. In 1997 the Steller sea lion population was split into two separate stocks (western and eastern stocks) based on demographic and genetic dissimilarities (Bickham *et al.* 1996, Loughlin 1997)(62 FR 30772). Due to the continued decline, the status of the western stock was changed to endangered, while the status of the increasing eastern stock was left as threatened. Since 1977 the western population has continued to decline while the eastern population has maintained steady increases and may be considered for de-listing over the next few years if the positive trend continues.

3.2 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.

Since the release of the FMP biological opinion, new information has become available to the agency on the behavior and foraging ecology of Steller sea lions. This information is part of an extensive ongoing research program by NMFS and the Alaska Department of Fish and Game (ADF&G). Most of the information has been collected using tagged animals and satellite telemetry (see Section x below). Although admittedly incomplete, the white papers referenced in Section 1.3 represent the best available scientific information. NMFS will describe how this new information impacts decision making and how it relates to current literature and the previous decisions made by the agency on Steller sea lions.

3.2.1 Designation of Critical Habitat - August 27, 1993

On August 27, 1993 NMFS published a final rule to designate critical habitat for the threatened and endangered populations of Steller sea lions (August 27, 1993; 58 FR 45269). The areas designated as critical habitat for the Steller sea lion were determined using the best information available at the time. This included information on land use patterns, the extent of foraging trips, and the availability of prey items. Particular attention was paid to life history patterns and the areas where animals haul out to rest, pup, nurse their pups, mate, and molt. Critical habitat areas were finally determined based upon 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 (Figure 3.1).

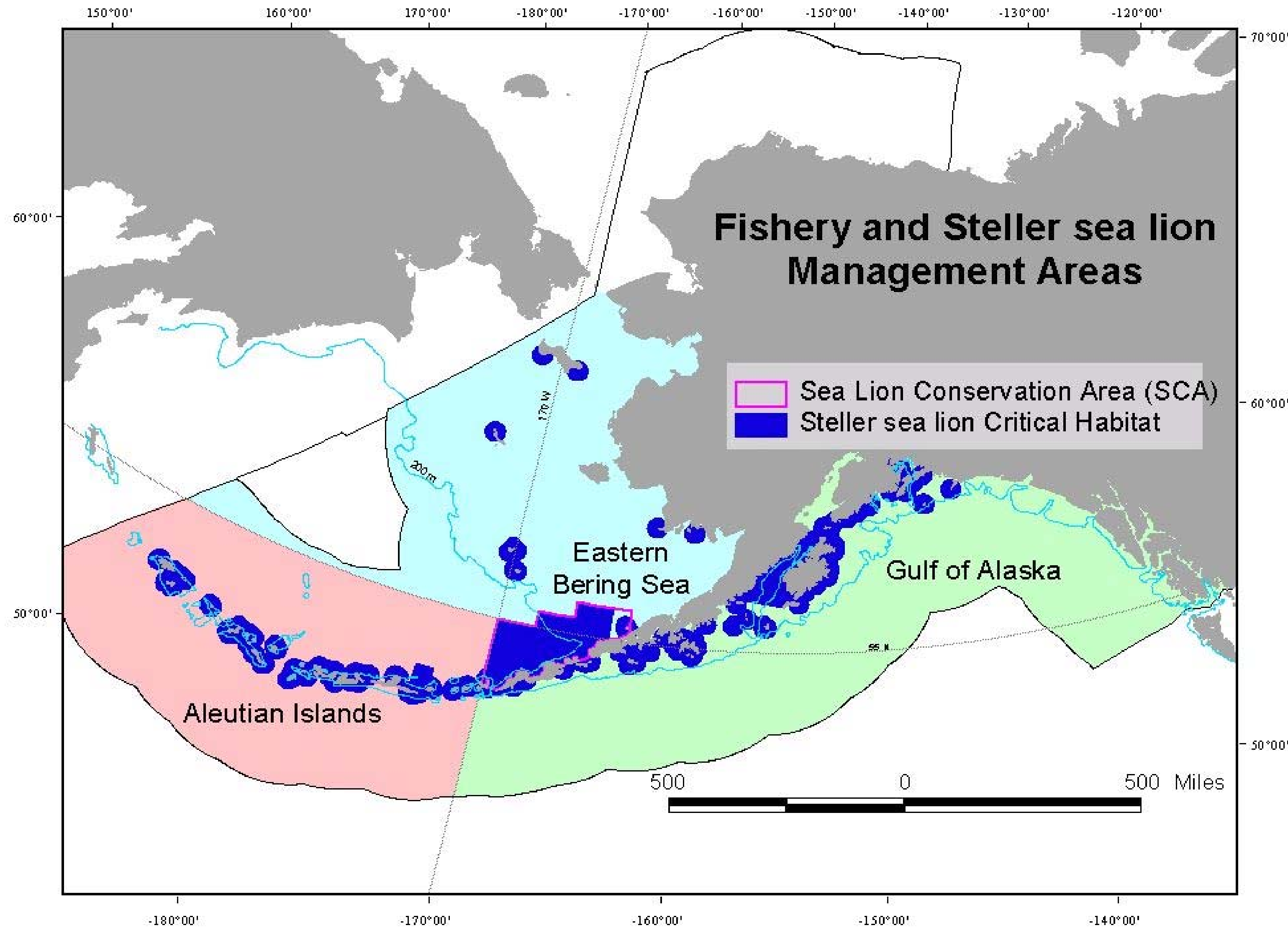

Figure 3.1. Critical habitat for the western population of Steller sea lion.

Two kinds of marine foraging habitat were designated as critical: (1) areas immediately around rookeries and haulouts, and (2) three aquatic foraging areas where large concentrations of important prey species were known to occur. Rookery and haulout areas 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 considered to be 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.

Three aquatic foraging areas were determined to be critical habitat based on (1) at-sea observations indicating that sea lions 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 provided evidence that Shelikof Strait was 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 was 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 supported the notion that this was an important foraging area for sea lions (Fiscus and Baines 1966, Kajimura and Loughlin 1988). Finally, large aggregations of Atka mackerel were 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. Records of incidental take in fisheries also indicate that the Seguam area was an important area for sea lion foraging (Perez and Loughlin 1991). Generally, when the recovery team recommended these areas to be listed as critical habitat, telemetry information was not a major factor.

There has been considerable debate over the last few years on the appropriateness of current critical habitat designations given the body of new information available to NMFS and the public since 1993. During the last 6 months the Council's RPA committee had many discussions on the essential features of critical habitat. These discussions were based on recently compiled information on Steller sea lion locations, dive patterns, stomach telemetry, and scat analyses (ADF&G and NMFS 2001, Loughlin *et al.* unpublished, Sinclair and Zeppelin submitted, DeMaster *et al.* 2001). This information has provided scientists and managers with more precise information on the possible foraging requirements of Steller sea lions, although NMFS recognizes the long list of caveats associated with these data (see the discussion in ADF&G and NMFS 2001). The re-evaluation of designated critical habitat is a lengthy public process which requires the agency to consider both the conservation of the species and possible economic consequences. NMFS anticipates that the newly reconstituted Steller sea lion recovery team will address this issue and provided guidance in a revised recovery plan. In the meantime, our interpretation of the essential features of critical habitat (as described in 50 CFR §424.12) has changed since previous biological opinions due to the best available scientific and commercial data now at hand. The use of this information to make determinations on the effects of the action on critical habitat is appropriate and does not constitute a defacto amendment of the current boundaries of critical habitat. (see Section 3.2.3 below).

3.2.2 Description of Designated Critical Habitat (50 CFR §226.202)

Steller sea lions require both terrestrial and aquatic resources for survival in the wild. Land sites used by Steller sea lions are referred to as rookeries and haulouts. 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 by sea lions 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 critical habitat is listed in 50 CFR §226.202. All major Steller sea lion rookeries are identified in Table 1 [their Table 1] and major haulouts in Table 2 [their Table 2] along with associated terrestrial, air, and aquatic zones. NMFS recognizes that the locations listed in 50 CFR §226.202 are out of date. Advances in technology and repeated surveys to these areas has resulted in more precise and accurate location estimates. NMFS intends to update these locations as soon as practicable. Critical habitat includes the following areas:

- 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

- An air zone that extends 3,000 feet (0.9 km) above the terrestrial zone, measured vertically from sea level

- 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.

- 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.

Critical habitat also includes three special aquatic foraging areas in Alaska; 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.

3.2.2.1 Additional Areas Important to the Conservation of Steller Sea Lions

Since the designation of critical habitat in 1993, NMFS has collected additional information on the habitat requirements of Steller sea lions. NMFS has identified an additional 19 haulouts which have been observed to have substantial usage by Steller sea lions. A thorough discussion of these sites and the requirements for significance was described in a 1998 biological opinion on the pollock fisheries (NMFS 1998). A map of these additional sites is provided in Figure 3.2. NMFS considers these sites very important for the conservation of the species. If we considered them as additional closure areas, the amount of area added to critical habitat is roughly 3%. However, the most important reason for adding these sites is the protection necessary close to shore (0-10 nm) which the consideration of these sites will allow. Without the addition of these sites fishery closure areas from nearby sites might overlap, but are unlikely to protect the core areas close to shore (if they are determined to be necessary). The inclusion of these sites as critical habitat for purposes of this biological opinion allows OPR to make a more accurate determination of jeopardy and adverse modification based on the areas truly important to the western population of Steller sea lions. Table 3.1 contains descriptions of ESA listed rookeries and haulouts and the additional 19 haulouts which have been observed to have substantial usage by Steller sea lions.

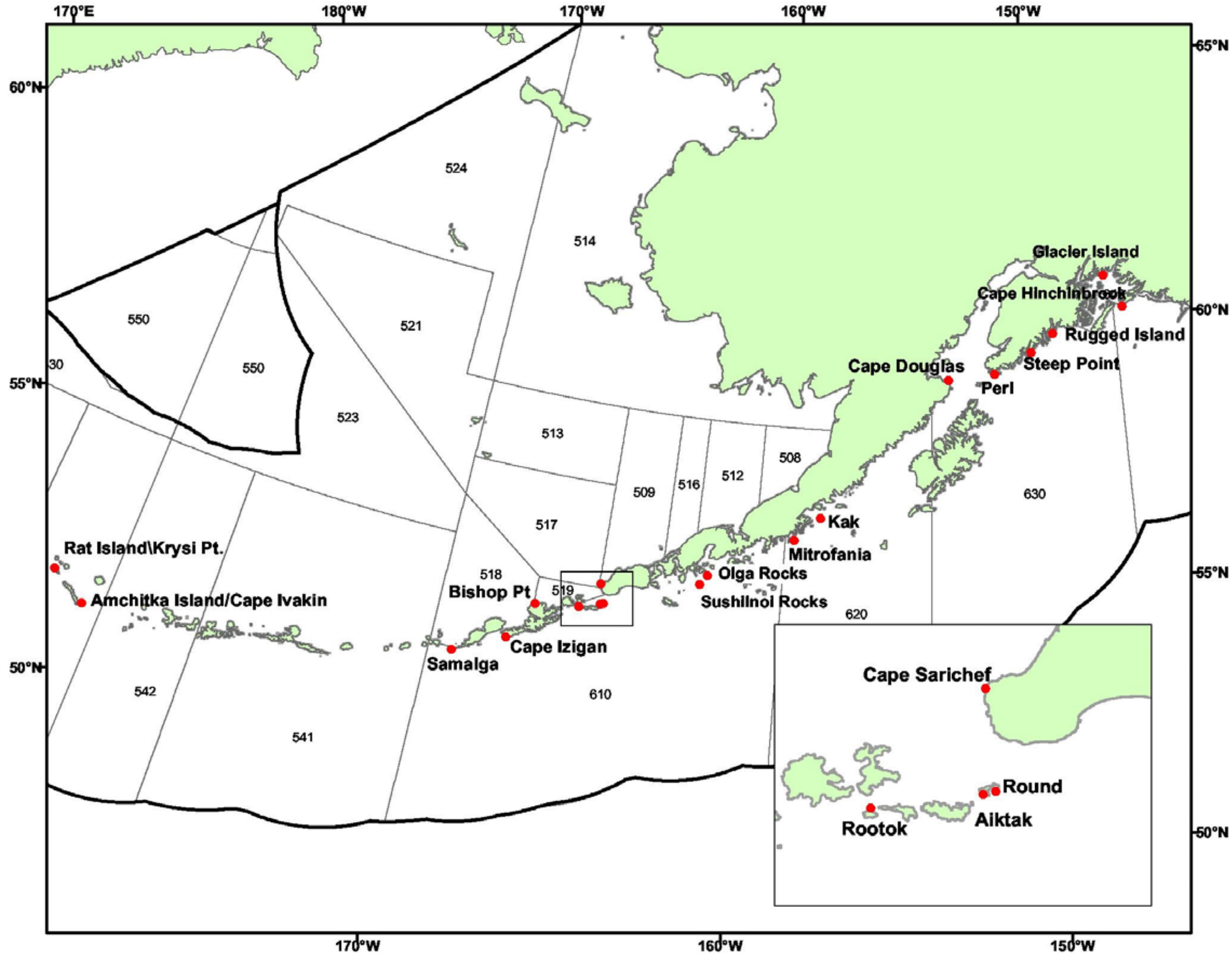

Figure 3.2. Additional 19 haulouts which will be considered as critical habitat for purposes of this biological opinion.

Table 3.1. Steller sea lion protection areas and site specific protection measures under the proposed action.

Site name	Management Region	Boundaries from		Boundaries to[1]		Site Type[2]	No Transit 3 nm	Critical habitat 20 nm?	Pollock Closure	Atka Mackerel Closure	P. Cod Trawl Closure	P. Cod Fixed Gear Closure[3]	P. Cod Longline Only	P. Cod Pot
		Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)									
St. Lawrence I./S Punuk I.	Bering Sea	63 04.00 N	168 51.00 W			H		Y	20	20	20	20		
St. Lawrence I./SW Cape	Bering Sea	63 18.00 N	171 26.00 W			H		Y	20	20	20	20		
Hall I.	Bering Sea	60 37.00 N	173 00.00 W			H		Y	20	20	20	20		
St Paul I./Sea Lion Rock	Bering Sea	57 06.00 N	170 17.50 W			H		Y	3	20	3	3		
St Paul I./NE Pt.	Bering Sea	57 15.00 N	170 06.50 W			H		Y	3	20	3	3		
Walrus I. (Pribilofs)	Bering Sea	57 11.00 N	169 56.00 W			R	Y	Y	10	20	10	3		
St. George I./Dalnoi Pt.	Bering Sea	56 36.00 N	169 46.00 W			H		Y	3	20	3	3		
St. George I./S Rookery	Bering Sea	56 33.50 N	169 40.00 W			H		Y	3	20	3	3		
Cape Newenham	Bering Sea	58 39.00 N	162 10.50 W			H		Y	20	20	20	20		
Round (Walrus Islands)	Bering Sea	58 36.00 N	159 58.00 W			H		Y	20	20	20	20		
Attu I./Cape Wrangell	Aleutian Islands	52 54.60 N	172 27.90 E	52 55.40 N	172 27.2 E	R	Y	Y	20	10	10			
Agattu I./Gillon Pt	Aleutian Islands	52 24.13 N	173 21.31 E			R	Y	Y	20	10	10			
Attu I./Chirikof Pt.	Aleutian Islands	52 49.75 N	173 26.00 E			H		Y	20	3	3			
Agattu I./Cape Sabak	Aleutian Islands	52 22.50 N	173 43.30 E	52 21.80 N	173 41.4 E	R	Y	Y	20	10	10			
Alaid I.	Aleutian Islands	52 46.50 N	173 51.50 E	52 45.00 N	173 56.5 E	H		Y	20	3	3			
Shemya I.	Aleutian Islands	52 44.00 N	174 08.70 E			H		Y	20	3	3			
Buldir I.	Aleutian Islands	52 20.25 N	175 54.03 E	52 20.38 N	175 53.8 E	R	Y	Y	20	15	10	10		
Kiska I./Cape St. Stephen	Aleutian Islands	51 52.50 N	177 12.70 E	51 53.50 N	177 12.0 E	R	Y	Y	20	10	10			
Kiska I./Sobaka & Vega	Aleutian Islands	51 49.50 N	177 19.00 E	51 48.50 N	177 20.5 E	H		Y	20	3	3			
Kiska I./Lief Cove	Aleutian Islands	51 57.16 N	177 20.41 E	51 57.24 N	177 20.5 E	R	Y	Y	20	10	10			
Kiska I./Sirius Pt.	Aleutian Islands	52 08.50 N	177 36.50 E			H		Y	20	3	3			
Tanadak I. (Kiska)	Aleutian Islands	51 56.80 N	177 46.80 E			H		Y	20	3	3			
Segula I.	Aleutian Islands	51 59.90 N	178 05.80 E	52 03.06 N	178 08.8 E	H		Y	20	3	3			
Ayugadak Point	Aleutian Islands	51 45.36 N	178 24.30 E			R	Y	Y	20	10	10			
Rat I./Krysi Pt.	Aleutian Islands	51 49.98 N	178 12.35 E			RPA			20	3	3			
Little Sitkin I.	Aleutian Islands	51 59.30 N	178 29.80 E			H		Y	20	3	3			
Amchitka I./Column Rocks	Aleutian Islands	51 32.32 N	178 49.28 E			R	Y	Y	20	10	10			
Amchitka I./East Cape	Aleutian Islands	51 22.26 N	179 27.93 E	51 22.00 N	179 27.0 E	R	Y	Y	20	10	10			
Amchitka I./Cape Ivakin	Aleutian Islands	51 24.46 N	179 24.21 E			RPA			20	3	3			
Semisopochnoi/Petrel Pt.	Aleutian Islands	52 01.40 N	179 36.90 E	52 01.50 N	179 39.0 E	R	Y	Y	20	10	10			
Semisopochnoi I./Pochnoi Pt.	Aleutian Islands	51 57.30 N	179 46.00 E			R	Y	Y	20	10	10			
Amatignak I./Nitrof Pt.	Aleutian Islands	51 13.00 N	179 07.80 W			H		Y	20	3	3			
Unalga & Dinkum Rocks	Aleutian Islands	51 33.67 N	179 04.25 W	51 35.09 N	179 03.6 W	H		Y	20	3	3			
Ulak I./Hasgox Pt.	Aleutian Islands	51 18.90 N	178 58.90 W	51 18.70 N	178 59.6 W	R	Y	Y	20	10	10			
Kavalga I.	Aleutian Islands	51 34.50 N	178 51.73 W	51 34.50 N	178 49.5 W	H		Y	20	3	3			
Tag I.	Aleutian Islands	51 33.50 N	178 34.50 W			R	Y	Y	20	10	10			
Ugidak I.	Aleutian Islands	51 34.95 N	178 30.45 W			H		Y	20	3	3			
Gramp Rock	Aleutian Islands	51 28.87 N	178 20.58 W			R	Y	Y	20	10	10			
Tanaga I./Bumpy Pt.	Aleutian Islands	51 55.00 N	177 58.50 W	51 55.00 N	177 57.1 W	H		Y	20	20	3			
Bobrof I.	Aleutian Islands	51 54.00 N	177 27.00 W			H		Y	20	20	3			
Kanaga I./Ship Rock	Aleutian Islands	51 46.70 N	177 20.72 W			H		Y	20	20	3			
Kanaga I./North Cape	Aleutian Islands	51 56.50 N	177 09.00 W			H		Y	20	20	3			
Adak I.	Aleutian Islands	51 35.50 N	176 57.10 W	51 37.40 N	176 59.6 W	R	Y	Y	20	20	10			

Table 3.1. Steller sea lion protection areas and site specific protection measures under the proposed action.

Site name	Management Region	Boundaries from		Boundaries to[1]		Site Type[2]	No Transit 3 nm	Critical habitat 20 nm?	Pollock Closure	Atka Mackerel Closure	P. Cod Trawl Closure	P. Cod Fixed Gear Closure[3]	P. Cod Longline Only	P. Cod Pot
		Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)									
Little Tanaga Strait	Aleutian Islands	51 49.09 N	176 13.90 W			H		Y	20	20	3			
Great Sitkin I.	Aleutian Islands	52 06.60 N	176 07.00 W	52 07.00 N	176 07.0 W	H		Y	20	20	3			
Anagaksik I.	Aleutian Islands	51 50.86 N	175 53.00 W			H		Y	20	20	3			
Kasatochi I.	Aleutian Islands	52 11.11 N	175 31.00 W			R	Y	Y	20	20	10			
Atka I./N. Cape	Aleutian Islands	52 24.20 N	174 17.80 W			H		Y	20	20	3			
Amlia I./Sviech. Harbor	Aleutian Islands	52 01.80 N	173 23.90 W			H		Y	20	20	3	20		
Sagigik I.	Aleutian Islands	52 00.50 N	173 09.30 W			H		Y	20	20	3	20		
Amlia I./East	Aleutian Islands	52 05.70 N	172 59.00 W	52 05.75 N	172 57.5 W	H		Y	20	20	3	20		
Tanadak I. (Amlia)	Aleutian Islands	52 04.20 N	172 57.60 W			H		Y	20	20	3	20		
Agligadak I.	Aleutian Islands	52 06.09 N	172 54.23 W			R	Y	Y	20	20	20	20		
Seguam I./Saddleridge Pt.	Aleutian Islands	52 21.05 N	172 34.40 W	52 21.02 N	172 33.6 W	R	Y	Y	20	20	10	20		
Seguam I./Finch Pt.	Aleutian Islands	52 23.40 N	172 27.70 W	52 23.25 N	172 24.3 W	H		Y	20	20	3	20		
Seguam I./South Side	Aleutian Islands	52 21.60 N	172 19.30 W	52 15.55 N	172 31.2 W	H		Y	20	20	3	20		
Amukta I. & Rocks	Aleutian Islands	52 27.25 N	171 17.90 W			H		Y	20	20	3	20		
Chagulak I.	Aleutian Islands	52 34.00 N	171 10.50 W			H		Y	20	20	3	20		
Yunaska I.	Aleutian Islands	52 41.40 N	170 36.35 W			R	Y	Y	20	20	10	20		
Uliaga	Bering Sea	53 04.00 N	169 47.00 W	53 05.00 N	169 46.0 W	H		Y	10	20	10	3		
Chuginadak	Gulf of Alaska	52 46.70 N	169 41.90 W			H		Y	20	20	20		10	20
Kagamil	Bering Sea	53 02.10 N	169 41.00 W			H		Y	10	20	10	3		
Samalga	Gulf of Alaska	52 46.00 N	169 15.00 W			RPA			20	20	20		10	20
Adugak I.	Bering Sea	52 54.70 N	169 10.50 W			R	Y	Y	10	20	10	3		
Umnak I./Cape Aslik	Bering Sea	53 25.00 N	168 24.50 W			H		Y	10	20	10	3		
Ogchul I.	Gulf of Alaska	52 59.71 N	168 24.24 W			R	Y	Y	20	20	20		10	20
Bogoslof I./Fire Island	Bering Sea	53 55.69 N	168 02.05 W			R	Y	Y	10	20	10	20***		
Polivnoi Rock	Gulf of Alaska	53 15.96 N	167 57.99 W			H		Y	20	20	20		10	20
Emerald I.	Gulf of Alaska	53 17.50 N	167 51.50 W			H		Y	20	20	20		10	20
Unalaska/Cape Izigan	Gulf of Alaska	53 13.64 N	167 39.37 W			RPA			20	20	20		10	20
Unalaska/Bishop Pt	Bering Sea	53 58.40 N	166 57.50 W			RPA			10	20	10	3	10	
Akutan I./Reef-lava	Bering Sea	54 08.10 N	166 06.19 W	54 09.10 N	166 05.5 W	H		Y	10	20	10	3	10	
Unalaska I./Cape Sedanka	Gulf of Alaska	53 50.50 N	166 05.00 W			H		Y	20	20	20		10	20
Old Man Rocks	Gulf of Alaska	53 52.20 N	166 04.90 W			H		Y	20	20	20		10	20
Akutan I./Cape Morgan	Gulf of Alaska	54 03.39 N	165 59.65 W	54 03.70 N	166 03.6 W	R	Y	Y	20	20	20		10	20
Akun I./Billings Head	Bering Sea	54 17.62 N	165 32.06 W	54 17.57 N	165 31.7 W	R	Y	Y	10	20	10	3		
Rootok	Gulf of Alaska	54 03.90 N	165 31.90 W	54 02.90 N	165 29.5 W	RPA			20	20	20		10	20
Tanginak I.	Gulf of Alaska	54 12.00 N	165 19.40 W			H		Y	20	20	20		10	20
Tigalda/Rocks NE	Gulf of Alaska	54 09.60 N	164 59.00 W	54 09.12 N	164 57.1 W	H		Y	20	20	20		10	20
Unimak/Cape Sarichef	Bering Sea	54 34.30 N	164 56.80 W			RPA			10	20	10	3		
Aiktak	Gulf of Alaska	54 10.99 N	164 51.15 W			RPA			20	20	20		10	20
Ugamak I.	Gulf of Alaska	54 13.50 N	164 47.50 W	54 12.80 N	164 47.5 W	R	Y	Y	20	20	20		10	20
Round (GOA)	Gulf of Alaska	54 12.05 N	164 46.60 W			RPA			20	20	20		10	20
Sea Lion Rock (Amak)	Bering Sea	55 27.82 N	163 12.10 W			R	Y	Y	10	20	10	7		
Amak I. and rocks	Bering Sea	55 24.20 N	163 09.60 W	55 26.15 N	163 08.5 W	H		Y	10	20	10	3		
Bird I.	Gulf of Alaska	54 40.00 N	163 17.2 W			H		Y	10	20	10			

Table 3.1. Steller sea lion protection areas and site specific protection measures under the proposed action.

Site name	Management Region	Boundaries from: Latitude (N)	Boundaries from: Longitude (W)	Boundaries to[1]: Latitude (N)	Boundaries to[1]: Longitude (W)	Site Type[2]	No Transit 3 nm	Critical habitat 20 nm?	Pollock Closure	Atka Mackerel Closure	P. Cod Trawl Closure	P. Cod Fixed Gear Closure[3]	P. Cod Longline Only	P. Cod Pot
Caton I.	Gulf of Alaska	54 22.70 N	162 21.30 W			H		Y	3	20	3	3		
South Rocks	Gulf of Alaska	54 18.14 N	162 41.3 W			H		Y	10	20	10			
Clubbing Rocks (S)	Gulf of Alaska	54 41.98 N	162 26.7 W			R	Y	Y	10	20	10			
Clubbing Rocks (N)	Gulf of Alaska	54 42.75 N	162 26.7 W			R	Y	Y	10	20	10			
Pinnacle Rock	Gulf of Alaska	54 46.06 N	161 45.85 W			R	Y	Y	3	20	3	3		
Sushilnoi Rocks	Gulf of Alaska	54 49.30 N	161 42.73 W			RPA			10	20	10			
Olga Rocks	Gulf of Alaska	55 00.45 N	161 29.81 W	54 59.09 N	161 30.8 W	RPA			10	20	10			
Jude I.	Gulf of Alaska	55 15.75 N	161 06.27 W			H		Y	20	20	20			
Sea Lion Rocks (Shumagins)	Gulf of Alaska	55 04.70 N	160 31.04 W			H		Y	3	20	3	3		
Nagai I./Mountain Pt.	Gulf of Alaska	54 54.20 N	160 15.40 W	54 56.00 N	160 15.0 W	H		Y	3	20	3	3		
The Whaleback	Gulf of Alaska	55 16.82 N	160 05.04 W			H		Y	3	20	3	3		
Chernabura I.	Gulf of Alaska	54 45.18 N	159 32.99 W	54 45.87 N	159 35.7 W	R	Y	Y	20	20	20	3		
Castle Rock	Gulf of Alaska	55 16.47 N	159 29.77 W			H		Y	3	20	3	3		
Atkins I.	Gulf of Alaska	55 03.20 N	159 17.40 W			R	Y	Y	20	20	20	3		
Spitz I.	Gulf of Alaska	55 46.60 N	158 53.90 W			H		Y	3	20	3	3		
Mitrofania	Gulf of Alaska	55 50.20 N	158 41.90 W			RPA			3	20	3	3		
Kak	Gulf of Alaska	56 17.30 N	157 50.10 W			RPA			20	20	20	20		
Lighthouse Rocks	Gulf of Alaska	55 46.79 N	157 24.89 W			H		Y	20	20	20	20		
Sutwik I.	Gulf of Alaska	56 31.05 N	157 20.47 W	56 32.00 N	157 21.0 W	H		Y	20	20	20	20		
Chowiet I.	Gulf of Alaska	56 00.54 N	156 41.42 W	56 00.30 N	156 41.6 W	R	Y	Y	20	20	20	20		
Nagai Rocks	Gulf of Alaska	55 49.80 N	155 47.50 W			H		Y	20	20	20	20		
Chirikof I.	Gulf of Alaska	55 46.50 N	155 39.50 W	55 46.44 N	155 43.4 W	R	Y	Y	20	20	20	20		
Puale Bay	Gulf of Alaska	57 40.60 N	155 23.10 W			H		Y	10	20	10			
Kodiak/Cape Ikolik	Gulf of Alaska	57 17.20 N	154 47.50 W			H		Y	3	20	3	3		
Takli I.	Gulf of Alaska	58 01.75 N	154 31.25 W			H		Y	10	20	10			
Cape Kuliak	Gulf of Alaska	58 08.00 N	154 12.50 W			H		Y	10	20	10			
Cape Gull	Gulf of Alaska	58 11.50 N	154 09.60 W	58 12.50 N	154 10.5 W	H		Y	10	20	10			
Kodiak/Cape Ugat	Gulf of Alaska	57 52.41 N	153 50.97 W			H		Y	10	20	10			
Sitkinak/Cape Sitkinak	Gulf of Alaska	56 34.30 N	153 50.96 W			H		Y	10	20	10			
Shakun Rock	Gulf of Alaska	58 32.80 N	153 41.50 W			H		Y	10	20	10			
Twoheaded I.	Gulf of Alaska	56 54.50 N	153 32.75 W	56 53.90 N	153 33.7 W	H		Y	10	20	10			
Cape Douglas (Shaw I.)	Gulf of Alaska	59 00.00 N	153 22.50 W			RPA			10	20	10			
Kodiak/Cape Barnabas	Gulf of Alaska	57 10.20 N	152 53.05 W			H		Y	3	20	3	3		
Kodiak/Gull Point	Gulf of Alaska	57 21.45 N	152 36.30 W			H		Y	10	20	10			
Latax Rocks	Gulf of Alaska	58 40.10 N	152 31.30 W			H		Y	10	20	10			
Ushagat I./SW	Gulf of Alaska	58 54.75 N	152 22.20 W			H		Y	10	20	10			
Ugak I.	Gulf of Alaska	57 23.60 N	152 17.50 W	57 21.90 N	152 17.4 W	H		Y	10	20	10			
Sea Otter I.	Gulf of Alaska	58 31.15 N	152 13.30 W			H		Y	10	20	10			
Long I.	Gulf of Alaska	57 46.82 N	152 12.90 W			H		Y	10	20	10			
Sud I.	Gulf of Alaska	58 54.00 N	152 12.50 W			H		Y	10	20	10			
Kodiak/Cape Chiniak	Gulf of Alaska	57 37.90 N	152 08.25 W			H		Y	10	20	10			
Sugarloaf I.	Gulf of Alaska	58 53.25 N	152 02.40 W			R	Y	Y	20	20	20	10		
Sea Lion Rocks (Marmot)	Gulf of Alaska	58 20.53 N	151 48.83 W			H		Y	10	20	10			

Table 3.1. Steller sea lion protection areas and site specific protection measures under the proposed action.

Site name	Management Region	Boundaries from		Boundaries to[1]		Site Type[2]	No Transit 3 nm	Critical habitat 20 nm?	Pollock Closure	Atka Mackerel Closure	P. Cod Trawl Closure	P. Cod Fixed Gear Closure[3]	P. Cod Longline Only	P. Cod Pot
		Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)									
Marmot I.	Gulf of Alaska	58 13.65 N	151 47.75 W	58 09.90 N	151 52.0 W	R	Y	Y	20	20	20	10		
Nagahut Rocks	Gulf of Alaska	59 06.00 N	151 46.30 W			H		Y	10	20	10			
Perl	Gulf of Alaska	59 05.75 N	151 39.75 W			RPA			10	20	10			
Gore Point	Gulf of Alaska	59 12.00 N	150 58.00 W			H		Y	10	20	10			
Outer (Pye) I.	Gulf of Alaska	59 20.50 N	150 23.00 W	59 21.00 N	150 24.5 W	R	Y	Y	20	20	20	10		
Steep Point	Gulf of Alaska	59 29.05 N	150 15.40 W			RPA			10	20	10			
Seal Rocks (Kenai)	Gulf of Alaska	59 31.20 N	149 37.50 W			H		Y	10	20	10			
Chiswell Islands	Gulf of Alaska	59 36.00 N	149 34.00 W			H		Y	10	20	10			
Rugged Island	Gulf of Alaska	59 50.00 N	149 23.10 W	59 51.00 N	149 24.7 W	RPA			10	20	10			
Point Elrington	Gulf of Alaska	59 56.00 N	148 15.20 W			H		Y	**20**	**20**	**20**			
Perry I.	Gulf of Alaska	60 44.00 N	147 54.60 W			H		Y	**20**	**20**	**20**			
The Needle	Gulf of Alaska	60 06.64 N	147 36.17 W			H		Y	**20**	**20**	**20**			
Point Eleanor	Gulf of Alaska	60 35.00 N	147 34.00 W			H		Y	**20**	**20**	**20**			
Wooded I. (Fish I.)	Gulf of Alaska	59 52.90 N	147 20.65 W			R		Y	20	20	20			
Glacier Island	Gulf of Alaska	60 51.30 N	147 14.50 W			RPA			**20**	**20**	**20**			
Seal Rocks (PWS)	Gulf of Alaska	60 09.78 N	146 50.30 W			R		Y	20	20	20			
Cape Hinchinbrook	Gulf of Alaska	60 14.00 N	146 38.50 W			RPA			20	20	20			
Middleton I.	Gulf of Alaska	59 28.30 N	146 18.80 W			H		Y	10	20	10			
Hook Point	Gulf of Alaska	60 20.00 N	146 15.60 W			H		Y	20	20	20			
Cape St. Elias	Gulf of Alaska	59 47.50 N	144 36.20 W			H		Y	20	20	20			
Cape Fairweather	Gulf of Alaska	58 47.50 N	137 56.30 W			H								
Graves Rock	Gulf of Alaska	58 14.30 N	136 45.40 W			H								

H = Haulout

R = Rookery

RPA = RPA Haulout

** open to 15 nm first half of the year

*open to 3 nm after 2nd half of the year

***Bogoslof Area is closed to pollock, P. cod and Atka mackerel fishing

Bolded sites are located in the PWS state waters.

[1]Where two sets of coordinates are given, the baseline extends in a clock-wise direction from the first set of geographic coordinates along the shore line at mean lower-low water to the seond set of coordinates. Whre only one set of coordinates is lister, that location is the base point.

[2]Listed rookery and haulout sites under the ESA designated in this table are defined at 50 CFR 226.202. Three nm no transit zones and other protections for listed rookery sites listed in this table are defined at 50 CFR 223.202. Sites in this table that have an RPA description have not been listed under the ESA as a rookery or haulout with the appropriate critical habitat designation. However, these sites are used as haulouts by Steller sea lions and have been determined by NMFS to be of special importance to the endangered western population of Steller sea lions.

[3]Jig gear fishing is exempt from haulout closures, except in Area 9 of the Bering Sea and in the Seguam Foraging Area.

3.2.2.2 Critical Habitat Areas with few Observations of Steller Sea Lions

The most notable areas that have not received extensive survey coverage are the 5 northernmost haulouts in the Bering Sea (those not in the Pribilof Islands). These were included in the 1993 designation of critical habitat although admittedly NMFS has very few observations of Steller sea lions at these sites. These sites are considered to be important, due in large part to males which migrate through the region in the summer months. There are more observations from the Pribilof Islands. On the rookery at Walrus Island in the Pribilofs, NMFS counted 5,797 pups in 1954, 2,866 in 1960, and only 61 pups in 1994 (NMML unpublished data). Pups were also counted on St. Paul/northeast point in the late 1940s and early 1950s. Although surveys in this region have been sporadic and opportunistic, NMFS does consider these areas to be important to the future recovery of the species. These areas may represent an outer range, and might be some of the areas abandoned first during a range contraction due to a long term declining population.

There are also numerous haulouts throughout the range that have had little use over the past 10-15 years (NMFS unpublished data). In previous biological opinions (NMFS 1998 and the subsequent Revised Final RPA), NMFS has outlined those sites that have had substantial seasonal use in the last 10 years. Observations at about 22 sites have resulted in either few or no animals counted there during the last survey (less than 10 animals). It is not surprising that some areas would be deserted after a substantial decline of the species from about 180,000 animals in the 1970s to about 33,000 animals today.

3.2.3 Essential Features of Critical Habitat in the Action Area

The regulations at 50 CFR §424.12(b) outline those physical and biological features which should be considered when designating critical habitat for listed species:

(1) Space for individual and population growth, and for normal behavior;
(2) Food, water, air, light, minerals, or other nutritional or physiological requirements;
(3) Cover or shelter;
(4) Sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and generally;
(5) Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

The physical and biological features of critical habitat essential to the conservation of Steller sea lions are those items that support successful foraging, rest, refuge, and reproduction. This can be broken out into two major habitat categories; terrestrial and foraging habitat.

3.2.3.1 Terrestrial habitat

Because terrestrial areas are more easily observed by humans, terrestrial habitat is relatively easy to identify based on use patterns. The shoreline, offshore rocks, cliffs, and caves used by sea lions 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. Generally, the rookery and haulout sites are well scattered along the Alaska shoreline, and are about 5-10 nm apart from each other. They provide access to a variety of prey resources which is represented in the scat collections taken from terrestrial sites (Sinclair and Zeppelin 2001).

Reports of disruption of breeding and pup rearing activities on these sites has been well documented. On rookeries, human disturbance may disrupt breeding and nursing activities, lead to pup abandonment, and possibly increase the likelihood of predation. On haulouts, disturbance can also lead to increased chance of predation and the disruption of the social structure of sea lions. Since the early 1990s and the passage of critical habitat regulations, as well as the Marine Mammal Protection Act, these terrestrial sites have been largely undisturbed by humans, and are not considered to be a major factor in the continued decline of the species. One of the main concerns in the 1980s was that animals were being shot at from vessels nearby rookeries and haulouts. This is considered to be a rare occurrence today. Anecdotal information suggests that animals have different tolerances to boat traffic. In some areas sea lions are known to co-exist with fishing vessels, often taking advantage of the presence of nets to catch fish, in other areas tour vessels have been known to come within a few feet of a sea lion haulout with no observed impact on the group. However, there are also anecdotal accounts of vessels sounding a loud horn in order to evacuate a haulout and provide a show for the tourists on board, and other accounts from research vessels indicate that the animals on most haulouts will become nervous when a boat is within 3,000-2,000 feet and abandon the site. In summary, in Alaska, terrestrial habitat critical to the survival and recovery of Steller sea lions appears to be in good physical condition (i.e., no loss of habitat due to construction of other physical degradations), with some concern for the take of animals due to encroachment by humans near sites for viewing, research, or intentional harassment.

3.2.3.2 Foraging habitat

Prey resources are the most important feature of marine critical habitat for Steller sea lions. 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. A complete discussion of the foraging needs is discussed in Section 3.6 below and in Section 3.1.1.7 of the Steller sea lion SEIS. In this section we intend to point out the important areas of aquatic critical habitat that is currently viewed as essential to the species survival and recovery in the wild, and that will be used in the biological opinion to assess whether the action is likely to jeopardize the continued existence of the species or destroy or adversely modify its critical habitat.

The at-sea distribution of Steller sea lions is a critical element to any understanding of potential effects of fisheries on sea lions and their critical habitat. Substantial new information has been collected on the at-sea distribution of Steller sea lions as reported in Loughlin *et. al.* (unpublished) and ADF&G and NMFS (2001). Although not without limitations (discussed in ADF&G and NMFS 2001), information on location reflects the best scientific information available on the distribution of Steller sea lions in their aquatic habitat. Ideally, location would be combined with dive data to indicate at which locations sea lions are actively foraging. However, this combination of analyses is not yet available. In the absence of this combined information, NMFS must assume that the new information on location of sea lions does reflect, at least in part, where sea lions forage.

Loughlin *et. al.* (unpublished) identifies three types of sea lion movement: (1) long range trips (>8 nm and >20 hours), (2) short-range trips (<8 nm and < 20 hours), and (3) transits to other sites (3.5 - 245 nm). They also found that for pre-breeding age sea lions, about 93.8% of the at-sea locations were within 10 nm of land, only 2.2% were in the 10-20 nm zone, and only 4% was outside of critical habitat. For breeding age animals only 1.5% of the at-sea locations were in the 10-20 nm zone, and 10% of the locations were outside of critical habitat. ADF&G and NMFS (2001) also provides numerous figures displaying the relatively high at-sea locations inside the 0-10 nm zone, especially within the 0-3 nm zone. NMFS recognizes many limitations in interpreting these data, many of those caveats were clearly articulated in Loughlin *et. al.* (unpublished) and ADF&G and NMFS (2001).

- Due to a larger proportion of time spent at the surface nearshore, the probability of obtaining at-sea locations near haulouts and rookeries is likely higher than when further offshore when sea lions are diving to depth in deeper waters,

- At-sea locations do not directly indicate where sea lions are foraging,

- The large majority of pups, and perhaps most juveniles, were likely still nursing and thus not foraging independently for prey, and

- Telemetry data are lacking for subadults and females without pups.

Undoubtedly, the combination of accurate seasonal fisheries surveys combined with detailed at-sea locations and dive data for sea lions would allow a much finer level of understanding of sea lion foraging patterns, nursing strategies, energetics, and dispersal. However, little published information is available, and at best NMFS can only speculate on the foraging conditions optimal for sea lions to survive and recovery in the wild. Many types of sea lion behaviors have been observed in the wild. 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, Loughlin *et al.* unpublished), but such descriptions are essential for understanding foraging patterns, nursing strategies, energetics, and therefore their critical habitat needs. 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.* unpublished 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.

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 the essential features of critical habitat. 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 (Sinclair and Zeppelin submitted). 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), and the causes for their (apparent) two- to three-fold changes in abundance over the last two decades. 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.

3.3 Population 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).

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). Sinclair and Zeppelin (submitted) also identified sub-populations based on current data on diet diversity from scat collections. These examples indicate that, depending on the purpose at hand, the total sea lion population may be split meaningfully into sub-populations 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).

3.4 Population Dynamics and Risks (*for further information see the SEIS Section 3.1.1*)

Assessments of Steller sea lion population dynamics 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.

3.4.1 Population 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% (Figure 4.3; Table 4.1; NMFS 1995, Strick et al. 1997, Sease and Loughlin 1999; Sease *et al.* 2001). In 2000, that number further declined to 18,193 animals, an 18% decrease (Sease *et al.* 2001). 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 3.2, Figure 3.3). 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 (Table 3.3). 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 counter's 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 (Sease 2000; Loughlin and York 2001) 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) with an increase of about 3.5% to 4.0% per year (Calkins 1999). 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 2,200 in 1979 to 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).

Table 3.2. Counts of adult and juvenile (non-pup) Steller sea lions at rookery and haulout trend sites by region (NMFS unpubl. Sease 2000). For the GOA, the eastern sector includes rookeries from Seal Rocks in Prince William Sound to Outer Island; the central sector extends from Sugarloaf and Marmot Islands to Chowiet Island; and the western sector extends from Atkins Island to Clubbing Rocks. For the Aleutian Islands, the eastern sector includes rookeries from Sea Lion Rock (near Amak Island) to Adugak Island; the central sector extends from Yunaska Island to Kiska Island; and the western sector extends from Buldir Island to Attu Island.

Year	Gulf of Alaska			Aleutian Islands			Southeast Alaska
	Eastern	Central	Western	Eastern	Central	Western	
1975				19,769			
1976	7,053	24,678	8,311	19,743			
1977				19,195			
1979					36,632	14,011	6,376
1982							6,898
1985		19,002	6,275	7,505	23,042		
1989	7,241	8,552	3,800	3,032	7,572		8,471
1990	5,444	7,050	3,915	3,801	7,988	2,327	7,629
1991	4,596	6,273	3,734	4,231	7,499	3,085	7,715
1992	3,738	5,721	3,720	4,839	6,399	2,869	7,558
1994	3,369	4,520	3,982	4,421	5,790	2,037	8,826
1996	2,133	3,915	3,741	4,716	5,528	2,190	8,231
1997		3,352	3,633				
1998		3,346	3,361	3,847	5,761	1,913	8,693
1999	1,952						
2000	1,894	3,117	2,842	3,842	5,427	1,071	

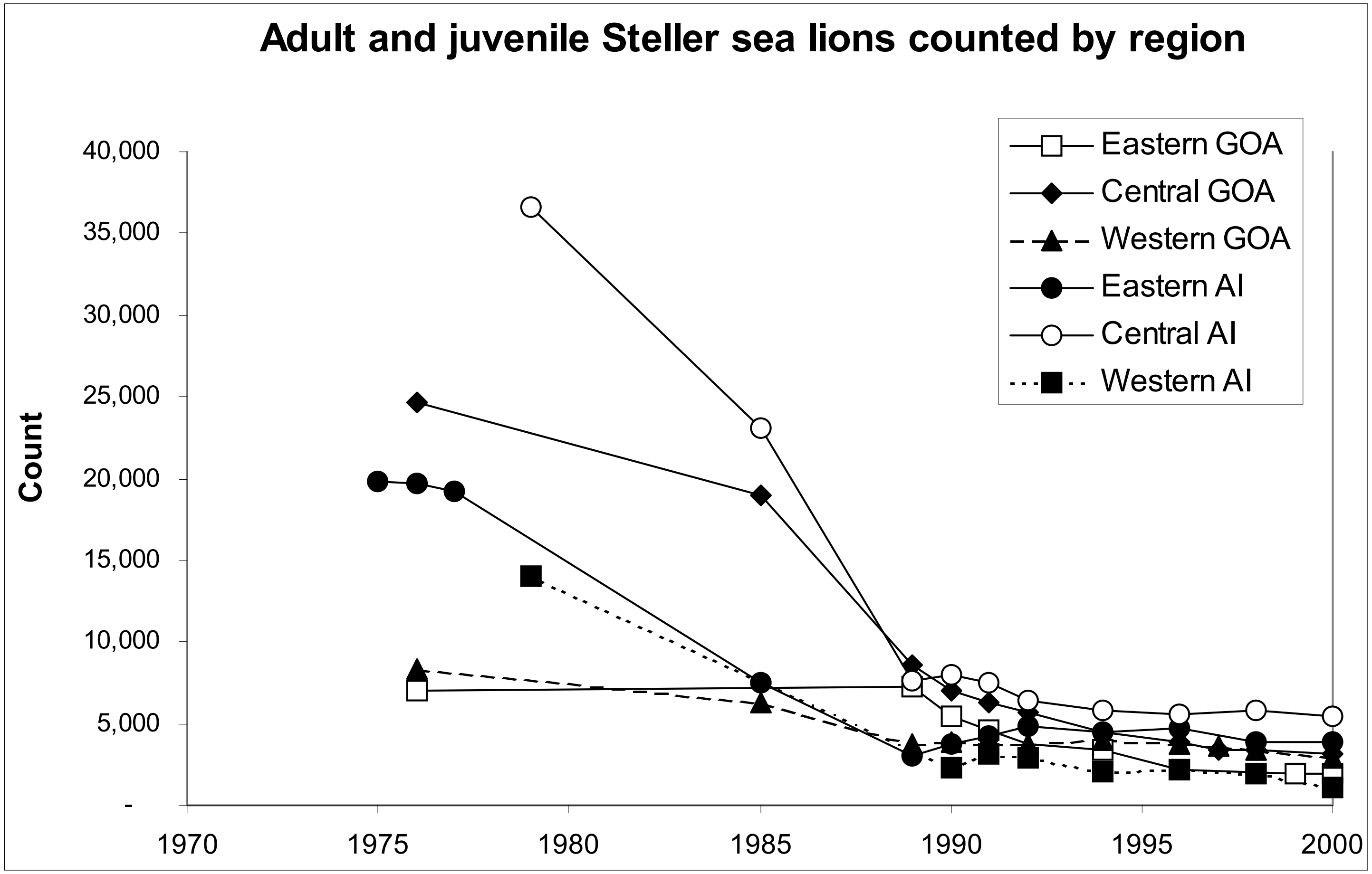

Figure 3.3. Counts of adult and juvenile Steller sea lions in the western population (by region) from the late 1970s to 2000.

Table 3.3. Counts of Steller Sea Lion Pups in Alaska, 1994 to 1998. (NMFS unpublished data; Sease 2000).

Region	Number of rookeries	1994	1997	1998	Percent change 94-98	97-98
Western Aleutian Islands	4		979	803		-18.0
Central Aleutian Islands	16	3,162		2,862	-9.5	
Eastern Aleutian Islands	6	1,870		1,516	-18.9	
Western Gulf of Alaska	4	1,662		1,493	-10.2	
Central Gulf of Alaska	5	2,831		1,876	-33.7	
Eastern Gulf of Alaska	2	903	610	689	-23.7	13
Western Stock subtotal (Kiska to Seal Rocks)	33	10,428		8,436	-19.1	
Southeast Alaska	3	3,770	4,160	4,234	12.3	1.8

3.4.2 Population Variability and Stability

Populations change as a function of births, deaths, immigration, and emigration (see Section 3.1.1.4 of the SEIS for further discussion). 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 would likely be limited to no more than 8% to 10% annually (based on its life history characteristics and observed growth rates of other Otariids). 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 existence of smaller demographic units may exacerbate factors that accelerate small populations toward extinction (e.g., unbalanced sex ratios, allee effects, inbreeding depression). Current information on the western population of Steller sea lions, including demography and food habits data, are inconsistent with one single stock. Ongoing studies will provide further information on this issue over the next 12 months (DeMaster pers. comm.).

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.

3.4.3 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 (from the publication of the paper) 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. In a recent paper by Loughlin and York (2001), they estimated that the population may decline to only about 11,430 animals in the year 2020, of that only about 6,325 would be counted in the bi-annual survey, about a third of the current numbers. At that low an abundance, current survey techniques would have much higher errors associated with it and research would be difficult to undertake with few pups or juveniles available for studies with an adequate sample size.

3.5 Life History Characteristics and Foraging Requirements

The life history of Steller sea lions, disease, predation, and physiology is presented in Section 3.1.1 of the SEIS. A detailed description of the historical and current diet of Steller sea lions is also presented in the FMP biological opinion (NMFS 2000). The following is a summary of the foraging ecology of Steller sea lions from Section 3.1.1.7.5 of the SEIS:

The SEIS describes that the foraging patterns of Steller sea lions are still far from being completely understood. However, the available information suggests that:

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

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

- 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.

- Pups dependent upon mothers for nutrition tend not to disperse greatly and remain relatively near-shore conducting shallow dives.

- Yearlings that have reached nutritional independence greatly increase their foraging area, and begin deeper diving.

- Food availability may be extremely important during April - June, when pups are likely to be making a transition to nutritional independence, and the energy requirements of pregnant females are about double that of nonpregnant females.

- Steller sea lions consume a variety of demersal, semi-demersal, and pelagic prey, indicating a potentially broad spectrum of foraging styles.

- Diet diversity may influence status and growth of Steller sea lion populations.

- The life history and spatial/temporal distribution of important prey species are likely important determinants of sea lion foraging success

- The broad distribution of sea lions sighted in the POP database indicates that sea lions also forage at sites distant from rookeries and haulout sites.

- Dominant prey items vary with region and season, but pollock, Atka mackerel, Pacific cod and salmon are generally the most common or dominant prey (see Table 3.3).

- 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 haulout sites.

- 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.

In a variety of previous documents, NMFS has determined that there is sufficient niche overlap between some federally authorized commercial fisheries and Steller sea lions, such that the potential for competitive interactions is likely. In the FMP biological opinion (their Table 6.6), pollock, Pacific cod, and the Atka mackerel fisheries were identified as likely to overlap with sea lion foraging. Additionally, herring and salmon fisheries were also identified as fisheries likely to overlap with sea lion foraging. Although not all fisheries overlap completely with observed sea lion diet, a qualitative analysis by the agency found that enough overlap had been observed in the size, depth, location, and time of removals that overlap was likely, at least at some unknown magnitude (NMFS 2000). Overlap has been described in the final rule and supporting NEPA documents for the Atka mackerel conservation measures implemented in 1999 (64 FR 3446; January 22, 1999), the 1998 biological opinion on the pollock and

Atka mackerel fisheries (NMFS 1998) and supporting NEPA documents to implement emergency rules, and the FMP biological opinion (NMFS 2000).

Table 3.4. Percent frequency of occurrence of key Steller sea lion prey items as identified in scat samples collected from 1991-2000 (modified from Sinclair and Zeppelin submitted; see their Figure 6 for a description of regions).

Species	All seasons	May - September					December - April				
	RANGE	Reg-1	Reg-2	Reg-3	Reg-4	RANGE	Reg-1	Reg-2	Reg-3	Reg-4	RANGE
Pollock	46.4	63.9	79.8	54.0	9.6	33.2	56.2	85.5	59.1	2.7	63.2
Pacific cod	16.1	5.0	11.0	6.2	6.5	6.9	30.9	35.9	19.6	16.9	27.7
Atka mackerel	39.6	--	1.6	26.4	92.6	58.1	2.1	3.9	24.7	64.9	16.1
Herring	6.9	7.1	11.4	32.0	<1	7.7	22.8	3.1	<1	--	6.0
Salmon	20.4	41.1	44.5	35.4	15.5	25.9	10.8	8.8	17.3	23.6	13.4
Sand lance	6.3	9.5	24.9	1.9	1.0	5.7	17.7	8.3	1.4	--	7.1
Irish lord	8.3	<1	10.1	4.0	4.5	4.8	14.7	8.5	16.4	12.8	12.8
Squid & Octopus	8.8	3.7	<1	6.2	18.2	12.1	7.2	2.5	3.9	11.5	4.7
Arrowtooth	7.4	35.3	10.4	3.1	<1	6.3	21.3	7.5	4.4	2.7	8.8

A detailed look at Steller sea lion physiology and nutrition is presented in Section 3.1.1.8 of the SEIS. The following has been extracted from that document:

> Field measurements of metabolic rate or energy consumption show that otariids generally operate at 3-6 times their basal metabolic rate while traveling and foraging (Costa *et al*. 1989, Arnould *et al*. 1996, Winship 2000). This is higher than measurements for phocids, and reflects a high energy strategy for foraging. In general, otariids have adopted an "energy maximizer" type foraging strategy, which is characterized by high energy turnover. That is, sea lions expend comparatively (to phocids) high levels of energy to acquire relatively high levels of energy. This strategy is advantageous in highly productive ecosystems with concentrated and predictable prey (Costa 1993).
>
> Otariids can make adjustments to foraging strategies on many behavioral and metabolic scales. Changes in foraging trip duration and in time at a prey patch have been observed in response to prey availability (Boyd 1996, Boyd 1999, Andrews 2001). Responses by sea lions will vary depending upon life history status, for example, whether an adult female is lactating or not, or whether a mother-pup pair is at a rookery (central place foraging), or foraging from multiple haulouts (multiple central place foraging). This change in strategy is likely related to costs of lactation, when at some point it becomes more advantageous energetically for the female to move away from the rookery with the pup, though it is not yet weaned, to allow exploitation of prey with a higher rate of energy return (Boyd 1998), either because of prey proximity, quality, or abundance at sites other than near the rookery.
>
> Individual foraging strategies will vary depending upon prey location and quality. If prey are not shallow, travel costs increase to access the prey patch. At some combination of prey size, quality, number, catchibility and depth, it will become suboptimal for a sea lion to forage on a given prey type (Boyd 1997). This type of foraging decision was recently directly observed by Thomas and Thorne (2001), where sea lions in Prince William Sound were observed feeding on surface schooling herring, rather than diving to a deeper, though more concentrated, school of pollock.

A discussion of field studies on the health and condition of Steller sea lions is described in Section 3.1.1.11 of the SEIS. Comparisons of growth measurements, such as mass or length at age, are more reflective of longer term conditions experienced by an animal. Steller sea lions sampled in the 1980s weighed less and were shorter for age than sea lions sampled during the 1970s (Calkins *et al*. 1998), and were less massive than expected based on length-girth relationships (Castellini and Calkins 1993). These differences were most notable among animals less than 10 years old (Calkins and Goodwin 1988), and may have been declining since the 1960s (Calkins *et al*. 1998). These changes are consistent with nutritional limitation. Recent comparisons of body size across regions of decline and stability do not recapitulate the long-term trend, however. There is evidence for larger pup sizes in areas of decline (Rea 1995, Merrick *et al*. 1995, Adams 2000, Fadely and Loughlin 2001), arising from differential growth rates (Brandon and Davis 1999). Adult females with pups were not different in size between the regions of stability and decline (Davis *et al*. 1996), though this sample of unknown age females may not be representative of the populations as a whole. This issue was discussed recently at a workshop on the food limitation hypothesis (DeMaster *et al.* 2001), which is discussed in further detail in Section 4 (*Baseline*) of this document.

3.6 Overview of Current and Future Steller Sea Lion Research Programs

Researchers have had a keen interest in the biology, ecology, and population dynamics of Steller sea lions for decades, and have produced hundreds of reports and publications outlining their findings. The following is a general overview of the current, major Steller sea lion research programs, new programs, and expected results of some of these new programs.

3.6.1 Current Research Programs

There are several agencies/organizations which have had very productive Steller sea lion research programs for years to decades. Some of the highlights of these research programs are as provided here.

National Marine Fisheries Service

The primary goals of NMFS' Steller sea lion research program are to determine the abundance, distribution, trends in abundance, and the causes for trends in abundance for the western and eastern stocks of Steller sea lions. The first aerial surveys designed to estimate abundance were made in the 1970's (Braham *et al.* 1980); since then, aerial surveys are flown every year (1989-1992) or ever two years (1992-2000), often in cooperation with the Alaska Department of Fish and Game. Sease et al. (2001) provides the most recent results of these efforts. Trends in abundance are calculated using the annual or biennial abundance estimates, and are also calculated for certain trend rookeries and haulouts. NMML's research program also includes projects critical to determining the cause of the Steller sea lions decline, including the following: demographic studies at Marmot Island, foraging ecology, population genetics analysis, and seasonal diet trends. Because the western stock of Steller sea lions is currently declining, NMFS has focused the majority of its research efforts in areas west of Prince William Sound.

NMFS' Resource Ecology and Fisheries Management (REFM) division has also carried out studies which directly relate to determining the cause of the Steller sea lion population decline. Studies to determine the efficacy of trawl exclusion zones on maintaining prey availability and studies to determine the effects of trawling on pollock distribution and abundance have been conducted (NMFS, unpublished document) and results are expected to be forthcoming.

Alaska Department of Fish and Game

The overall research objective of the ADF&G Steller sea lion program has focused on designing projects aimed at investigating basic vital rates. These include the development of capture methods for juveniles, aerial surveys in collaboration with NMML to estimate abundance, the use of satellite-linked transmitters for recording dive and location data, body condition and blood chemistry studies to investigate the timing of weaning and numerous collaborative projects with other agencies and universities. Ongoing work designed to produce data on age-specific survival and reproductive success continues and includes marking pups and annual trips to re-sight marked animals.

The hypothesis that the decline of Steller sea lions in the western stock hinges on reduced juvenile survival prompted ADF&G to concentrate research on juveniles since 1998. Prior to this time, little was known about the life history of juveniles due to the difficulty of capture and studies were limited by small sample sizes and short telemetry deployment periods (Merrick and Loughlin 1997). Unlike the declining western stock, the Steller sea lion population in Southeast Alaska has been increasing or stable, yet little information is available on juvenile life history traits in either population. Therefore, intensive research on juveniles in Southeast Alaska offered the opportunity to develop methods and collect data useful in understanding the biology of Steller sea lions without requiring the handling of animals in the areas of greatest decline and potentially more sensitive to disturbance. This work has focused on using satellite telemetry, combined with health and condition measurements, in order to describe some of the life history of juveniles with the intent of distinguishing differences in the biology and habits of juveniles between the western and eastern stock.

North Pacific Universities Marine Mammal Research Consortium

The North Pacific Universities Marine Mammal Research Consortium (NPUMMRC) was formed in 1992 and includes four participating universities: University of Alaska, University of British Columbia, University of Washington, and Oregon State University. The mission of the NPUMMRC is to conduct long term research on the relationship between commercial fisheries and marine mammals in the North Pacific Ocean and the Eastern Bering Sea (NPUMMRC 2001). Major programs involving field studies of behavior, changes in body size, diet and foraging success, and movements have been carried out for several years.

Alaska SeaLife Center

The major focus of the research at the Alaska SeaLife Center involves determining the nutritional demands and overall health of Steller sea lions, and considering this information in the context of the potential contribution of commercial fisheries to the decline of the species. Long-term studies on captive Steller sea lions provides critical information on the nutritional value of different prey species. In addition, the Alaska SeaLife Center has pioneered the remote monitoring of a Steller sea lion haulout site using remotely-controlled video cameras. In addition, the Alaska SeaLife Center is involved in extensive research on Steller sea lion endocrinology and physiology, the results of which may provide a way to determine the metabolic conditions of free-ranging Steller sea lions without requiring that the animal be captured and handled.

University of Alaska, Fairbanks

The Gulf Apex Predator study at Kodiak Island (an area where Steller sea lions are declining at > 5% per year) was initiated by the University of Alaska, Fairbanks in 1999. The goals of this study are to assess the seasonal abundance and distribution of Steller sea lions, to determine seasonal diet, and simultaneously to determine the seasonal and spatial distribution of prey species near 5 critical haulout sites on the eastern side of Kodiak Island, in order to compare the seasonal use of prey to availability of prey near these haulout sites.

Table 3.5. Summary of ongoing and new/proposed Steller sea lion research. Note that this list is current as of 6/28/01, and is subject to change as project titles are revised, or as overlapping projects are eliminated. Projected titles for ongoing research are those found in the report of the January 2001 Steller Sea Lion Research Planning Meeting. Project titles for new research were obtained from proposals submitted to NMFS in 2001, or are projects funded under SSLIR or CIFAR. This list will be augmented and refined as information is compiled describing specific studies and cooperators.

Organization/ Institution	Study description/title	Ongoing (O)/ New & Proposed (N)
NMFS/NMML	Satellite tagging	O
NMFS/NMML	Food habits studies foraging behavior	O
NMFS/ABL	Forage fish assessment and biology	O
NMFS/NMML	AIeutian Pass study and GLOBEC GOA	O
NMFS/NMML	Monitoring surveys branding food habits	O
NMFS/ RACE/REFM	Fish stock assessment	O
NMFS/NMML	SSL genetics	O
NMFS/NMML	Seasonality of prey availability in regions of contrasting SSL abundance & trends	O
NMFS/NMML	Killer whale studies - Southeast AK	O
NMFS/ NMML	Steller sea lions in Oregon	N
NMFS/ NMML	Predation of SSL pups by sleeper sharks around rookeries	N
NMFS/ NMML	IBM of SSL foraging behavior & energetics	N
NMFS/ SWFSC/ABL	Large format aerial photogrammetry of SSL rookeries	N
NMFS/ABL	Shark biology & tagging studies	N
NMFS/ABL	Shark stock assessment (in 02)	N
NMFS/ABL	Contaminants in SSL	N
NMFS/ NMML	Historical subsistence use	N
NMFS/ NMML	Killer whale studies - Kodiak to Seguam	N
NMFS/NMML	Retrospective analysis of killer whale sightings during past surveys	N
NMFS/ RACE/REFM	Walleye pollock fishery interactions	N
NMFS/ RACE/REFM	Efficacy of trawl fishery exclusion zones in maintaining prey availability: Atka mackerel tagging in the Aleutians	N
NMFS/	Cod pot before/after study	N

Organization/ Institution	Study description/title	Ongoing (O)/ New & Proposed (N)
RACE/REFM		
NMFS/ RACE/REFM	Archival tag work with Pacific cod	N
NMFS/ RACE/REFM	International Young Gadoid Pelagic Trawl	N
NMFS/ RACE/REFM	Temporal and spatial patterns of pelagic fish in the GOA	N
NMFS/ RACE/REFM	Retrospective analysis of ichthyoplankton data from the GOA & BS	N
NMFS/ RACE/REFM	Climate variability, front dynamics & zooplankton availability: what determines forage fish abundance around rookeries	N
NMFS/ RACE/REFM	Winter groundfish surveys	N
NMFS/ RACE/REFM	Economic impacts of SSL protection measures	N
NMFS/ RACE/REFM	Steller sea lion diseases	N
NMFS-SSLRI	University of St. Andrews: Implications of varying food distribution for fitness of SSL	N
NMFS-SSLRI	Mystic Aquarium: Investigation of vitamin A and E status in SSL: Contribution to nutritional stress in declining populations	N
NMFS-SSLRI	Native Village of Perryville: Collection of traditional knowledge on SSL	N
NMFS-SSLRI	NPUMMRC: Bioenergetics studies of captive SSL	N
NMFS-SSLRI	NPUMMRC: SSL diet quantification studies	N
NMFS-SSLRI	NPUMMRC: Killer whale predation on SSL in western AK	N
NMFS-SSLRI	NPUMMRC: Remote passive acoustic monitoring of killer whales	N
NMFS-SSLRI	University of Alaska, Southeast: Investigations of SSL predation by killer whales in Southeast Alaska	N
NMFS-SSLRI	Alaskan Sea Otter and SSL Commission: Traditional knowledge of SSL and community-based monitoring of local seasonal haulouts	N
NMFS-SSLRI	Aleut Community of St. Paul: Subsistence harvest monitoring of SSL on St. Paul Island, Alaska	N
NMFS-SSLRI	University of Alaska, Anchorage: High-resolution foraging behavior and movement patterns of SSL juvelines in regions of increase and decline	N
NMFS-SSLRI	University of Alaska, Fairbanks: Comparison of prey availability and ecology in SSL foraging regions: a coordinated aerial remote sensing study	N
NMFS-SSLRI	University of Alaska, Fairbanks: Fish assemblages associated with sea lion haul-outs	N
NMFS-SSLRI	University of Alaska, Fairbanks: Geographical ecology of SSL and ephemeral, high-quality prey spp in SE AK	N
NMFS-SSLRI	University of Alaska, Fairbanks: Seasonal forage patterns of Steller sea lions	N
NMFS-SSLRI	University of Washington: Nutritional significance of ephereral, high-quality foraging opportunities for SSL	N

Organization/ Institution	Study description/title	Ongoing (O)/ New & Proposed (N)
NMFS-SSLRI	University of Washington: Assessment of fine-scaled interactions between SSL abundance and trends of local fisheries	N
NMFS-SSLRI	Texas A&M: Installation of a remote census & photogrammetry network: validation & assessment of seasonal and indivdiual SSL body condition & population trends	N
NMFS-SSLRI	Texas A&M: Satellite-linked mortality transmitters in SSL: assessing the effects of health status, foraging ability, and environmental variability on juvenile survival and population trends	N
NMFS-SSLRI	Texas A&M: Linking animal-borne data recorders to autonomous remote imaging systems	N
NMFS-SSLRI	Texas A&M: Foraging ecology and hunting behavior of adult and juvenile Steller sea lions	N
NMFS-SSLRI	University of Washington: Acoustic characterization of Steller sea lion forage species	N
NMFS-SSLRI	Aleutians East Borough: Assessing population trends and dietary intake of SSL populations along the western AK Peninsula and eastern Aleutians	N
NMFS-SSLRI	Yale University: Metal toxicity in SSL tissues and cell lines	N
NMFS-SSLRI	University of California: Early and late pregnancy rates of AK SSL and examination of the role of maternal condition	N
NMFS-SSLRI	State of Alaska: Coastal bathymetry within the range of SSL in Alaska	N
NMFS-SSLRI	Colorado State University: Study to evaluate transmitter implant methodology	N
NMFS-SSLRI	State of Alaska: Improving access to ADF&G's lower Cook Inlet Pacific herring stock assessment and commercial fishery databases, including observations of SSL	N
NMFS-SSLRI	State of Alaska: The subsistence harvest of sea lions and harbor seals by Alaska Natives. Harvest Assessment Program, 2001	N
NMFS-SSLRI	Prince William Sound Science Center: Estimates of changes in the foraging behavior of Steller sea lions in response to precipitous declines of the herring popualtion in Prince William Sound	N
NMFS-SSLRI	State of Alaska: Interaction of SSL and fisheries managed by the State of Alaska	N
NMFS-SSLRI	Bristol Bay Native Association: Identify Steller sea lion rookeries; gathering traditional ecological information on Steller sea lions from Perryville, Alaska	N
ADF&G	Identification of sensitive life history stages of SSL, ability to monitor changes in body condition, PTT deployments	O
ADF&G	Collection of SSL vital statistics in collaboration with NMML	O
ADF&G	Modeling population responses of SSL to incidental take	O
ADF&G	Surveys of blood borne disease	O
ADF&G	Measurment of contaminants of SSL tissues	O
ADF&G	PWS Cook Inlet and Kodiak bottom trawl surveys	O

Organization/ Institution	Study description/title	Ongoing (O)/ New & Proposed (N)
ADF&G/ PWSSC	PWS hydroacoustic pollock survey collaboration with PWSSC	O
ADF&G	SE Alaska herring assessment	O
ADF&G	Salmon enumeration	O
ADF&G	Evaluate SSL movement patterns to assess habitat use and dispersal	N
ADF&G	Describe ontogeny of diving behavior & nutritional independence in juvenile SSL	N
ADF&G	Evaluation of nutritional limitation in juvenile SSL in the western Alaska population	N
ADF&G	Estimation of survival and natality rates of Alaska SSL	N
ADF&G	Investigation of sea lion contaminant loads & disease screening	N
ADF&G	Development of long-term instrument attachments for SSL	N
UAF	Kodiak seasonal diets of SSL	O
UAF	Kodiak seasonal prey availability for SSL	O
UAF	Kodiak seasonal prey quality for SSL	O
UAF	Kodiak diet of SSL competitors	O
UAF	Kodiak killer whale and shark diets	O
UAF	Assess role of potential sea lion competitors	O
UAF	Kodiak seasonal counts of SSL	O
UAF	Gulf Apex Predator-Prey study (not clear how this overlaps with the ongoing studies)	N
NPUMMRC	Bioenergetics of SSL	O
NPUMMRC	Bias in scat analysis	O
NPUMMRC	New technologies implantable VHF	O
NPUMMRC	Effects of Atka mackerel and SSL condition	O
NPUMMRC/ ADF&G	SSL scat collection and diet studies in SE Alaska	O
NPUMMRC	Bioenergetic modeling of SSL	O
NPUMMRC	Timing of molt	O
NPUMMRC	Killer whale predation model	O
NPUMMRC	Pribilof Is. & Kodiak Is. monitoring subsistence harvest	O

Organization/ Institution	Study description/title	Ongoing (O)/ New & Proposed (N)
NPUMMRC	Long-term variability in forage fish abundance	O
NPUMMRC	Trends in diet and population of SSL in Oregon	O
NPUMMRC	Monitoring diet and demographics of SSL in Washington State	O
NPUMMRC	Evaluation of blubber fatty acid diet analyses	N
NPUMMRC	Fatty pollock: nutritional effects of fat & lean fish	N
NPUMMRC	SSL - shark interactions	N
NPUMMRC	PVA for SSL	N
NPUMMRC	Effects of climate variability and fish size	N
NPUMMRC	A review of the nutritional stress hypothesis in seabirds & SSL	N
NPUMMRC	An investigation into the use of bone marrow	N
NPUMMRC	Body growth and feeding rates	N
NPUMMRC	Leptin, reproductive cycles	N
NPUMMRC	Satiation in young SSL	N
NPUMMRC	Foraging Behavior of Juvenile SSL	N
ASLC	Feeding and metabolic studies on captive animals and diet analysis of wild animals. Inhouse studies and RFP	O
ASLC	Remote video cameras and branding/monitoring in collaboration with NMML.	O
ASLC	Capture and short-term holding of SSL. Collection of pups	O
ASLC	Endocrine and immune function, RFP or contract for a portion of this work.	O
ASLC	Chiswell Is. seasonal prey availability for SSL	O
ASLC	Chiswell Is. Shark predation studies	O
ASLC	Reproductive biology of SSL and effects of disease in collaboration with NMML	O
ASLC	Kuril Islands survey in Russia	O
ASLC	Investigation of an increasing SSL rookery in Russia	O
ASLC	Innovations in remotely moniotring SSL	O
ASLC	Assess sea lion reproductive failure in the eastern GOA	O

Organization/ Institution	Study description/title	Ongoing (O)/ New & Proposed (N)
ASLC	New technologies for implants and instrumentation	O
ASLC	A final list of new projects conducted by ASLC was not available as of 5/10/01	N
OAR/NOS	CIFAR: Impacts of climate change on the Bering Sea Ecosystem over the past 500 years	N
OAR/NOS	CIFAR: Retrospective studies of climate impacts on Alaska SSL	N
OAR/NOS	CIFAR: The nature of North Pacific regime shifts and their impact on SSL	N
OAR/NOS	CIFAR: Ocean climate variability as a potential influence on SSL populations	N
OAR/NOS	CIFAR: North Pacific climate variability and SSL ecology: a retrospective and modeling view - Part one	N
OAR/NOS	CIFAR: North Pacific climate variability and SSL ecology: a retrospective and modeling view - Part two	N
OAR/NOS	CIFAR: North Pacific climate variability and SSL ecology: a restrospective and modeling view - Part 3	N
OAR/NOS	CIFAR: Interannual variability of biophysical linkages between the basin and shelf in the Bering Sea - Part 1	N
OAR/NOS	CIFAR: Interannual variability of biophysical linkages between the basin and shelf in the Bering Sea - Part 2	N
OAR/NOS	CIFAR: Predator-prey investigations of killer whales and SSL in Alaska	N
OAR/NOS	CIFAR: The role of physiological constraint in the acquisition of foraging ability: development of diving capacity in juvenile SSL	N
OAR/NOS	CIFAR: Seasonal assessment of prey competition between SSL and walleye pollock	N
OAR/NOS	CIFAR: Investigation of foraging behavior of SSL in the vicinity of Kodaik Island, AK	N
OAR/NOS	CIFAR: Addressing scientific and coastal community informational needs relating to SSL	N
OAR/NOS	CIFAR: Climate-driven bottom-up processes and killer whale abundance as factors in SSL population trends in the Aleutian Islands - Part 1	N
OAR/NOS	CIFAR: Climate-driven bottom-up processes and killer whale abundance as factors in SSL population trends in the Aleutian Islands - Part 2	N
OAR/PMEL	Investigate relationships between North Pacific Ocean climate and Steller sea lions	N
NPFMC	National Academy of Science BiOp review	N
NPFMC	National Academy of Science abbreviated BiOp review	N
NPFMC	Support additional meetings re. SSL/groundfish fisheries	N

3.6.2 Future Research Programs

In response to the need for additional information on the cause of the Steller sea lion decline, Congress appropriate significant new funds in FY01 for research related to Steller sea lions (Table 3.5). Most research projects funded using these monies will start in FY02. Organizations and agencies which received increases in funds (e.g. NMFS, ADF&G, ALSC) will be using those funds to expand their research efforts; some of these are highlighted in section 3.7.3. The following provides a summary of two major new research programs funded by these monies.

Steller Sea Lion Research Initiative (SSLRI)

Congress appropriated $20M to fund Steller sea lion "Protective Measures" in FY01. These funds were provided to the Department of Commerce, which delegated the implementation of this program to NOAA/NMFS. In order to allocate the funds, NMFS established a competitive grants process, the Steller Sea Lion Research Initiative (SSLRI). A Federal Register notice announcing the availability of funds was published on 21 March 2001 (66 FR 15842), 74 research proposals were submitted, and 32 projects were selected for funding. These projects include research on forage fish species near haulout sites, the determination of the extent of killer whale predation on Steller sea lions, Steller sea lion physiology, and the application of new technologies to study Steller sea lions. Funded organizations included the NPUMMRC, the University of Alaska, Fairbanks, Texas A&M University, the University of Washington, the Aleutians East Borough, and the Alaska Department of Fish and Game. Most research projects supported by SSLRI are 2-3 year projects which will begin their field research in 2002.

Table 3.6. Summary of Congressionally designated funds for Steller sea lion research and recovery in FY02.

Recipient	**FY01 Appropriation**
NMFS - Steller sea lion recovery	$7M
NMFS - Endangered Species Act	$850K
DOC/NOAA/NMFS/External - Protective Measures	$20K
Oceanic and Atmospheric Research	$6M
NPFMC - Independent Analysis	$2M
ADF&G - Steller Recovery	$1M
NPUMMRC - Steller recovery	$800K
UAF - Steller recovery	$800K
Alaska SeaLife Center - Steller Recovery	$1M (+ $5M from the Protective Measures appropriation)
TOTAL	$43.15M

Cooperative Institute for Arctic Research (CIFAR)

Congress appropriated $8M for the National Ocean Service (NOS) and Office of Oceanic and Atmospheric Research (OAR) combined, of which $1.8M and $2M was earmarked for CIFAR from NOS and OAR, respectively. These funds were allocated via a competitive grants process to projects designed to study either ocean climate variability, with an emphasis on its impacts on marine mammal abundance, or relationships between Steller sea lions and their potential predators. The majority of the successful projects involve either modeling or field work to examine the impacts of climate change on the ecosystem.

Coordination of Research Programs

One of the challenges now faced by NMFS, the ADF&G, and the other endowed agencies/organizations is coordination of the multitudes of Steller sea lion research projects and communication between researchers. As the overall, interagency and inter-organizational Steller sea lion research program has been greatly expanded, it will be increasingly important to

1. ensure that research is directed at addressing the most important management and scientific questions,
2. facilitate communication between researchers and agencies/organizations,
3. ensure that new research projects are logically related to the results of the previous research projects, and
4. ensure that research is not duplicative.

In order to meet these challenges, the NMFS Alaska Fisheries Science Center has recently appointed a Steller Sea Lion Research Coordinator. Although the role of this individual is still evolving, the hope is that this individual will serve as the point person for all communication and coordination regarding Steller sea lion research.

3.6.3 Expectations for Information from New Research Programs

It is not possible to speculate on the precise results which will be produced by the large number of research programs. However, some generalizations can be made about the types of information which will be collected over the next few years. The expectations for all studies are not discussed here, instead this section focuses on those studies which provide information which address some of the most immediate and critical information deficits.

<u>Age-specific demographic rates</u>
The most recent estimates of age-specific demographic rates available for the Steller sea lion population are from the 1970's; thus, new information on survival and fecundity is urgently needed. Substantial new information on age-specific survival and reproductive rates is expected to be available within the next 5 years. This new information will be the result of several different studies which were initiated in 2000 or 2001, or will be initiated in 2002.

- NMML researchers renewed efforts to brand Steller sea lions in 2000, and started brand-resight efforts in 2001. This will allow researchers to individually identify animals and estimate age-specific survival rates, age at first reproduction, and birth interval. Some information on juvenile survival should be available within the next year or two; information on age of first reproduction will be forthcoming in 4-5 years. Because branding and resight efforts will be carried out at several locations, comparisons of demographic rates between sites will be possible and are likely to be highly instructive.
- Texas A&M University-Galveston has received funding through the SSLRI program to pursue the development, testing, and deployment (provided the testing goes well and the necessary permits can be obtained) of a “mortality tag”. These tags would be implanted under the skin of healthy Steller sea lions. When the sea lion dies, the tag would be released, and would send a signal to a satellite that the animal has died. This will provide substantial new information on mortality rates, such as the location and date of death, that cannot be collected using brand/resight data. Although this research will be initiated in 2001, because of the extensive testing required before the technique can be used with Steller sea lions, it is likely to be 3-5 years before results are available.
- The University of California, funded via the SSLRI, will be carrying out a project designed to examine pregnancy status of Steller sea lions in an increasing and decreasing subpopulations. If successful, this research will provide a

Foraging behavior and health assessments of non-pup juvenile Steller sea lions

Historically, the majority of data on Steller sea lion movements and physiology have been collected from lactating adult female Steller sea lions and pups because 1) it has been hypothesized that these were the stage classes most vulnerable to nutritional stress and 2) they are easier to capture than other stage classes. Since 1998, a new method involving at-sea capture has been utilized by NMFS and ADF&G. This capture technique allows researchers to capture juvenile Steller sea lions which are 2-3 years old. Once captured, satellite-linked time-depth recorders are placed on the animals to determine diving abilities and habitat use, and tissue and blood samples are taken to determine health status/body condition. The results of these studies on 2-3 year old Steller sea lions will be available in the near future. Another new method, which involves capturing and holding juvenile Steller sea lions for brief periods, was implemented by the Alaska SeaLife Center in 2001.

Impacts of predation on Steller sea lions

There are several new studies supported by CIFAR, SSLRI, NMFS, and OAR which will improve our understanding of the impacts of predation on Steller sea lions. From 2001-2003, dedicated surveys for killer whales will be extended into the western Gulf of Alaska and Bering Sea for the first time since the early 1990s. These projects should greatly improve our knowledge of the abundance of killer whales in the areas where Steller sea lions are declining, and should provide an indication of the number of transient versus resident killer whales in the area. In addition, these surveys will provide new information on the numbers of Steller sea lions eaten by transient killer whales in this area. However, predation events are rarely observed: a 12-year study resulted in the observations of only 31 documented kills (2.4 kills/year) and 43 “harassments of potential prey” (3.6 harassments/year; Saulitas et al. 2000). In addition, Saulitas et al. point out that different pods may specialize and only predate on certain prey species. Thus, because of the low probability that many predation events will be observed in any one year, and because there may be pod-specific predation behavior which may be difficult to determine during a 3-year study, it may be optimistic to assume that vessel surveys will result in a precise estimate of killer whale predation on Steller sea lions. Analysis of fatty acids in killer whale blubber (collected from stranded animals or using a biopsy technique) may provide an alternate method of determining whether Steller sea lions are a significant prey species.

The pilot study on shark predation on Steller sea lions planned by NMFS Auke Bay Laboratory (Hulbert et al., 2001) will occur where high concentrations of sleeper sharks are located near major Steller sea lion rookeries during seasons when the Steller sea lions are most vulnerable to predation. Provided sufficient sharks are captured during the study, this project should be able to determine whether sleeper sharks are a major predator of sea lions in this particular area. Should sleeper sharks be found to have a major impact on the Steller sea lion population in this area, additional studies would have to be undertaken in order to understand the impacts to the population as a whole.

Comparison of prey availability in regions of contrasting Steller sea lion abundance trends: Gulf Apex Predator and Southeast Alaska projects

The Gulf Apex Predator study at Kodiak Island (an area where Steller sea lions are declining at > 5% per year) was initiated by the University of Alaska-Fairbanks in 1999. The goals of this study are to assess the seasonal abundance and distribution of Steller sea lions, to determine seasonal diet, and simultaneously to determine the seasonal and spatial distribution of prey species near 5 critical haulout sites on the eastern side of Kodiak Island, in order to compare the seasonal use of prey to availability of prey near these haulout sites. A new study in Southeast Alaska was initiated by NMFS, in conjunction with the University of Alaska and the ADF&G, in 2001. This study is designed to mimic the University of Alaska’s GAP project, and will provide data on an increasing population of Steller sea lions, and will provide a valuable contrast to the GAP project.

4 ENVIRONMENTAL BASELINE

The purpose of this section is to identify "the past and present effects of all federal, State, or private activities in the action area, the anticipated effects of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the effect of State or private actions which are contemporaneous with the consultation in process" (50 CFR §402.02, definition of "effects of the action"). These factors affect the species' environment or critical habitat in the action area. The factors are described in relation to the action area biological requirements of the species.

4.1 Description of the Action Area

The action area relative to the two populations of Steller sea lions is the part of their habitat that is affected by fisheries authorized by NMFS for pollock, Pacific cod, and Atka mackerel as described in Section 2.2 of this document and Section 2.0 of the SEIS.

4.2 Biological Requirements In the Action Area

To some degree, each of the two populations of Steller sea lions considered in this opinion reside in, migrate through, or forage in the action area. Biological requirements during these life history stages are obtained through the essential features of critical habitat. Essential features include adequate 1) haulout and rookery sites, 2) food, 3) water quality, and 4) freedom from disturbance.

4.2.1 Essential Features of Critical Habitat

The sections below describe essential features of critical habitat for each of the relevant habitat types: 1) haulout and pupping areas, 2) pregnant or lactating female foraging areas, 3) juvenile foraging areas, 4) adult foraging areas, and 5) transit areas.

4.2.1.1 Haulout and Pupping Areas

As described in Section 3.2.3, terrestrial sites for pupping and hauling out are located throughout the Alaskan shoreline (Figure 3.1). In general, there has been little disturbance to these sites other than current research programs, and some construction activities near a few sites. A few sites have viewing platforms built near them in order to allow research without disturbing the animals, and other sites have remote video cameras placed near them to view sea lions throughout the year.

4.2.1.2 Foraging Areas for Pregnant or Lactating Females

Pregnant or lactating females are generally thought to stay close to rookeries and haulouts and are more susceptible to limited prey resources because of their inability to range widely (i.e., they need to return to their pup within a limited period of time). Studies by Merrick *et al.* (1994), Merrick and Loughlin (1997), Loughlin *et al.* (1998) and Merrick *et al.* (1990) showed that during the breeding season adult female Steller sea lions generally spent about half their time at sea on relatively brief foraging trips (18-20 hours). Observations during winter showed that females with suckling yearlings had feeding trips of about 2.3 days while those with pups of the year had much shorter trips lasting only 0.9 days (Loughlin *et al.* unpublished).

4.2.1.3 Juvenile Foraging Areas

Juvenile sea lions are the group considered to be most susceptible to limited prey resources. They are not only limited to the horizontal swimming distances, but they are limited divers, and don't have the experience to find prey that the adults have. Recent research has focused on juvenile foraging ecology and has begun to yield results which are presented in Loughlin *et al.* (unpublished) and ADF&G and NMFS (2001). Preliminary data suggest that the areas close to rookeries and haulouts are most important for juvenile sea lions. However, juveniles are known to travel long distances on foraging trips, however, the vast majority of at-sea locations collected from instrumented animals is within 10 nm from shore (for pre-breeding age sea lions, about 93.8% of the at-sea locations were within 10 nm of land, only 2.2% were in the 10-20 nm zone, and only 4% was outside of critical habitat [Loughlin *et al.* unpublished], and 58.2% in summer and 89.4% in winter based on a modified database from ADF&G and NMFS [2001]).

4.2.1.4 Adult Foraging Areas

Adults, especially males, range widely and are the least likely group to be impacted by limited prey resources because of their ability to travel and locate prey patches. They are experienced foragers and adept divers. Very few adult males have been tagged due to the difficulty in safely apprehending the large animals (e.g., safe for the sea lion and safe for the research staff). Thus, the Platforms of Opportunity (POP) database, which contains records of opportunistic Steller sea lion sightings, may best reflect the foraging distribution of adult animals. Adult Steller sea lions have been sighted over a widespread extent of the BSAI and GOA areas, including the shelf breaks (Figure 4.1; in the SEIS, Figure 3.1-6 shows sightings back to the origin of the POP database in 1958). Because this group is the least likely to be affected by competition and is unlikely to be a substantial factor in the decline, research has not focused on these animals.

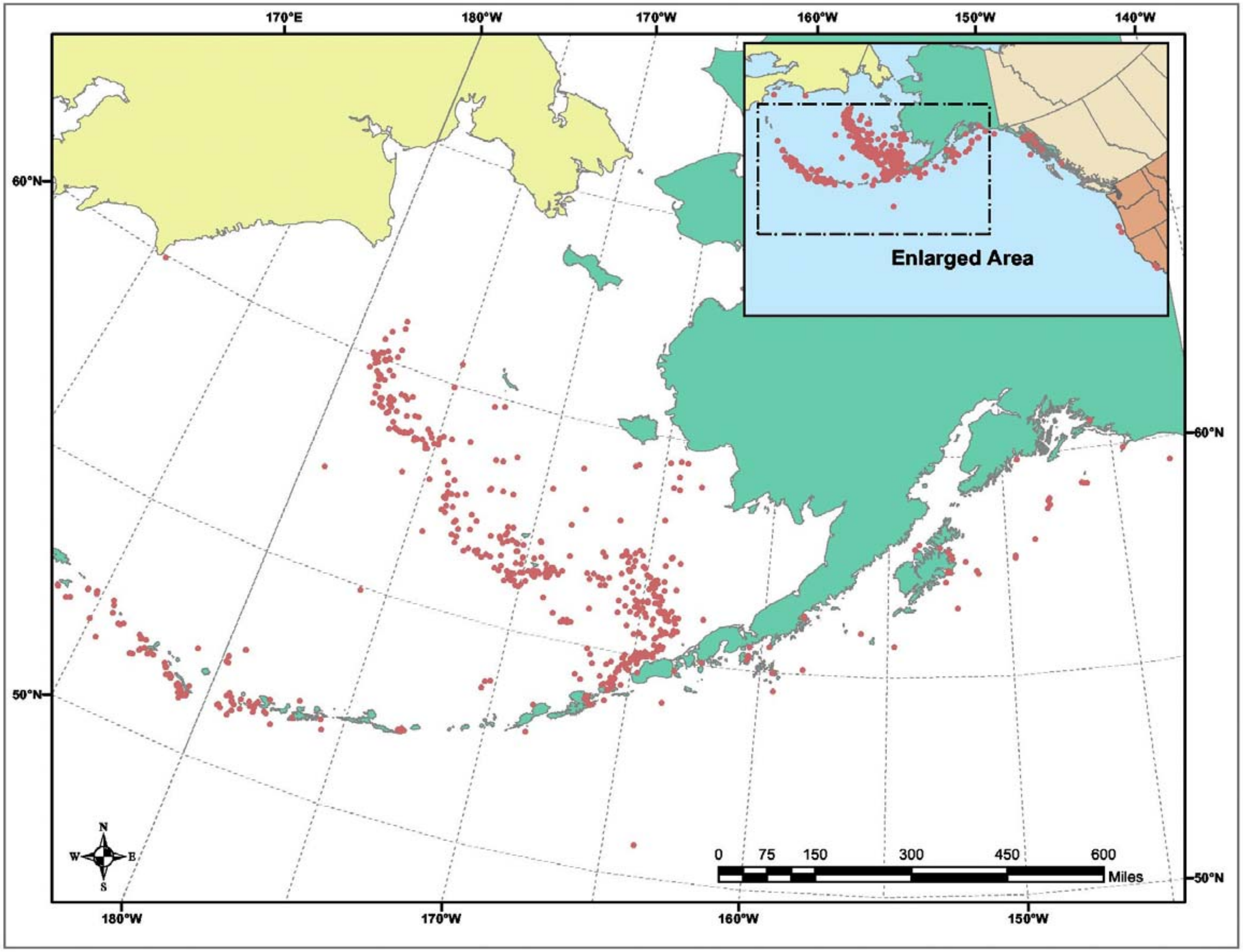

Figure 4.1. Sighting locations for Steller sea lions in the BSAI and the GOA based on data from the Platforms-of-Opportunity Program, 1990-1997.

4.2.1.5 Transit Routes

Sea lions are known to migrate long distances, possibly in search of prey or mating areas. These trips are often destination oriented and they don't appear to do a lot of foraging on the way (Loughlin *et al.* unpublished, ADF&G and NMFS 2001). Prey resources are not likely to be important on these bouts and disturbance from vessels and other predators such as orcas is probably their most likely difficulties.

4.2.2 Adequacy of Essential Features of Critical Habitat

The most essential feature of critical habitat is the prey resources contained therein. NMFS conducts groundfish surveys throughout the BSAI and GOA which are essential for the groundfish stock assessment process. However, they were never intended to provide information on the availability of prey for marine mammals. In other words, we have excellent information on the status of prey species throughout broad regions, but we have little information on the amount of biomass in critical habitat at various times of the year (e.g., winter vs. summer, or the proportion within 10 nm, or from 10 nm to 20 nm). NMFS has attempted to look at the ratio of biomass available to biomass consumed by Steller sea lions (see the FMP biological opinion). The availability of Steller sea lion prey can be roughly estimated but there are no data to determine an appropriate forage to biomass ratio for a healthy population of sea lions. The inability to quantify confounding variables such as benthic terrain complexity and the catchability of the fish further limits our ability to quantify ratios of prey availability. Further discussion of biomass ratios is presented in Section 5 of this document.

In the FMP level biological opinion, the limitations of the groundfish surveys were noted. Since the completion of that document, NMFS has begun a series of groundfish surveys in the winter and summer designed to be more amenable to determining the amount of biomass inside critical habitat. NMFS has also begun a number of reasonably large scale prey availability experiments for pollock and Atka mackerel and are planning further studies for Pacific cod.

To determine the effects of commercial fishing activity on the availability of walleye pollock as prey for Steller sea lions, studies have been initiated by researchers at the Alaska Fishery Science Center and the University of Washington. A feasibility study was conducted off the east side of Kodiak Island in August of 2000 to test and establish the methodology, experimental design, and sites to be used in subsequent years of the study. Two adjacent sites with similar bathymetry were selected for a treatment site (commercial fishing activities are allowed) and a control site (commercial fishing is prohibited). The survey design employed echo integration trawling (EIT) from midwater and bottom trawls during both daylight and dark hours. This sampling resulted in the collection of echo integration data for determining fish density and catch data from concurrent trawl hauls to determine the species and age composition of fish corresponding to the various acoustic echosigns. Conductivity, temperature, and depth data were also collected at all trawl locations.

Results from the 2000 feasibility study showed that adult pollock were twice as abundant in the treatment site as compared to the control site and that adult pollock were found at similar depths in both gullies (12 m and 20 m, respectively). Though adult pollock abundance was greater in the treatment site, there were virtually no age 1 pollock in the gully. Diel comparisons revealed that adult pollock did not display diel vertical migration and remained within 30 m of the bottom. Echosigns of juvenile pollock were often indistinguishable from other similar sized fish during the night and thus, no conclusions were drawn regarding their diel migrations (Hollowed *et al.* unpublished).

The feasibility study dispelled doubts about the use of EIT to detect adult pollock in the summer and validated the use of the two gullies selected in this study as treatment and control sites over the next three years. Subsequent years will employ a similar sampling design with added sampling before and after the fishing season. The duration of the study (3 years) and the collection and analysis of physical oceanographic data are expected to account for and separate interannual variability due to natural shifts in ocean conditions from variations in the species' age composition which may influence pollock's response to fishing activities. This project will involve coordination with the National Marine Mammal Lab in an effort to understand the linkage between changes in pollock abundance and distribution and Steller sea lion foraging efficiency.

Another research project currently underway is using Atka mackerel mark and recapture data to develop a tag model which will be used to determine the impact of fishing on the localized abundance and distribution of mackerel inside and outside of trawl exclusion zones around Steller sea lion rookeries and haulouts. The mark and recapture phase of the study has been completed. In August of 1999 and again in July - August of 2000, 2,340 and 8,733 Atka mackerel, respectively, were tagged with spaghetti tags and released in the Seguam Pass area of the Aleutian Islands. All fish were released in the same area they were captured with the exception of the fish from one haul which were caught in the opened area and released into the closed area. Recovery effort supplied by the fishery outside of the trawl exclusion zone and from a chartered recovery cruise inside the closed area (in 2000) resulted in the recovery of 104 tags from 1999 and 78 tags from 2000. Most of the Atka mackerel were recovered within 25 km of their release location and only eight of the fish recovered had moved between the opened and closed areas (not including the fish that were released into the area where they were not caught). The data suggest that Atka mackerel aggregations in the open and closed areas may have little exchange between them at time periods of less than 50 days in the mid to late summer (Fritz *et al.* unpublished manuscript). Expected outcomes of the tag model are quantitative estimates of Atka mackerel population sizes in the open and closed areas and movement rates between the areas.

Though studies have recently commenced, NMFS currently has no reliable method for quantitatively determining the adequacy of forage in critical habitat for Steller sea lions, and there is no clear guidance in the current Steller sea lion recovery plan for us to use in this evaluation. Therefore, we will qualitatively describe areas of concern and how those areas are likely to be affected by fisheries, environmental change, and various other factors.

4.3 Overview of the Decline of the Steller Sea Lion

Throughout their entire breeding range, Steller sea lions have declined by over 50 percent since the 1960s (Loughlin *et al.* 1992). Prior to the 1990s both the eastern and western stocks of Steller sea lions were declining. The majority of the declines occurred in the western stock where the population of Steller sea lions from 1956-1960 was estimated to be approximately 140,000 animals throughout the Aleutians and Gulf of Alaska (Merrick 1987). By 1998, Steller sea lion abundance in this area was estimated to have declined to 39,031 animals (Ferrero et al. 2000). The decline was first observed in the eastern Aleutians (Braham *et al.* 1980) in the early 1970s and spread throughout the Aleutians and into the Gulf of Alaska by 1985 (Merrick *et al.* 1987). Between 1985 and 1989 the rate of the decline increased, and after 1989 population declines were observed in Prince William Sound and the eastern gulf area. Currently, the eastern stock of Steller sea lions is slightly increasing in abundance (York *et al.* 1996). The western stock of Steller sea lion has been declining at an annual rate consistently around 5% since the 1990s (Strick *et al.* 1997; Sease *et al.* 1999; Sease and Loughlin 1999; Sease *et al.* 2001).

4.3.1 Phases of the Decline

Total population numbers for the western stock of Steller sea lions have dropped by over 80% since the late 1960s (Loughlin and York 2001). The population decline was steep from the 1970s through 1990 and the population declined by approximately 70% (York *et al.* 1996). In 1991 the decline decreased and stabilized at a rate around 5% per year (Loughlin and York 2001). Figure 4.2 (a schematic) illustrates the dramatic difference in the rate of decline that occurred from the 1970s to 1990 and the rate of decline that has occurred since 1991, along with possible factors for the decline. The population declined at a significantly higher rate from 1975-1985 (15.6% yr^{-1}) than it did from 1985-1990 (5.9% yr^{-1}) or from 1990 - 1994 (4.5% yr^{-1}) based on counts from Kenai-Kiska trend sites (York *et al.* 1996).

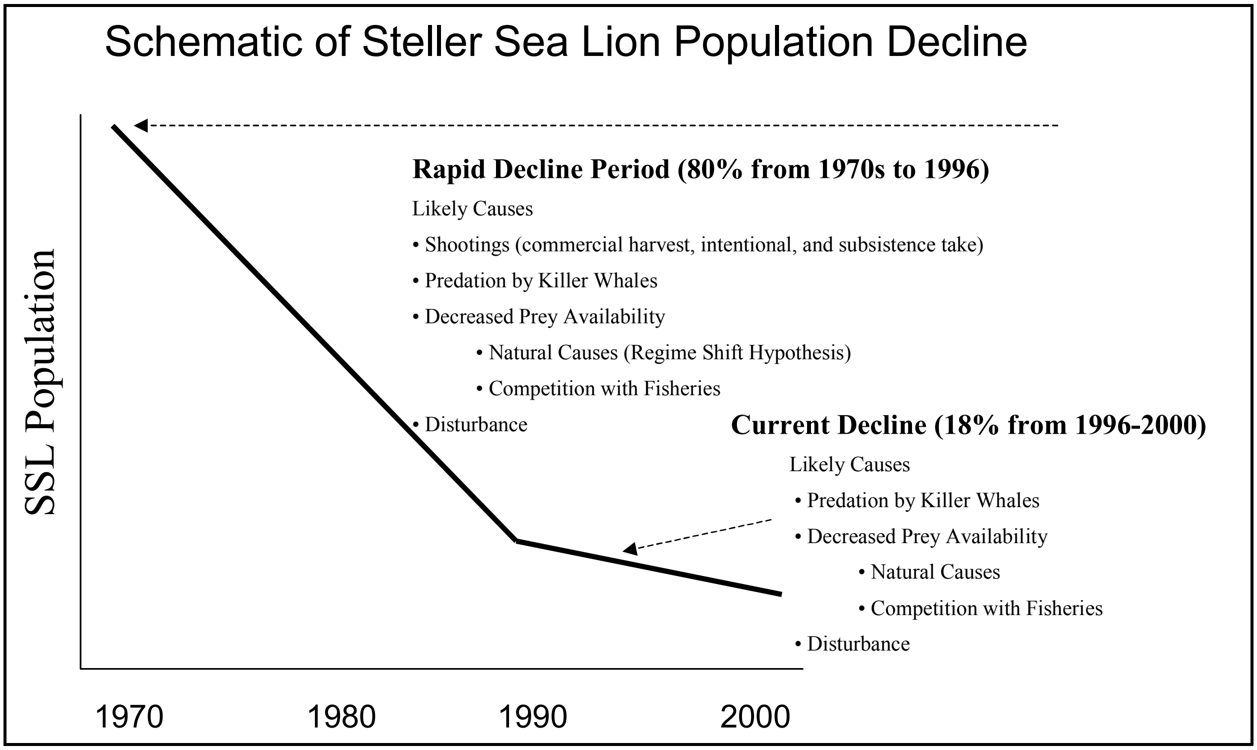

Figure 4.2. A schematic of the phases of the Steller sea lion decline and possible factors of the decline.

4.3.2 Possible Factors Contributing to the Decline

The causes of the decline of the western stock of Steller sea lion are not clearly understood, and experts agree that these causes have probably changed over time (DeMaster *et al.* 2001, Loughlin and York 2001). The marked change in the rate and spatial extent of the decline over the past decade suggests that the factors that contributed most strongly to the more rapid declines prior to the 1990s may not be the most significant factors operating today (Bowen *et al.* 2001).

Both natural and human-caused factors have been hypothesized as contributing to each phase of the decline. The causes of the decline prior to the early 1990s can be attributed to commercial harvests of sea lions, entanglement of juvenile sea lions in commercial fishing gear, intentional shooting of sea lions by fishermen, taking of sea lions in subsistence hunts and nutritional stress. Intentional shootings of Steller sea lions and entanglements with fishing gear were much more common in the past, with thousands of animals being taken each year. These factors are considered to be minor today and it is estimated that only 10-30 animals die as a result of direct interactions with fisheries each year and commercial harvests have been eliminated. Subsistence harvest of Steller sea lions continues today. Studies conducted from 1992-1999 estimated a mean harvest rate of 353 animals per year (Wolfe and Mishler 1997, Wolf and Hutchinson-Scarbrough, 1999). At this rate, Loughlin and York (2001), attributed 20 % of the current decline to subsistence harvest.

In addition to the direct taking of animals through commercial and subsistence harvests and interactions with fisheries, there is a lot of evidence that supports that sea lions were nutritionally stressed and that nutritional stress likely resulted in reductions in recruitment and reproductive rates in the first phase of the decline (DeMaster *et. al.* 2001). Comparisons of adult female body measurements and masses from three time periods, 1958, 1975-1978, and 1985-1986, showed reduced growth and an increased level of abortions in the 1980s (Calkins *et al.* 1998). Analyses of samples collected from 1975-1978 and 1985-1986 showed that in 1985: animals were smaller, maturity was later, there were fewer adult females with offspring, adult females that did have pups were older, and there were Steller sea lions with reported signs of anemia (York 1994 and Calkins and Goodwin 1998). Calkins *et al.* (1998) also noted that the harbor seal, which feeds on similar prey as Steller sea lions, declined rapidly at a major rookery in the Gulf of Alaska during the late 1970s (Pitcher 1990) indicating that changes to the prey base may have caused this sympatric species to suffer from nutritional stress. Factors such as disease and predation may have had an influence on the population during the rapid decline, but there is not sufficient information to evaluate their possible impact (NMFS 1992).

Hypotheses to explain the second phase or continued decline of the western stock of Steller sea lions include nutritional stress due to competition with fisheries for prey and/or changes in the ocean environment due to climate change and an increase in the natural predation of Steller sea lions by sharks and killer whales.

Direct evidence for the nutritional stress hypothesis in the second phase of the decline is lacking. Decreased foraging success has been linked to the diet of Steller sea lions in the 1990s, which in general, had a lower caloric density, than it did in the 1970s (DeMaster *et al.* 2001). Predators must increase the amount of prey they consume in order to receive the same energetic benefit from prey with lower caloric densities as they do from prey with higher caloric densities. The diet of Steller sea lions has shifted from one dominated by forage fish such as sandlance and herring to one that is dominated by pollock, which have a lower caloric density than the fatty forage fish. It was estimated that Steller sea lions would need to consume 56% more pollock than herring for the same net energy intake (Rosen and Trites 2000).

Environmental variability is considered to be responsible for the shift in the species composition in the Gulf of Alaska and Bering Sea/Aleutian Islands, however it is surmised that commercial fisheries reduce the local abundance of the target species over spatial and temporal scales that may be impacting the Steller sea lions' food supply. Fritz (unpublished ms.) showed that the catch per unit of effort (CPUE) for Atka mackerel declined steeply during repeated trawling over relatively short periods (3 days to 17 weeks). Estimated harvest rates of Atka mackerel ranged from 55% and 91%, suggesting that there was substantial local depletion in the exploitable biomass at least in the short term.

A reduction in the availability of prey would compromise the foraging success of Steller sea lions as the amount of time and effort spent foraging would increase. An increase in the energy spent foraging would make foraging less profitable. When coupled with a dominance of energetically less profitable prey, it can be argued that foraging success has decreased and is resulting in nutritional stress. Additional links between the diet composition and foraging success can be inferred from a diet study which found that the differences in the diets of Steller sea lions in subregions of the Gulf of Alaska and the Bering Sea/Aleutian Islands are highly correlated with the population dynamics in the temporal and spatial scales of these regions that are important to the foraging success of Steller sea lions (Sinclair and Zepplin submitted).

Body measurements taken from Steller sea lions in the western stock do not indicate that animals are suffering from nutritional stress. Measurements of girth, length, and blood chemistry parameters of lactating females from both western and eastern populations between 1993 and 1997 revealed that animals in the western population were rounder, longer, and heavier than animals in the eastern population (Castellinni unpublished data, SSL Research peer Review Physiology Workshop, Seattle, Feb, 1999). There was also no indication of nutritional stress among 238 free-ranging pups (< 1 month old) sampled from 1990-1996 in the Gulf of Alaska, the Aleutian Islands, and Southeast Alaska.

The nutritional stress theory is also weakened by a study that found no difference in the energy intake of 40 pups at 5 rookeries in the declining and stable stocks of Steller sea lions sampled from 1993-1997 (unpublished data, SSL Research peer Review Physiology Workshop, Seattle, Feb, 1999). Recent studies on adult female and pup Steller sea lions from the Gulf of Alaska showed no direct indications of disease problems or malnutrition (Merrick *et al.* 1995, Adams *et al.* 1996, Brandon *et al.* 1996, Davis *et al.* 1996, and Spraker and Bradley 1996) which fails to support the nutritional stress hypothesis.

There are indications of decreased survival among juvenile Steller sea lions in the western stock as the proportion of juveniles counted in surveys has declined in recent years (Merrick *et al.* 1988, Chumbley *et al.* 1997). Though data are insufficient to isolate nutritional stress of juveniles as the causal factor in the second phase of the decline, it remains a viable hypothesis due to the lack of contemporary data from all life stages of Steller sea lions in all seasons (ASSLRT 2001 [Final Report]).

Increased predation by killer whales and sharks has also been advanced as a hypothesis for the continued decline of Steller sea lions. The analysis of stomach contents from six "transient" (marine mammal eating) killer whales showed that Steller sea lions were contained in two of the stomachs (Matkin in DeMaster *et al.* 2001). Barrett-Lennard *et al.* (1994) suggest that 18% of all sea lion mortality could be attributed to killer whale predation, however, more data are needed to evaluate this relationship, as there are no data to estimate the number of killer whales that occur west of Kodiak Island in the GOA and BS (Matkin in DeMaster *et al.* 2001). Pacific sleeper sharks also prey on marine mammals and have increased in abundance in the Gulf of Alaska since 1996 (Hulbert *et al.* in DeMaster *et al.* 2001). It is not known if or to what extent sleeper sharks prey on Steller sea lions though studies are being designed to investigate the magnitude of sleeper shark predation on Steller sea lions by collecting samples of sleeper shark stomach contents during periods when sea lions are vulnerable to shark predation. Sleeper shark tagging studies are also being conducted to determine the vertical overlap of Steller sea lions and sharks in the water column (Hulbert *et al.* in DeMaster *et al.* 2001).

4.3.3 Lack of Sufficient Information to Determine Causal Factors in the Current Decline

The information currently available regarding the proposed hypotheses are not sufficient to determine or quantify the significance of the causal factors responsible for the continuing decline of the western stock of Steller sea lions. Though some mortality can be accounted for (i.e., incidental take from fisheries), 75% of the current decline is unexplained (DeMaster *et al.* 2001). Poor foraging success may be due to competition from fisheries and/or environmental change, however, without additional information it is not possible to determine the causal factor. Furthermore, there are uncertainties with estimates of historic groundfish biomass, Steller sea lion population estimates and foraging rates, and the effects of multiple regime shifts on sea lions' prey base. Available data are inadequate to evaluate whether nutritional stress is currently affecting Steller sea lion adults or juveniles in the winter (DeMaster *et al.* 2001). Additional information from weaned pups and juveniles from other seasons and other areas are needed to resolve uncertainties regarding the nutritional stress hypothesis. To date, studies have not linked nutritional stress with the actual decline of numbers in the 1990s and early 2000s.

Furthermore, data are lacking to estimate the magnitude of killer whale predation on Steller sea lions. There are no killer whale population estimates west of Kodiak Island and only rough estimates on the percentage of Steller sea lions in the diet of transient killer whales. Field studies were initiated in 2001 to provide the information needed to address the issue of whether killer whale predation on sea lions is an important component in causing the current decline (DeMaster *et al.* 2001).

More data are also needed to evaluate the relationship of shark predation on Steller sea lions. As with killer whales, information is needed on how many sharks occur in the range of the western stock of Steller sea lion, the fraction of the sharks' diet that is comprised of Steller sea lions and at what ages and sizes. Field studies were also initiated in 2001 to fill data gaps on the effects of shark predation on Steller sea lions (DeMaster *et al.* 2001).

Though there has been an increased effort to instrument Steller sea lions with satellite linked depth recorders, there are virtually no data on Steller sea lion movement patterns or reproductive site fidelity (Bowen *et al.* 2001).

4.4 Factors Affecting Species' Environment in the Action Area

There are many factors which may be acting to affect the environment for Steller sea lions. The following is a discussion of the leading, and sometimes competing hypotheses. All of these hypotheses were discussed at the recent workshop on the food limitation hypothesis at the Alaska SeaLife Center (DeMaster *et al.* 2001). In general, the 24 participants were divided on the leading hypothesis for the decline of the Steller sea lion. However, most participants felt that some combination of factors is most likely the cause of the continued decline, and that no one factor is likely to be responsible for the lack of recovery of the species. In this section we attempt to point out all known impacts to the environment for Steller sea lions and those factors which may be impeding their recovery.

4.4.1 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 may affect designated critical habitat as well as the likelihood that listed 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).

4.4.1.1 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 indicates that another regime shift may have occurred in the North Pacific in 1989 (Benson and Trites 2000).

4.4.1.2 Impacts on Biological Productivity and Steller Sea Lions

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.

The dietary needs of Steller sea lions are discussed in detail in Section 3.1.1. of the SEIS. From these 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. However, 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.

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).

It is reasonable that the regime shift created environmental conditions that produced very large year classes of gadids (i.e. pollock and Pacific cod). 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, relative to other forage fish 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. It is clear from physiological studies that Pollock as an energy source are less calorically dense than most forage fish. Therefore, it is likely that environmental change and the switch from a large biomass of forage species like herring and capelin to pollock and Pacific cod, has contributed to the decline of Steller sea lions. In a recent workshop at the Alaska SeaLife Center (DeMaster *et al.* 2001), 10 out of 24 participants rated environmental change as a more likely factor in the continued decline of Steller sea lions than competition with fisheries (4 out of 24 participants).

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 is likely to be partially responsible for the decline of the western population of Steller sea lions.

Therefore, NMFS concludes that the cause of the continued decline of Steller sea lions is partially a function of the regime shift. Although it is impossible with the best available scientific and commercial data to determine what magnitude of an effect climatic change has had, or whether the population of Steller sea lions may recover if environmental conditions were more favorable.

4.4.1.3 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. It is unknown today whether natural or un-natural changes in the carrying capacity of the BSAI and GOA are continuing to reduce the population of Steller sea lions. This hypothesis, as well as many other were reviewed at a recent sea lion workshop, and most of the participants stated that they did not believe that a single factors could be the cause for the current sea lion decline (DeMaster 2001), other groups have also come to this similar conclusion (ASSLRT 2001). In closing, it is unclear how much sea lions are reacting to changes in their environment through climate patterns, a regime shifts, or other unknown factors as opposed to finding a new carrying capacity based on food limitation due to anthropogenic causes.

4.4.2 Predation by Killer Whales and Sharks

4.4.2.1 Predation by Killer Whales

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 346 is reported by Forney et al. (1999). No data are reported concerning overall trends in abundance for this stock, although one well-documented transient pod (AT1) is known to have recently declined by approximately 50% (Matkin *et al.* 1999).

Forney *et al.* (1999) noted that because of lack of survey effort in some portions of this stock's range, the minimum population estimate is expected to be conservative. The Bering Sea is one area where there has been little survey effort. However, two recent manuscripts (Waite *et al.* in review, Tynan in review) report results from recent surveys in the Bering Sea. Based on surveys in 2000, Waite *et al.* (in review), estimated that there are 408 (95% CI 185-904) killer whales on the Bering Sea shelf to the east of 174° W (no killer whales were observed to the west of 174°W). Tynan (in review) provided estimates of the killer whale population based on surveys in 1997 and 1999. The estimate of 5,333 (94.5% C.V.) from the 1997 survey is unrealistically high, possibly as a result of including one sighting of 200 killer whales. The estimate of 414 (59.5% C.V.) from the 1999 surveys is similar to that reported by Waite *et al.* (in review) during the survey of roughly the same area in 2000. The majority of the sightings reported by both studies were near the Pribilof Islands or the Alaska Peninsula. A recent cruise along the Aleutian Islands during the summer of 2001 recorded 40 sightings (roughly 295 animals) of killer whales along the Aleutian Islands; concentrations of killer whales were seen near Makushin Bay (N. side of Unalaska Island), southwest of Unimak Pass, and north of Seguam (Moore, personal communication). None of the killer whales observed were near a Steller sea lion haulout, and no animals were observed foraging on

Steller sea lions. All three surveys may overestimate the abundance of killer whales, as the animals are highly mobile and there is no way to determine whether the same group was observed more than once without obtaining photographs.

If the work by Waite *et al.* (2001) and Tynan (2001), is not considered, the total number of transient killer whales with a known range overlapping that of the western stock of Steller sea lions would be 87. However, if the population size of roughly 400 estimated by Waite *et al.* (2001), Tynan (2001), and Forney *et al.* (2001) is prorated using existing information on the proportion of transient killer whales in a particular area (see Matkin *et al.* unpublished), the number of killer whales in western Alaska would be between 102-194.

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; most sightings occurred in Bristol and Kuskokwim Bays. 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, most of which occurred in areas far away from Steller sea lion haulout or rookery sites, one sighting of 4 whales near Round Island involved the chasing of a Steller sea lion. Ford *et al.* (1999) reports that Steller sea lions make up 12% of the diet of west coast transient killer whales and Saulitas *et al.* (2000) indicates that Steller sea lions make up 19% of the diet of transient killer whales in Prince William Sound. However, both estimates include known kills and harassments; if only 50% of the harassments are included as presumed kills, then the percents of Steller sea lions in the diet is reduced to 9% and 10%, respectively. Interestingly, although the vast majority of observations of transient killer whales in Prince William Sound involved AT1 pod, which is frequently seen in zones which also contain Steller sea lion rookeries and haulouts (Scheel *et al.* 2001), nearly all of the observations of Steller sea lion harassment (and presumed mortality) in Prince William Sound involved one group of killer whales, the so-called Gulf of Alaska transients, which are infrequently seen in the area. Based on this behavioral difference between groups of animals, Saulitas *et al.* (2000) suggests that individual pods of killer whales may have developed very different foraging strategies. Based on 12 years of observations of transient killer whales in the inside waters of Southeast Alaska, Dahlheim (personal communication) indicated that Steller sea lions were not a major prey item. Comparable data for waters outside Southeast Alaska, where Steller sea lions are more abundant, are not available.

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 125 transient killer whales 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.

Although 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, a simplified approach was developed to provide an approximation of the number of Steller sea lions deaths which could be attributed to killer whale. The results are similar to those reported by Barrett-Lennard *et al.* (1995). 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 4.1 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 4.1) 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 2.5% to 8%. If the population of killer whales includes a maximum of 200 animals, the estimated annual mortality rate would be between 4% and 12%. Expressed as a fraction of the crude death rate, killer whale predation could be responsible for a minimum of 20% or as much as 40% 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%.

Further information on killer whales reveals that they may have increased their dependence on other species such as sea otters (Estes *et al.* 1998, Recer 1998, Schneider 1999, Bellisle 2000, and Henderson 2000). The first observed attacks on sea otters occurred in 1991 (Estes *et al.* 1998). Since then, the sea otter population has decreased on an average of about 25% per year, presumably in response to increased predation by killer whales. This new reliance on sea otters may indicate prey switching by killer whales from traditional species such as sea lions and harbor seals.

Table 4.1 Summary of estimates of Steller sea lion (SSL) mortality caused by killer whale (KW) predation. In alternatives 1-4, it was assumed that the SSL population was fixed at 42,000 animals and the crude death rate was 20%, excluding killer whale predation. In alternative 5, the SSL population was fixed at 100,000. In alternatives 6-8, the population of killer whales was assumed to be a maximum of 200 instead of 125. All models used an underlying decline of 5% per year for SSLs in estimating the percent mortality due to killer whale predation.

	Alternative Models								
Input parameters for model	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
Amount Consumed by KW (kg/day)	74	74	74	74	74	74	74	74	
Number of Days Feeding	365	365	365	365	365	365	365	365	
Number of Killer Whales	125	125	125	125	125	200	200	200	
Weight Per SSL (kg)	160	160	160	160	160	160	160	160	
Percent of SSL in KW Diet	12.5%	10%	15%	5%	12.5%	5%	12.5%	15%	
Estimates regarding predation by killer whales									
Number of SSLs Eaten Per Year	2638	2110	3165	1055	2638	1688	4220	5064	1157 non pups (~1469 total)
Total number of SSL	42,000	42,000	42,000	42,000	100, 000	42,000	42,000	42,000	33,000 non pups
Mortality Rate = (# SSL eaten) /(total # of SSL)	6%	5%	8%	2.5%	2.6%	4%	10%	12%	3.5%
Total Proportion of Mortality Due to Killer Whales[5]	**24%**	**20%**	**27%**	**11%**	**12%**	**17%**	**33%**	**38%**	**23%**

[5] Calculated as # of SSLs eaten per year/((0.2*#SSLs) + # SSLs eaten per year)

4.4.2.2 Predation by Sharks

A second hypothesis is that the shark predation may now have a significant impact on the Steller sea lion population. Although there is no evidence that sharks consume Steller sea lions, the following may indicate that this potential does exist (DeMaster *et al.* 2001):

- There has been an increase in sleeper shark abundance in the Gulf of Alaska during the past 5 years,
- The diet of sleeper sharks includes fast-moving fish species (e.g. salmon and herring) and marine mammals (harbor seals, unidentified cetacean),
- Sleeper sharks can attain up to 25 ft in length and weight between 6000 and 8000 lbs.

Loughlin and York (2001) estimate that the incidence of shark predation is not substantial, and indicated that if they attribute 1% of the natural mortalities of Steller sea lions to shark predation, then 129 sea lion deaths per year would be attributed to sharks. At this time, there are no data available to either support or refute this assumption. However, the Auke Bay Laboratory of the National Marine Fisheries Service will be initiating shark studies near Steller sea lion rookeries in 2001 (Hulbert *et al.* 2001), so data indicating whether shark predation on Steller sea lions occurs may be forthcoming.

4.4.3 Effects of Commercial Fisheries in the Action Area

A complete historical review of commercial fisheries is provided in the FMP biological opinion (NMFS 2000). Three time periods were outlined:

1. Early commercial fisheries from the 1800s to the 1950s,
2. Large scale growth of fisheries from the 1950s to the 1970s, and
3. Commercial fisheries in the action area from the 1970s to the present.

Undoubtedly, these fisheries had adverse effects on the environment in the BSAI and GOA as pointed out in the FMP biological opinion. Historical fishing amounts are described below in Figure 4.3, and amounts in critical habitat in Figure 4.4. However, it is impossible to determine the severity and the downstream effects on sea lions and other marine mammals. The following is a general discussion of both the direct and indirect effects which are likely to have occurred as a result of commercial fisheries in the BSAI and GOA.

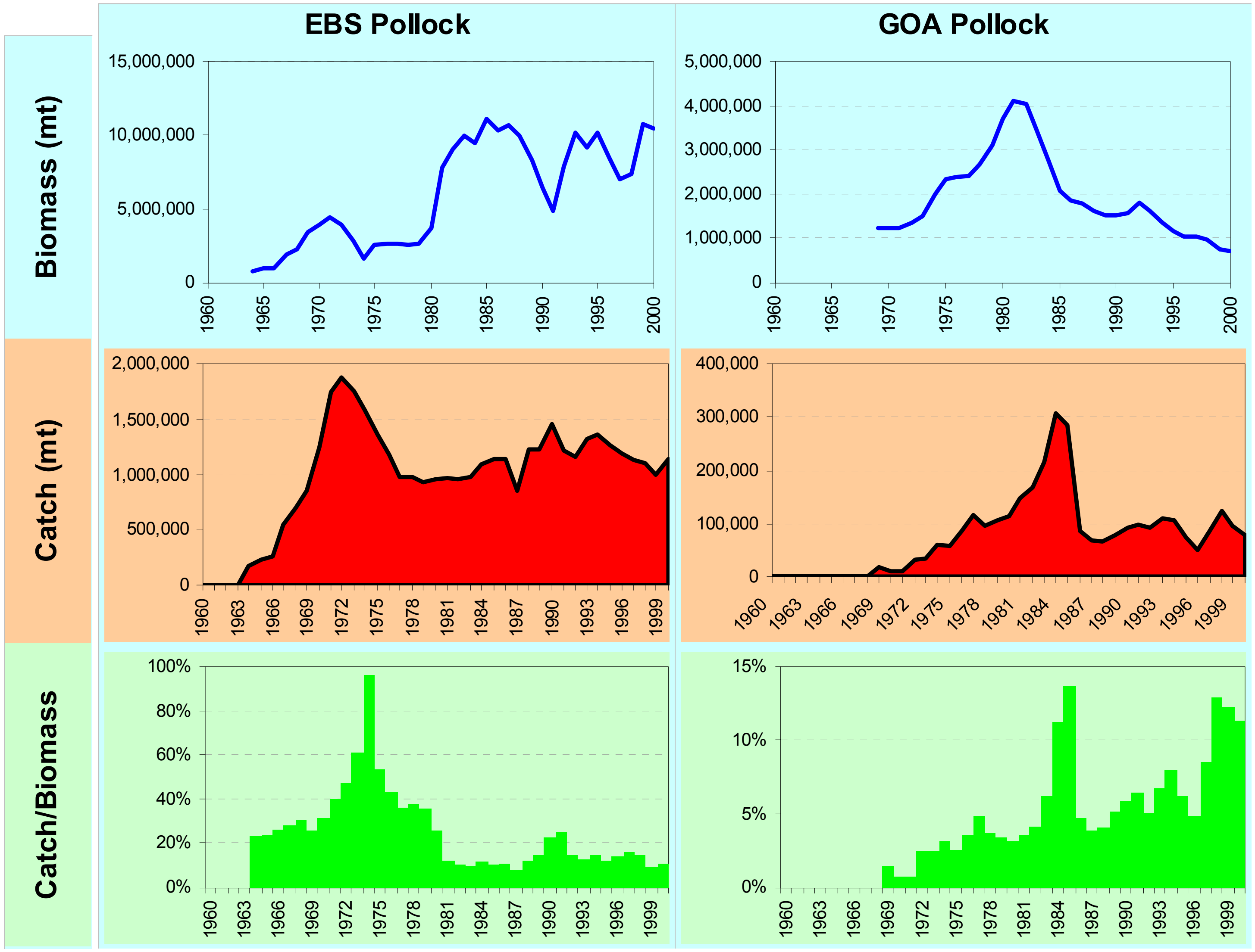

Figure 4.3. Historical catch of pollock in the Eastern Bering Sea and Gulf of Alaska 1960-2000.

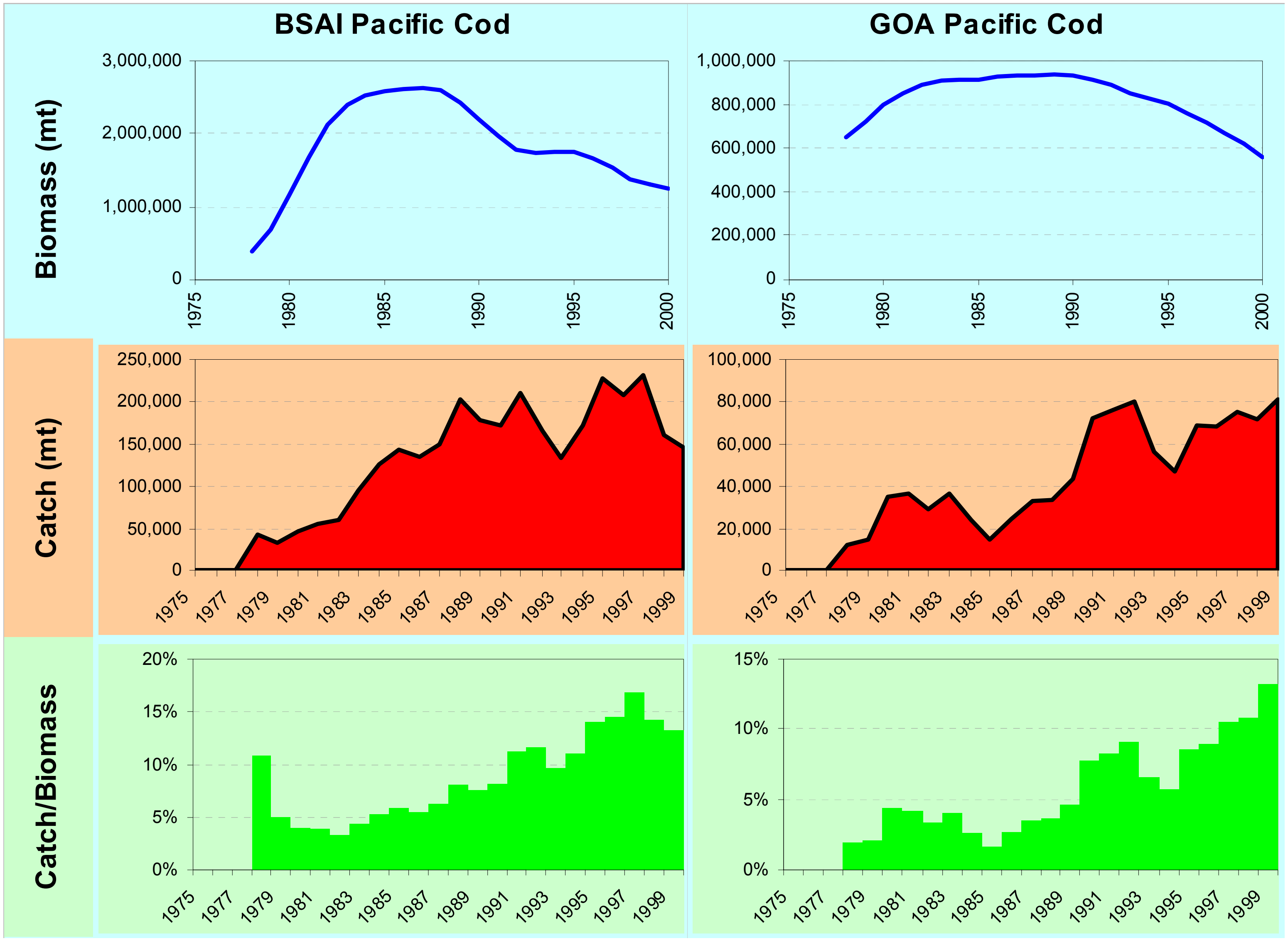

Figure 4.3. Historical catch of Pacific cod in the Eastern Bering Sea and Gulf of Alaska 1975-2000.

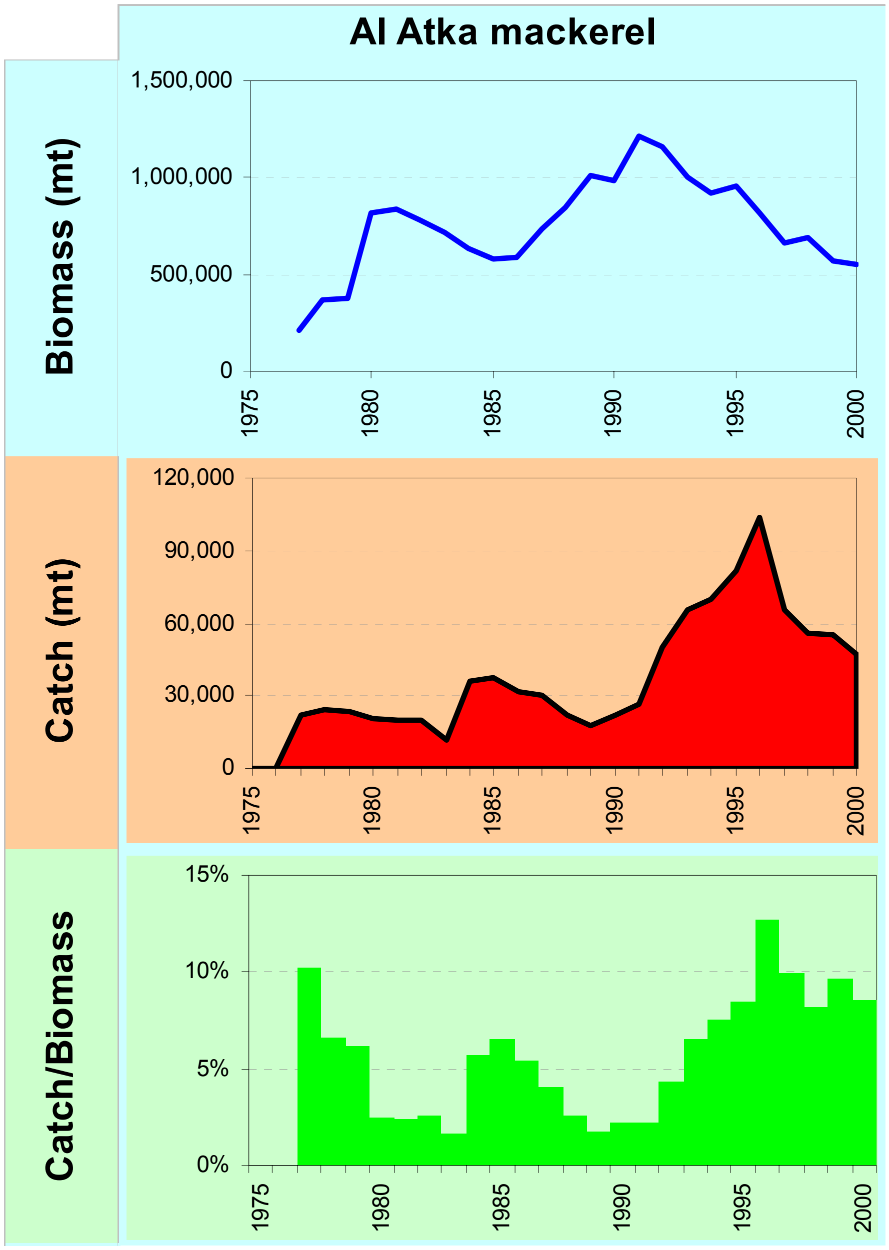

Figure 4.3. Historical catch of Atka mackerel in the Eastern Bering Sea and Gulf of Alaska 1975-2000.

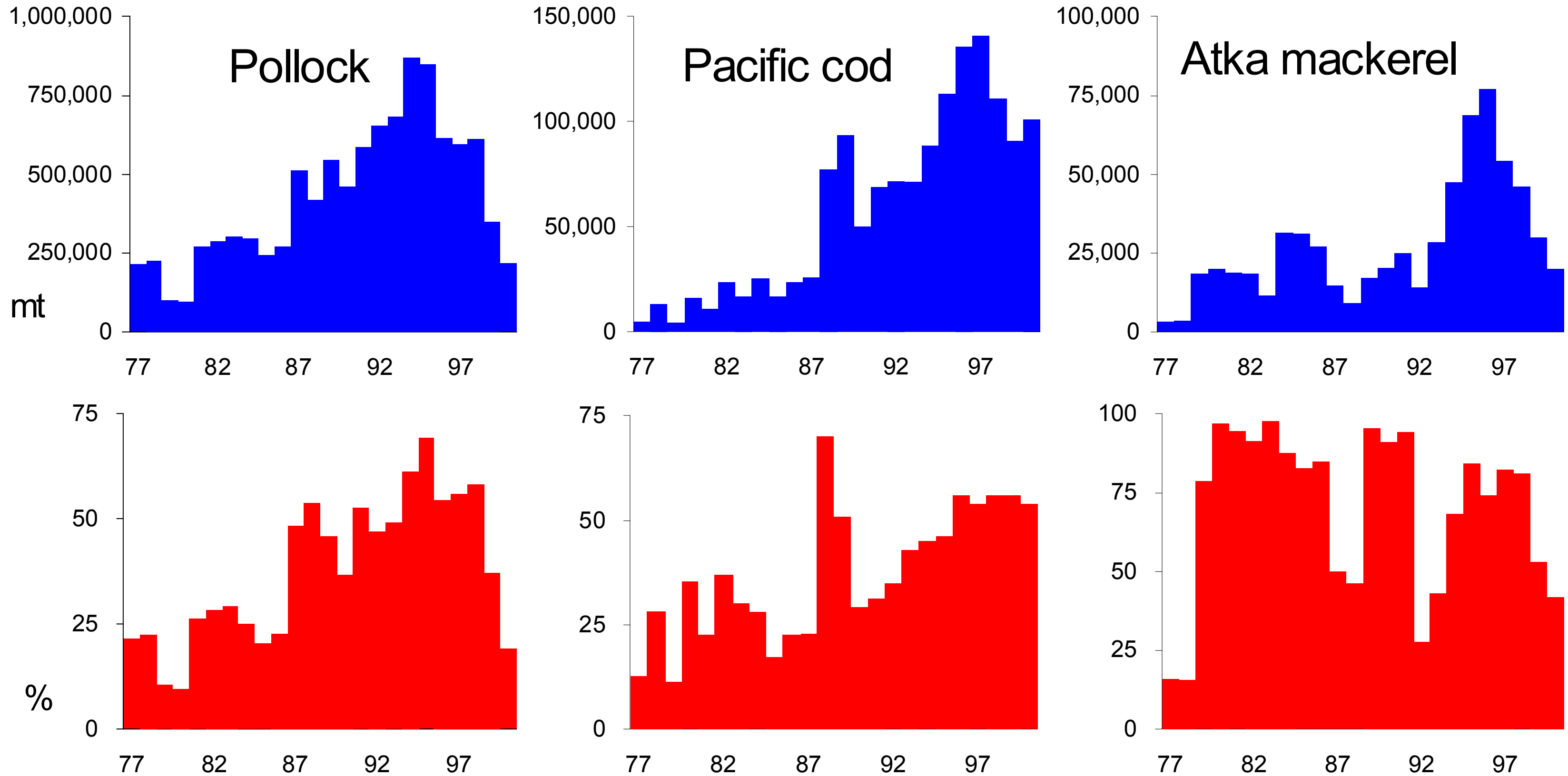

Figure 4.4. Catch of pollock, pacific cod, and Atka mackerel in critical habitat in the BSAI from 1977-2000

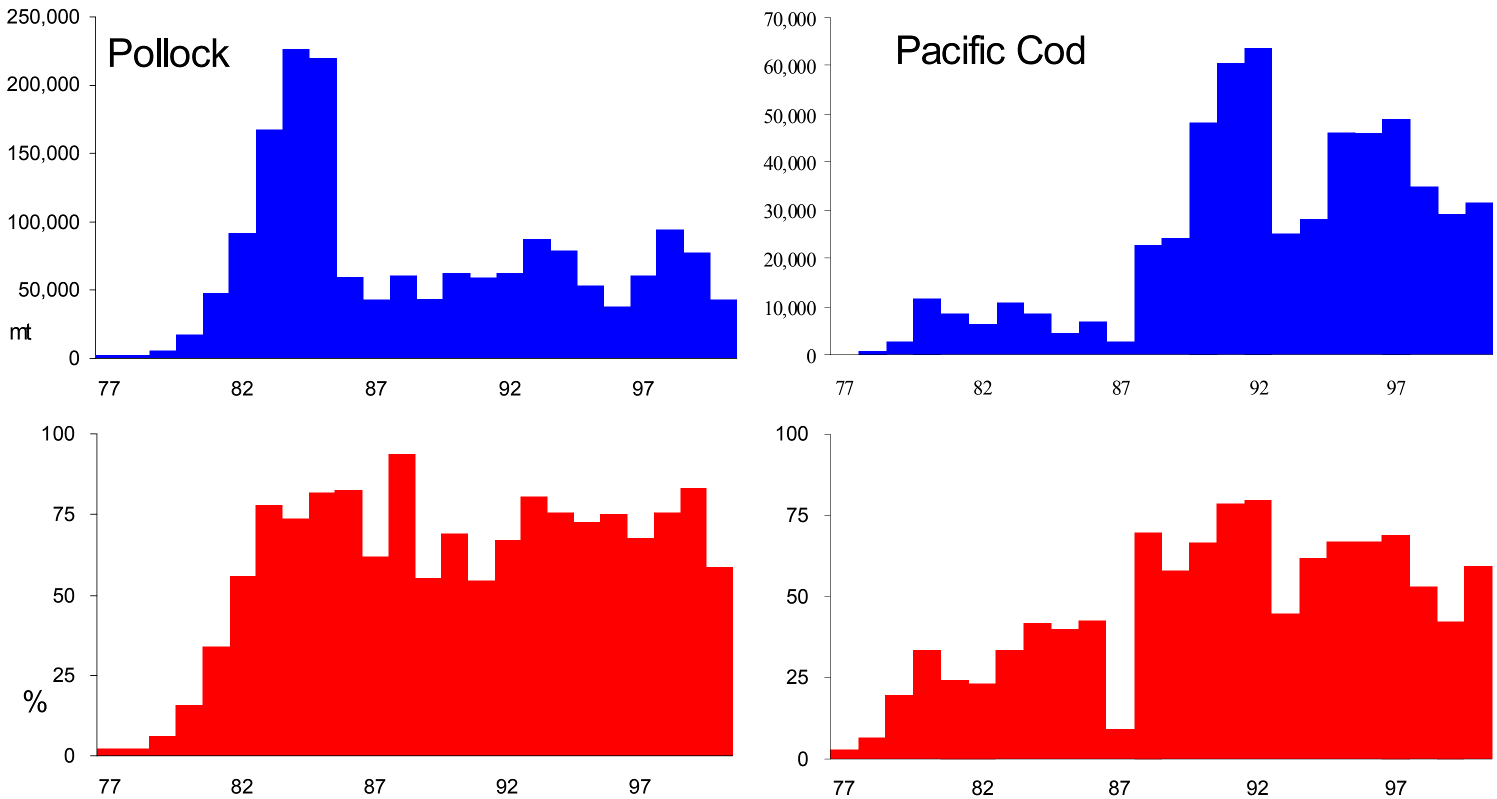

Figure 4.4. Catch of pollock, pacific cod, and Atka mackerel in critical habitat in the GOA from 1977-2000.

4.4.3.1 Direct Effects of Commercial Fisheries

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 suggest 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 9 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 (Ferrero *et al.* 2000). Ferrero *et al.* (2000) estimated that at least 2 Steller sea lions 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 (Ferrero *et al.* 2000).

4.4.3.2 Indirect Effects of Commercial Fisheries

Indirect effects of commercial fishing include: social, economic, physical, chemical, and biotic effects. The most notable indirect effect of commercial fisheries on Steller sea lions is removal of prey species which could either alter the animal's natural foraging patterns or its success rate, both of these effects could have further downstream results. Fisheries can also have indirect biological effects that occur when fisheries remove large numbers of target species and non-target species (incidental catch or 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.

4.4.3.2.1 Indirect Effects on Steller Sea Lions - Competition for Prey

At the center of this biological opinion is the following question: do fisheries compete for prey with Steller sea lions in such a way that reduces their survival and recovery in the wild? There is general scientific agreement that the continued decline of the western population of Steller sea lions results primarily from the lack of survival of juvenile Steller sea lions. There is considerable evidence from studies conducted in the 1970s and the 1980s that support the hypothesis that sea lions from the western population were nutritionally stressed and that nutritional stress likely resulted in reductions in the rate of recruitment and the reproductive rate. While few data from physiological research in the 1990s directly support the hypothesis that nutritional stress is a significant factor in contributing to the current decline in the western population of Steller sea lions, it cannot be ruled out as a cause of the continued decline. Most of the available data are from adult females and young of the year from the breeding season or young of the year from the latter winter. The results to date indicate that animals in the declining, western population are in better condition on average than animals from the eastern population, which is increasing in population. While these results are inconsistent with the nutritional stress hypothesis, important information from weaned pups and juveniles from other seasons and areas is needed to resolve uncertainties regarding the importance of the nutritional stress hypothesis as an important factor in understanding the current decline of the western population of Steller sea lions (DeMaster *et al.* 2001).

In previous biological opinions, NMFS has asserted that it is reasonable to conclude that fisheries may compete with Steller sea lions for prey. However, the scientific community in Alaska has conducted workshops (Alaska Sea Grant 1993, National Research Council 1996, Alaska SeaLife Center 2001) 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 numerous project and plan level biological opinions NMFS has prepared on the BSAI and GOA groundfish fisheries.

The most recent FMP level biological opinion (NMFS 2000) concluded that it was likely that the BSAI and GOA groundfish fisheries for pollock, Pacific cod, and Atka mackerel jeopardized the continued existence of the western population of Steller sea lions, and destroyed or adversely modified its critical habitat. This was based in large part on a risk averse approach to minimize the chance of type II error (the statistical error of not rejecting a false null hypothesis) in the face of equivocal scientific information on the link between fisheries removals and the continued decline of sea lions.

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. Both natural causes and exploitation from fisheries appear to have contributed to the decline of these stocks. 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)."

The amount of prey available for sea lions is rarely known in the areas where they 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 substantially 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.

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, 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

It has been argued that groundfish fisheries compete with Steller sea lions by overlapping in depth for the same fish resources. Depth overlap between foraging Steller sea lions and fisheries may occur for any species taken by fisheries on the shelf or shelf break. Competition may be less likely for species 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. Describing the overlap in depth between fisheries and Steller sea lions is further complicated by diel or seasonal vertical migrations of the fish resources for reproduction, refuge, or foraging.

Competition and the Winter Season

Changes in Steller sea lion behavior, foraging patterns, distribution, and metabolic or physiologic requirements throughout the annual cycle are all pertinent considerations 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 during this crucial life stage, when caloric requirements are high for rapid somatic growth.

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 unpublished) 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 target species can use fish finders which allow them to search for and locate fish schools or aggregations of suitable densities. Trawls are repeatedly towed through fish aggregations until the size or density of the catch becomes inefficient for further trawling. When catch efficiency decreases, the search resumes for another aggregation of suitable density.

The strategies used by fishing vessels likely alter schooling dynamics and important features of target schools such as 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, walleye pollock clearly dominate the diets of Steller sea lions, although the sea lions will prey on a variety of other species (see SEIS Section 3.1.1). Since the 1970s, commercial fisheries for pollock have been focused within the foraging areas of Steller sea lions, and have 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, and other species which are commercially harvested (both directly and as incidental catch). With each of these potential prey, Steller sea lions would find competitive pressure caused by a reduction of the biomass of a species, a change in its size structure, and a local reduction caused by fishing vessels in critical habitat for the sea lions. Certainly, not all Steller sea lion prey species are commercially harvested, but

4.4.3.2.2 Indirect effects on Water Quality

The preparation of fish products for human consumption can affect water quality . 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 consists 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.

4.4.3.2.3 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 clearly istinguish 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 can conclude that commercial fisheries are likely to reduce the amount of prey for Steller sea lions 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.

4.4.3.3 Effects of Alaska State Managed Fisheries

This section discusses the effects of state managed fisheries on Steller sea lions, further detailed information on these fisheries is contained in section 4.10 of the SEIS and is incorporated as background information for this opinion. New sources of information have emerged since the FMP biological opinion that highlight and place additional emphasis on the importance of near shore foraging habitats for Steller sea lions and the potential for state managed fisheries to affect sea lions and their critical habitat. As discussed in more detail below, this new information includes: (1) additional data and analysis indicating that sea lions, and especially pups, juveniles, and breeding aged sea lions, spend the vast majority of their time in areas within 10 nm of shore (ADF&G and NMFS 2001, Loughlin *et al.* unpublished), (2) a new summary of diet trends for the western population of sea lions that confirms the dominant prey species (Sinclair and Zeppelin submitted), and (3) new scientific papers indicating that herring has dietary advantages for sea lions (Rosen and Trites 2000) and that when herring is available it may be a preferred prey resource for sea lions (Thomas and Thorne 2001). For the reasons described in this section, this new information suggests that state managed fisheries may have greater effects on sea lions than NMFS previously realized.

ADF&G manages fishing activity in state territorial waters (zero to three miles from the baseline, herein referred to as state waters). Additionally, ADF&G oversees BSAI crab, salmon, and some rockfish fisheries in Federal waters (EEZ) under Council FMPs. With the exception of state managed fisheries that have specified guideline harvest levels (GHLs) for species such as sablefish, Pacific cod, and Prince William Sound pollock, ADF&G coordinates state fishery openings and in-season adjustments with federally managed fisheries (the "parallel" fisheries). For example, when groundfish fishing is open in Federal waters, 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 all fisheries within state waters.

The Alaska Board of Fisheries created "Guiding Principles for Groundfish Fishery Regulations" (5 AAC 028.89) which stipulate that state groundfish fisheries are managed conservatively to (1) conserve groundfish resources to ensure sustained yield, (2) minimize bycatch and prevent localized depletion of stocks, (3) protect habitat and other associated fish and shellfish, (4) maintain slower harvest rates by methods and means and time and area restrictions, (5) extend the length of fishing seasons by methods and means and time and area restrictions, (6) harvest the resource in a manner that emphasizes quality and value of the product, (7) use the best available information, and (8) manage cooperatively with the North Pacific Fishery Management Council and other federal agencies associated with groundfish fisheries.

These ecosystem-based guiding principles have led to a set of conservation measures for state-managed groundfish fisheries. A number of these management measures provide, directly or indirectly, some protection to Steller sea lions. Groundfish fisheries are excluded within 3 nm around Steller sea lion rookeries (through federal regulation) and some haulouts on a seasonal basis. Regulations at 50 CFR 223.202 prohibit entry of any vessel within 3 nm of ESA listed rookeries. These no-entry regulations apply to state permitted fishing vessels as well as federal permitted fishing vessels. These closures are intended to minimize disturbance of land-based animals and to maintain unaltered supplies of prey resources in the nearshore waters around rookeries that are critical to juveniles, pregnant females, and females with pups.

Another conservation measure is the closure of most state waters to non-pelagic trawling (Figure 4.5). Most areas are closed year-round, and some areas are closed seasonally as in Shelikof Strait. Moreover, a portion of eastern Prince William Sound is closed to pelagic trawl gear during the pollock fishery (5 AAC 28.263) and most of eastern Prince William Sound is closed to all (non-pelagic and pelagic) trawling year-round (5 AAC 39.165). These trawl closures were established by the Alaska Board of Fisheries to protect seafloor habitats, shellfish such as depressed crab populations, and non-target demersal fishes. Although only the 3 nm closures around most rookeries were designed specifically for Steller sea lions, the trawl area closures protect bottom habitats within Steller sea lion critical habitat, and they afford protection to non-target species that are part of the Steller sea lion diet in various amounts, including octopus, sculpins, flatfish, greenlings, and other forage fishes which are associated with bottom habitats. The non-pelagic trawling ban also reduces the possibility of direct cumulative impacts from state managed fisheries on marine habitat and particularly the benthic community.

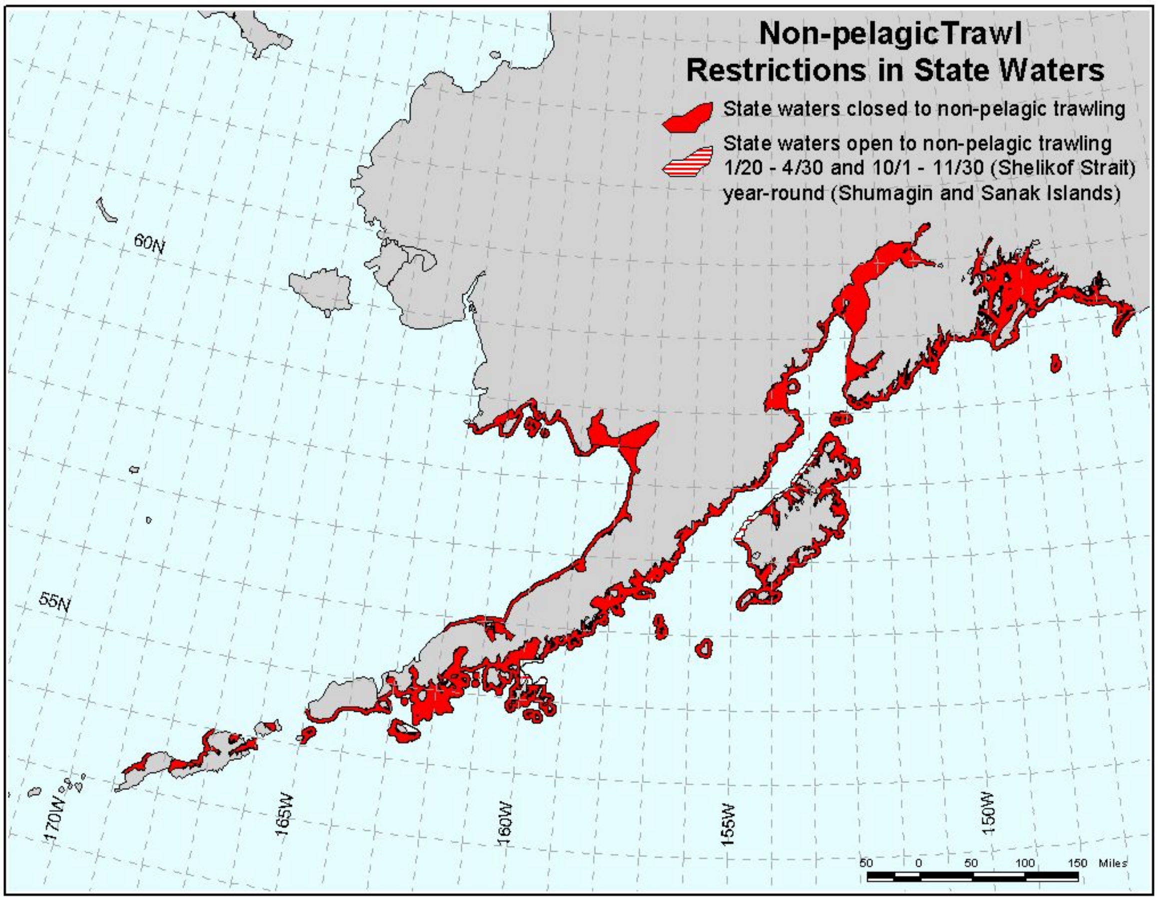

Figure 4.5 Year-round non-pelagic trawl closure areas (shaded areas) in state waters of the central and western Gulf of Alaska and southeastern Bering Sea.

The geographic range of state managed fisheries in state waters coincides almost entirely with the area designated as Steller sea lion critical habitat (Figure 3.1). To reduce interactions between sea lions and state managed fisheries, ADF&G in 1999 established fishing zones for pollock around most rookeries and a few haulouts out to 3 nm (by Emergency Order, March 17, 1999) and has closed several haulout sites seasonally in Prince William Sound out to 10 nm. Four rookeries designated as critical habitat (Agattu Island/Gillion Point, Agattu Island/Cape Sabak, Wooded Island, and Seal Rocks (Cordova)) were not protected from commercial fishing out to 3 nm by the state emergency order. Four haulouts are included in the March 17, 1999 emergency order because the entire island where a rookery was located is protected by the 3nm fishing closure. These protected haulouts are Seguam Island/Finch Point, Seguam Island/South Side, Kiska/Sobaka and Vega, and Amchitka/Cape Ivakin. The 3nm closures and 10 nm fishing restricted areas are based upon 1999 Federal regulations. Since this time, additional Steller sea lion sites have been added to the regulations at 50 CFR part 679.

Kruse et al. (2000) provide an overview of state managed fisheries that may interact with Steller sea lions, including historical catch, gear used, stock assessment methods, and status of the fish stocks. That information was summarized in the FMP biological opinion (NMFS 2000) and is not repeated here. The remainder of this section discusses possible direct and indirect effects of these fisheries on Steller sea lions and their critical habitat.

Direct interactions between state managed fisheries and listed Steller sea lions involve both lethal and nonlethal impacts. Lethal impacts include sea lions inadvertently killed in fishing gear such as trawls, seines, and gill nets. Nonlethal effects include short term impacts such as disturbance of sea lion haulouts, vessel noise, entanglement in nets, and preclusion from foraging areas due to active fishing vessels and gear. State managed fisheries are estimated to account for a lethal of about 23 Steller sea lions per year (Ferrero *et al.* 2000). Recently this number has been difficult to verify due to the lack of observer coverage and the expected under-reporting of takes through a voluntary reporting program. There are no available estimates of the frequency or severity of nonlethal takes. Illegal shooting of sea lions by fishermen still occurs, but the number of animals affected is difficult to evaluate given the lack of observer coverage on these vessels. This number is likely to not be trivial, Loughlin and York (2001) estimate that the mortality level from shooting is at least 50 sea lions per year. Although shooting is obviously not a State authorized activity, it is an indirect effect of authorizing fishing.

Indirect effects of state managed fisheries on listed Steller sea lions include the hypothesis that fisheries may compete with sea lions for common prey. In a recent analysis of Steller sea lion diet, Sinclair and Zeppelin (submitted) found that walleye pollock, Atka mackerel, Pacific salmon, Pacific cod, and Pacific herring were consumed in relatively high frequencies by the western stock of sea lions during certain times of the year. Observations from biologists and fishermen indicate spatial and temporal overlap between the state managed fisheries for these species and foraging sea lions (Kruse *et al.* 2000). Information on Steller sea lion foraging patterns has improved since the release of the FMP biological opinion. These data suggest that Steller sea lions, and especially pups and juveniles, spend the vast majority of their time in areas within 10 nm of shore (ADF&G and NMFS 2001, Loughlin *et al.* unpublished). Specifically, Loughlin *et al.* (unpublished) analyzed data from a total of 53 Steller sea lions equipped with satellite dive recorders in the Gulf of Alaska, Aleutian Islands, Washington, and Kuril Islands (Russia) between 1990 and 2000 and found that 93.8% of all observed locations for immature sea lions were within 10 nm of shore.

One possible explanation for a higher frequency of sea lion occurrence within 10 nm of shore is that Steller sea lions may rely more heavily on near shore prey than previously thought, which suggests that the areas of designated sea lion critical habitat that are in state waters may be more important foraging habitat than the portions of critical habitat that are farther offshore. Observed locations of Steller sea lions at sea do not directly demonstrate where they are foraging. However, the implication that sea lions depend very heavily on foraging habitat within 10 nm of shore increases the possibility that fisheries in state waters compete with sea lions for a common resource. As discussed below, depending on the extent of this competition, the indirect effects of state managed fisheries may reduce the prospects for survival and recovery of the western population of sea lions.

The most concerning aspects of state managed fisheries would be those fisheries which remove high volumes of fish in a short period of time, and may have a greater likelihood of causing localized depletions. Although the patterns of removals are generally similar from one fishery to the next (i.e. salmon and herring fisheries), the sheer number of distinct fisheries makes it difficult to describe them individually. Likewise, each fishery is different in the number of boats, gear used, time of year, length of season, and/or fish species. Therefore, a few examples are presented below (primarily from Kruse *et al.* 2000) to illustrate some of the competitive interactions that may occur between fisheries and sea lions. Although the information presented in Kruse *et al.* (2000) has been very helpful in developing this opinion, further information could be provided by the state regarding potential interactions between fisheries and endangered species. These studies are often long term and require substantial effort, but there is no doubt that future evaluations of these fisheries would benefit from a more exhaustive look at the myriad state fisheries and their individual potential for negative interactions on a small or local scale important to a foraging sea lion.

State Managed Groundfish Fisheries

State managed groundfish fisheries are relatively small in tonnage compared to the federally managed groundfish fisheries, but are also much smaller and are generally confined to specific management areas. The state managed pollock fishery is limited to Prince William Sound, while Pacific cod fisheries occur in Prince William Sound, Cook Inlet, Kodiak, Chignik, and South Alaska Peninsula areas. For a sense of scale, in 2000 the state managed GOA pollock harvest was 1.7% of the federal pollock fishery, and the state managed Pacific cod harvest was 22.5% of the total federal ABC.

State managed groundfish fisheries are likely to reduce the abundance and/or alter the distribution of several Steller sea lion key prey species, including walleye pollock and Pacific cod. Groundfish fisheries may cause dense schools of prey to scatter (depending upon the gear type used), affecting the foraging behavior of marine mammals and seabirds that target aggregated prey (Brock and Riffenburgh 1960, Dayton *et al.* 1995). Repeatedly causing fish schools to scatter reduces their density and may decrease the value of foraging areas to Steller sea lions. As a result, individual sea lions may feed less efficiently and would have to expend more time and energy to consume the same number of fish. On the other hand, research by Lokkeborg *et al.* (1989) and Lokkeborg (1998) indicate that some gears such as hook-and-line and pot gear may attract fish. At larger spatial scales, reductions of biomass due to fishing may exacerbate the effects of small-scale depletions, leaving fewer spawning-aged fish to replenish areas where fishing has occurred.

The effects of state managed groundfish harvesting on Steller sea lions are mitigated to some degree by existing restrictions on the fisheries (these restrictions are summarized in the following paragraphs based on NMFS 2001). For the pollock fishery, the Prince William Sound outside district (including Wooded Island, Seal Rocks, Cape Hinchinbrook, and Hook Point) is closed to fishing (Figure 4.6). Since the pollock fishery occurs only in the Prince William Sound inside district, it reduces the potential for removing sea lion prey in the vicinity of critical habitat sites Cape St Elias, Hook Point, Middleton Island, the Wooded Island rookery, and most of the Seal Rock and Cape Hinchinbrook sites. Pollock fishing is prohibited June 1 through November 1 within 10 nm of seven rookeries and haulouts in Prince William Sound (5 AAC 28.250). Two haulout sites within Prince William Sound, Perry Island and Point Eleanor, have no pollock fishing restrictions. The Needles, Point Elrington, and Glacier Island haulouts have no pollock harvest restrictions from November 2 through May 31. The fishery opens Janurary 20 (concurrent with CGOA) and closes by emergency order no later than March 31, 2001. Steller sea lions using Prince William Sound inside district haulouts may experience a depletion of pollock and disruption of the prey field during part or all of the year, and the time period of the pollock fishing restriction does not provide protection during the critical winter months.

Due to the relatively small harvest and few participants, the pollock fishery has not been apportioned seasonally aside from the seasonal closures within 10 nm of rookeries and most haulouts. Spatially, the Prince William Sound pollock harvest is divided between three areas with no more than 40% of the total harvest coming from any one area (5 AAC 28.263). ADF&G manages to a target of 30% of the total harvest from any one of these areas with a 10% reserve. These spatial management measures may help lessen competition for fish between the pollock fishery and sea lions.

The state managed cod fisheries also include management measures that may help to reduce interactions with sea lions by dispersing effort spatially. The eastern section of the Prince William Sound outside district is closed to cod fishing where several sea lion haulouts and rookeries are located. Cod harvests are apportioned spatially in the central Gulf of Alaska where 25% of the ABC is divided among Chignik (up to 8.75%), Kodiak (up to 12.5%), and Cook Inlet management areas (up to 3.75%).

Sablefish and rockfish are not important in the diet of Steller sea lions and no specific measures to protect sea lions are included in the state management plans for these species.

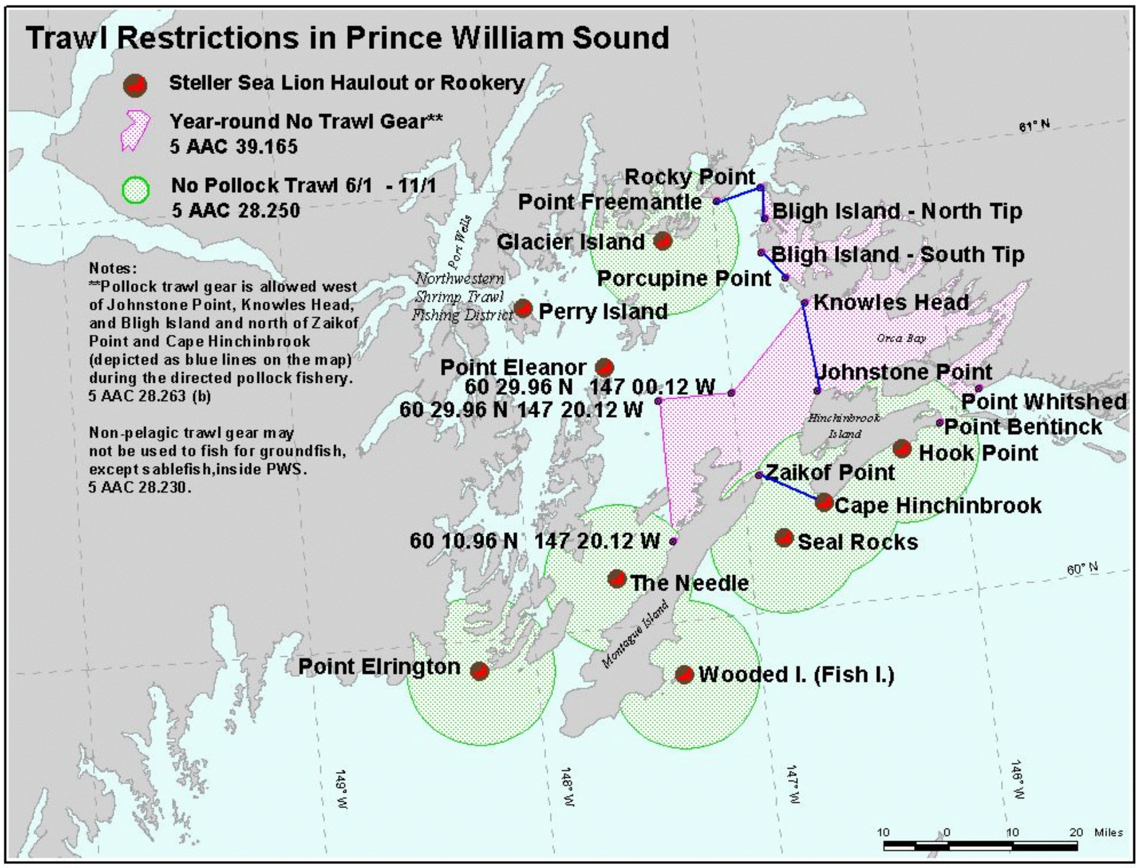

Figure 4.6. Year-round and seasonal trawl restrictions in Prince William Sound.

Existing state groundfish management measures limit fishing effort in ways that may reduce potential interactions with sea lions, although the extent of competitive interactions is not known. Moreover, portions of the state managed groundfish fishery are relatively new, so any effects they cause to the sea lion prey field also would be relatively new. Prior to 1995 very little pollock was harvested in Prince William Sound, so even though state management measures limit the harvest compared to unregulated fisheries, any localized reduction or dispersal of sea lion prey due to pollock harvesting is a recent phenomenon.

The amount of groundfish (pollock, Pacific cod, and Atka mackerel) harvested in the parallel fisheries is presented in Table 4.2. Although the amount of fish harvested in the 3 nm area around haulouts appears low, when compared to the actual area in the GOA, it may not be that clear. The amount of area composed inside 3 nm of haulouts in the GOA is rougly 0.5% of the total area, with catch percentages up to 7.4% (pot, Pacific cod), this represents two orders of magnitude higher catch rate than a theoretically dispersed fishery. Again, the type of data necessary to evaluate whether this may or may not be a problem is lacking, such as information on biomass availability on small scales. Further complicating matters, the fleet fishing within state waters during these parallel seasons are generally small unobserved vessels. Because of this, we get very limited information on these fishing activities as compared to larger boats operating in federally managed waters.

Table 4.2. Federal TAC harvested within 3 nm of listed Steller sea lion rookeries and haulouts and within all state waters during parallel fisheries in 1999 by area, fishery, gear type, and vessel type. Estimates of catch in mt follow percentage of that gear type's harvest in brackets.

Area	Fishery	Gear	Vessel Type	Within 3 NM of SSL Haulouts During Parallel Seasons	Within all State Waters During Parallel Seasons
GOA	Pollock	Trawl	CV	1.5% (1,361 mt)	31.9% (29,380 mt)
	Pacific cod	Trawl	CV	0.9% (296 mt)	8.2% (2,696 mt)
		H & L H & L	CV CP	5.3% (369 mt) 0% (0 mt)	37.1% (2,584 mt) 0% (0 mt)
		Pot	CV	7.4% (1,151 mt)	38.8% (6,038 mt)
		Jig	CV	0% (0 mt)	0% (0 mt)
BSAI	Pollock	Trawl	CV	0% (0 mt)	0.2% (1,053 mt)
		Trawl	CP	0% (0 mt)	0% (0 mt)
	Pacific cod	Trawl	CV	0.2% (69 mt)	10.3% (3,554 mt)
		Trawl	CP	0.2% (290 mt)	6.9% (1,001 mt)
		H&L	CP	0.1% (72 mt)	1.4% (997 mt)
		Pot	CV	1.0% (108 mt)	21.6% (2,337 mt)
		Jig	CV	1.5% (3 mt)	56.4% (112 mt)
	Atka mackerel	Trawl	CP	0.3% (155 mt)	0.6% (310 mt)

CV = catcher vessels, CP = catcher processors.

State Managed Herring Fisheries

Adverse impacts may accrue to sea lions from herring fisheries when vessel activity interferes with sea lion foraging. Additionally, direct mortality may result when sea lions are caught in nets or other fishing gear (although no direct mortalities have been observed in the herring fisheries; Ferrero *et al.* 2000). Steller sea lions are attracted to areas where herring spawn, and they feed on the dense aggregations of herring present during the short spawning period. Recent nighttime observations of Steller sea lions in Prince William Sound using infrared scanning technology and acoustic surveillance of their prey revealed that sea lions fed exclusively on herring, despite the presence of much greater abundances of pollock (Thomas and Thorne 2001). These results suggest that under some conditions (e.g., when highly aggregated in shallow water), herring may be a preferred prey resource for sea lions. Rosen and Trites (2000) found that sea lions on a pollock-only diet showed progressive metabolic depression while losing body mass. The authors attributed these responses to the lower gross energy content of pollock versus herring, the higher energetic cost of digesting pollock, and the increased energy loss from digesting a larger quantity of fish needed to compensate for the lower energy content of pollock. The sea lions would have had to consume 35% to 80% more pollock than herring to maintain similar net energy intakes (Rosen and Trites 2000). Thus, we can speculate that when herring are available in high enough densities, sea lions may prefer to feed on herring due to its higher energy content. However, field data to either support or refute this speculation is lacking. Human activities that diminish feeding opportunities for sea lions, such as herring fisheries, may have negative consequences for sea lions.

Because the time when herring spawn 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 fishery managers 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 are commonly observed in the middle of these fishing areas. There are two possible hypotheses regarding these observations:

1. Sea lions may venture into fishing grounds because the fishery is in someway either beneficial (or neutral), concentrating herring, creating confusion, and enhancing feeding opportunities for sea lions.

2. Some sea lions, perhaps the brave or curious ones, or those that cannot afford not to forage (i.e., nutritionally limited), forage in these fishery grounds. Other sea lions, those that are not observed (and would not be due to the type of observations) avoid these fishing grounds due to the intense vessel activity, nets, and other hazards. Additionally, some sea lions that do forage, may have higher stress levels involved with avoiding vessels, gear, and dealing with noise, yet may appear to be foraging effectively.

There is insufficient information to determine which hypothesis is more or less likely. Presumably, fishing in areas that were previously unfished, yet utilized by sea lions, would change the manner and success rate of foraging sea lions. This could be either a positive or negative effect. Given the high caloric content of herring, the historical dependence on the species (Sinclair and Zeppelin submitted), and the large decline in herring biomass during the last century (Kruse *et al.* 2000), this fishery should be the subject of further study specifically to determine if there may be negative impacts on Steller sea lions. The important point is that although we have adequate data which displays that sea lions attempt to forage during the times and places when herring fisheries occur, we have little or no information on either the net impacts to those sea lions or other sea lions which may avoid observation because they elect not to forage. There is no way of knowing how many sea lions may be precluded from foraging in the spawning areas due to fishing activity. Steller sea lions are observed leaving the grounds within a few days after the herring have spawned. Fishery biologists make note of their departure since spawn deposition SCUBA biomass surveys 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 4.7. 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. ADF&G uses that behavior to signal the fishery, then the fishery moves in and harvests herring at peak spawning condition. The 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 short term survival of animals such as Steller sea lions. They may depend on these short intervals of high prey availability to sustain them through other periods of low prey availability. Some individual sea lions may be able to adapt by learning to forage among the fishing boats, but others may choose to avoid the area and may thus forego prime foraging opportunities. Since we do not observe the sea lions that avoid fishing areas, we have no reliable way to estimate how many may be affected in this way, nor do we have a way to gauge the impact on those individual animals. For the sea lions that remain, we have no way to gauge their foraging success among fishing vessels relative to their potential foraging success in the absence of fishing vessels. Nevertheless, based on observations of interactions between the fishery and Steller sea lions, it is reasonable to conclude that some sea lions may be precluded by the fishery from foraging on spawning schools of herring. Likewise, the sea lions that do forage in the vicinity of the fishery may forage less efficiently due to active competition with the fishery for the available concentrations of herring.

Hundreds of individual sea lions may be affected by each of these brief fishery openings. The annual exploitation rate for herring is roughly 20% of the exploitable or mature biomass (Kruse *et al.* 2000), which is considered by the state to be conservative. This may be in relation to the target stock, but the question that arises is whether this is conservative from a sea lion perspective? This example from Hobart Bay is merely to make the point that foraging sea lions and herring fisheries operate in the same areas and times on the same resource.

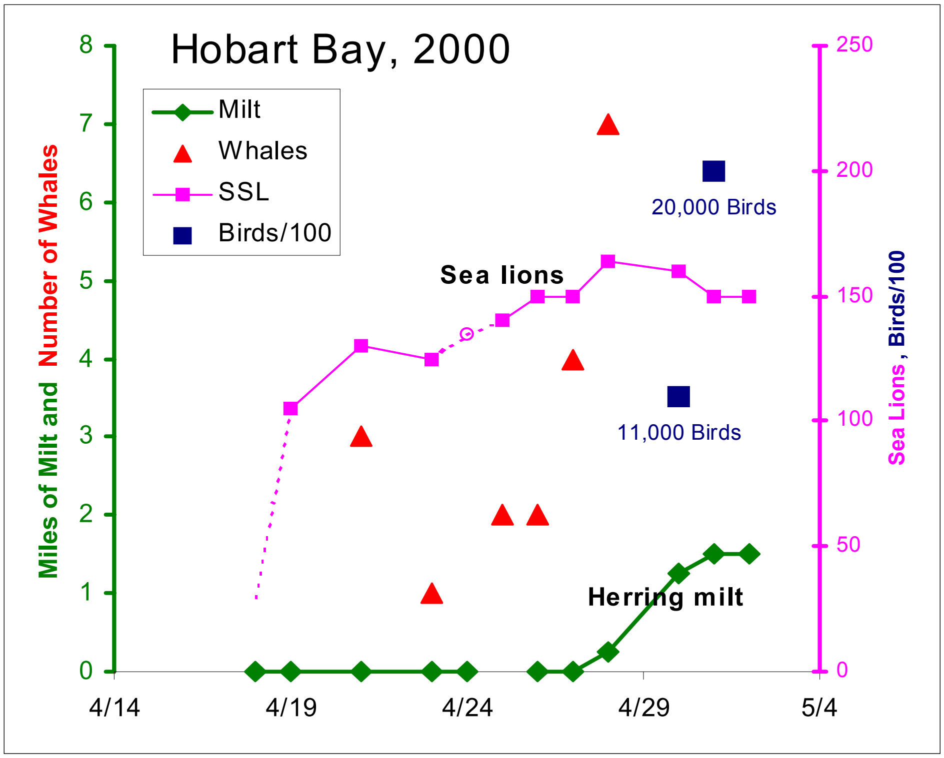

Figure 4.7. Response of marine mammals to herring in Hobart Bay, 2000.

State Managed Salmon Fisheries

State managed salmon fisheries interact with Steller sea lions as well. In the gillnet fishery sea lions cause significant catch loss and gear damage by taking fish from nets and tearing large holes in the nets (Hoover 1988). Sea lions cause damage to purse seine nets when they swim inside the nets to eat salmon before the nets are closed (Hoover 1988). Prior to the mid-1990s the only quantitative study on interactions between sea lions and the Alaska salmon gillnet fishery was on the Copper and Bering River deltas and the Coghill district in south central Alaska (Kruse *et al.* 2000; Matkin and Fay 1980). During the three week spring salmon season sea lions damaged 1.7-4.9% of the weekly catch, and most of the damage occurred in outside waters where relatively few boats fished. Sea lions were infrequently seen in the Coghill district and were absent during the fall Copper River district season. Observers also monitored the Prince William Sound salmon drift gillnet (Copper River) fishery in 1990 and 1991. No mortalities were observed in 1990 and two were recorded in 1991. When these observer data are extrapolated, the mean kill rate for 1990 and 1991 is 14.5 sea lions per year (Kruse et al. 2000). The Alaska Peninsula and Aleutian Islands salmon drift gillnet fishery was also monitored during 1990 and no Steller sea lion mortalities were observed. There were no incidental serious injuries or mortalities observed in the Cook Inlet salmon gillnet fishery in either 1999 or 2000 (NMFS unpublished data); for Bristol Bay the annual sea lion mortality is thought to be 3.5 (Kruse *et al.* 2000, Ferrero *et al.* 2000).

Indirect adverse effects of state managed salmon fisheries on Steller sea lions stem from competition for seasonal aggregations of fish. State managed salmon fisheries are open for relatively short periods, and only rarely remain open for 24 hours per day, 7 days per week (Kruse et al. 2000). Nevertheless, many of these fisheries take place at stream or river outlets where salmon congregate before moving upstream to spawn (Kruse *et al.* 2000). These same areas may provide important sea lion foraging opportunities on high density prey, enabling the sea lions to feed efficiently and survive other periods of low prey availability. As discussed above, salmon are a common prey resource for sea lions. Sinclair and Zeppelin (submitted) found that Pacific salmon were the third most dominant fish in the diet of Steller sea lions, based on scats (feces) observed from 1990-1998 on summer and winter island sites across the range of the western stock of sea lions. Sinclair and Zeppelin (submitted) observed that known seasonal and spatial distributions of aggregations of fish that are preyed upon by sea lions parallel the highest observed frequencies of occurrence in seasonal and regional prey consumed by sea lions. Due to intensive salmon fishing activity in such areas during the same times when sea lions target concentrations of salmon, individual sea lions may feed less efficiently or may avoid these feeding opportunities entirely. ADF&G's identified salmon escapement levels limit the harvest to the amount that is surplus to that needed for spawning (Kruse *et al.* 2000), but these harvest controls probably do not eliminate competition for available salmon between sea lions and the fishery. However, as noted in Kruse et al. (2000) the abundance of salmon biomass increased dramatically during the time period that the western stock of sea lions has been in decline. Further study and consideration is necessary to determine what affects salmon fisheries have on the availability of prey for Steller sea lions.

4.4.4 Effects of Intentional Take of Steller Sea Lions

4.4.4.1 Subsistence Harvest

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).

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 based on studies conducted by the ADF&G from 1992 to 1999 (Wolfe and Mishler 1997, Wolfe and Hutchinson-Scarbrough, 1999), indicate a mean annual subsistence take of 353 animals from the western U.S. stock (i.e., the endangered population) Estimates ranged from a high of 549 in 1992 to a low of 164 in 1997. 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. Declines in sea lion subsistence harvest between 1992-1998 have been reported by hunters in the following communities: Pribilofs (decrease from 297-78 animals/year), Aleutian Islands (decrease from 135-37 animals/year), and Kodiak (decrease from 58-18 animals/year; 107 animals harvested in 1995). Subsistence harvest of Steller sea lions has historically been low in Prince William Sound (10-20 animals/year). Declines in subsistence harvest is likely due to 1) a decline in the stock and 2) a decline in the number of hunters (Wolfe and Hutchinson-Scarbrough, 1999).

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 (PBR) 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 continued decline of the western population of Steller sea lions, particularly at certain locations. It is not known, however, whether the current harvest levels inhibit recovery at selected sites.

4.4.4.2 Commercial Steller Sea Lion Harvest

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.

4.4.4.3 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 presumed 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.

4.4.4.4 Research Takes

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 consider disturbance to have been a major factor in the decline of Steller sea lions.

4.4.5 Impacts of 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. 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.

4.4.6 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. 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.

4.5 Synthesis of the Effects

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 5.2% per year (Loughlin and York 2001). The precipitous decline during 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 by most scientists to be of lesser importance in explaining the 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.

4.5.1 Summary of the Direct Takes of Steller Sea Lions in the Action Area

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 small. 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 significant factor in the current decline. A summary of all known takes is provided below in Table 4.3.

Table 4.3. Estimate of Steller Sea lion baseline mortality due to take for 1959-1999 in the action area[6]

Description of Take	Dates	Rate of Take	Total Estimated Take
Entanglement in Marine Debris	(1970-1990) 1985	100 per year 0.07%	2,000 no estimate
Commercial Harvests	(1959) (1963-1972)		630 males 45,178 pups
Subsistence Harvests	1959-1991 (1992-1995) (1996-1999)	no estimate 448/ year (est) 178/year (est)	 2,000 700

[6] Based on the following reviews: Entanglement (Calkins 1985; Loughlin et al. 1986), Commercial Harvest (Merrick et al. 1987), Subsistence Harvest (Wolfe and Mishler [all 4 pubs]), Incidental catch (Perez and Loughlin 1991), Research (Calkins and Goodwin 1988; Calkins et al. 1994), and Intentional take (Trites and Larkin 1992)

Incidental Catch	1959-1966 1966-1977 1978-1988 1989-1999	no estimate 1,000-2,000/yr 100-2,000/yr <50/yr	no estimate 14,000-16,000 5,700-7,400 no estimate
Research	1975/78 1985/86 1989	62/yr 89/yr 16	250 178 16
Intentional Fisheries Take	(1956-1990)		52,000
Total Estimated Take	1970-1999		**123,000 – 126,000**

4.5.2 Discussion of Other Potential Sources of Losses to the Steller Sea Lion Population

In a draft white paper by Loughlin and York (2001), the authors attempted to account for the continued decline of the western population of Steller sea lions using all known or suspected sources of mortality. Although a highly theoretical paper, it does provide some guidelines and perspective for the number of animals concerned and the possible difficulties that we may encounter over the next 20 years trying to conduct research and monitoring of the population. The following is a summary of that paper, which will walk through the mathematical exercise in order to provide the background for understanding the results of the analysis.

From 1991-2000, they estimated that the western population of Steller sea lions declined at an estimated 5.2%. The decline was statistically significant ($P<0.10$) in all regions except the eastern Aleutian Islands (e.g., the area in the southwestern Bering Sea and western GOA). They estimated the entire population at 33,000 animals (based on published correction factors). Using published life tables and the estimated rate of decline, they determined that 6,425 animals would be lost from the population annually. Of this, 4,710 animals would be expected to die if the population was stable (about 73% of the total expected mortalities). This leaves about 1,715 that die annually, which accounts for the current population decline of 5.2%.

Loughlin and York (2001) then tabulated all the known possible sources of sea lion mortality, and made a determination whether they were likely to fall in one of the two categories: (1) the mortality above replacement (e.g., the 1,715), or (2) the natural mortality if the population were to stabilize (e.g., the 4,710). They estimated that 436 mortalities could be attributable to anthropogenic causes (i.e., not natural mortality). An additional 343 mortalities could be attributable to predation by killer whales and sharks that they considered to be unnatural mortality (see further discussions in Loughlin and York 2001). When you subtract out the known anthropogenic mortalities either 936 or 1277 animals remain unaccounted for depending on the analysis used (see Table 4.4). This is the amount of annual mortality that may be attributable to either environmental change or competitive interactions with fisheries (a decline of about 2.8-3.9% annually).

Table 4.4. Estimates and source of Steller sea lion mortality during 2001 and that mortality expressed as a percentage of all estimated mortality above replacement or additional losses(1,715) (reproduced with modifications from Loughlin and York 2001).

Source	Estimated mortality[a]	Estimated mortality[b]	% of estimated mortality above replacement
Subsistence harvest	353	353	20.6%
Incidental to fishing	30	30	1.7%
Illegal shooting	50	50	2.9%
Research	3	3	0.2%
Predation by killer whales	0	309	0.0/18.0%
Predation by sharks	0	34	0.0/2.0%
Total	**438**	**779**	**25.4/45.4%**
Remaining # unaccounted for	***1277***	***936***	
Decline unaccounted for	***3.9%***	***2.8%***	

[a] Assumes all predation is in the natural category (above replacement)
[b] Assumes some portion of predation is additional to natural mortality (decline)

However, this analysis relies on the reasonable assumption that the population would stabilize if anthropogenic sources were removed. But what is happening to the 4,710 animals lost annually to "natural" causes? We might expect that a population like the western stock of Steller sea lions should be growing at a rate somewhere between 4-6% due to the incredible reduction in the population over the last 30 years. The eastern stock has been growing at a rate of 1.9% per year. This might be a more appropriate expectation for a recovery mode for this stock. The paucity of information available at this time does not allow us to make any definitive determinations regarding an expected recovery rate or the exact number of animals which may die each year due to fishery interactions. Yet, we do know, that at a minimum, between 936-1277 animals are unaccounted for, and possibly more than that. And it is also true, that all of these, or perhaps none of these, may be attributable to natural environmental change.

4.6 Comparison to Other Pinnipeds Around the World: Review of Responses of Pinniped Populations to Local Prey Depletion

In any species, population size is controlled by four main parameters: immigration, birth rate, mortality rate, and emigration; any changes in these factors can result in changes in the population status or demographic structure (Hindell and Burton 1987; York 1994). Population declines can occur in two main ways: as a result of long-term gradual decline in abundance, or from short-term catastrophic events that cause either mass mortality or recruitment failure of one or more year classes (Gerber and Hilborn 2001).

In assessing causes of the decline of the western stock of Steller sea lions (*Eumatopias jubatus*), it can be informative to examine other pinniped populations that have experienced decreases in size or changes in demography (Geraci *et al.* 1999; Shima *et al.* 2000; Bowen *et al.* 2001). Populations that have responded to reductions in local prey availability or quality are of particular interest for comparison with Steller sea lions. Prey stocks may be depleted due to fisheries, environmental or climatic changes, or trophic-level variation such as increased predation or decreased food resources for prey species (Bowen *et al.* 2001). In general, these effects may result in changes in population size, age-class structure, or reproductive performance.

The following provides a summary of case studies for other species of pinnipeds in which a correlation between changes in population size or reproductive performance and local prey depletion has been investigated or strongly suspected. Other causes of pinniped population declines include harvesting or overexploitation, and disease and other epidemics; these have been reviewed elsewhere and are beyond the scope of this review (Harwood and Rohani 1996; Geraci *et al.* 1999; Gerber and Hilborn 2001).

4.6.1 Long-term, gradual declines or changes in reproductive performance

Wide-spread environmental variability over long time scales has been suggested to cause variation in the abundance and distribution of prey species for several populations of pinnipeds that have experienced declines, such as southern elephant seals in the Pacific and Indian sectors of the Southern Oceans, and South American sea lions in the Southern Atlantic Ocean. In other populations, such as Antarctic fur seals and North Sea grey and harbor seals, subtle changes in reproductive performance have also been observed in response to changes in prey availability and might be indicative of possible population declines in the future.

4.6.1.1 Southern elephant seals - Macquarie Island and Îles Kerguelen stocks

Southern elephant seals (*Mirounga leonina*) have a circumpolar distribution and can be divided into three geographically and genetically isolated stocks in the Southern Ocean: the South Georgia stock in the Atlantic sector, the Macquarie stock in the Pacific sector and the Kerguelen stock in the Indian Ocean sector (Laws 1994). They inhabit a variety of subantarctic islands around the Antarctic Convergence and forage widely in the Southern Ocean, feeding primarily on deep, benthic or pelagic prey, mostly squid (Laws 1994). Although most of the populations in the southern Atlantic Ocean are increasing, all other populations endured dramatic declines between the 1940s and 1980s (Hindell *et al.* 1994, Laws 1994).

South Georgia stock

The breeding population at South Georgia represents 54% of the world population of southern elephant seals. Although the number of elephant seals at different breeding colonies has fluctuated somewhat over time, the total population size has not changed significantly since the 1950s (McCann 1985;

McCann and Rothery 1988; Boyd *et al.* 1996). While most other populations in the Atlantic sector of the Southern Ocean are stable or increasing (e.g. Peninsula Valdez, Campagna and Lewis 1992; Falkland Islands, Galimberti and Boitani 1999), the small breeding population at Gough Island has declined over the last 25 years, with only 11 pups produced in 1997 compared to 38 in 1975 (Bester *et al.* 2001).

Macquarie Island stock

In 1990, the Macquarie Island stock represented about 12% of the world population of elephant seals, and had declined 57% from 1949-90 (Laws 1994). Both males and females declined at a rate of 2.1% per year between 1949-85 (Hindell and Burton 1987). In the main breeding area, population estimates declined 46% for females and 48% for males during this time, while census data for the whole island indicate a decline of 53% overall (44% for females and 60% for males) between 1959-85 (Hindell and Burton 1987).

First-year survival declined gradually from 47% in the early 1950s, to around 28% in the early 1960s, then dropped to less than 2% in 1965 (Hindell 1991). By 1993, first-year survival had recovered to 66%. However, the population continued to decline between 1985-93 at a rate of 1.5% annually (McMahon *et al.* 1999). Thus, first-year survival is now high, and comparable to that of the Marion Island population (Bester and Wilkinson 1994; see below).

Compared to the South Georgia population, both juvenile and adult mortality were higher, and weaning mass and adult body size were lower for the Macquarie Island population, suggesting lower growth rates in the declining population. Although the age at first breeding varied considerably since the 1950s, it was consistently higher at Macquarie Island than at South Georgia (5.2 years vs. 4 years, respectively) (McCann 1980; Hindell 1991).

Îles Kerguelen stock

In 1990, the Îles Kerguelen stock represented about 28% of the total population of elephant seals, and had declined dramatically over the previous 40 years (Laws 1994). The Îles Kerguelen stock comprises separate populations breeding at a number of subantarctic islands in the Indian sector of the Southern Ocean; specifically, Marion Island, Îles Crozet (Possession Island), Kerguelen Island and Heard Island.

<u>Marion Island</u>

The Marion Island population declined by 69.5% between 1951-86 and by 37.5% from 1986-97 (Wilkinson and Bester 1988; Pistorius *et al.* 1999a). The annual rate of decrease of the population was estimated to be 4.8 % between 1951-76, then ranged from 4.2% to 8.0% for the period 1973-83 and from 1.9% to 5.9% during 1983-91 (Skinner and van Aarde 1983; Wilkinson and Bester 1988; Bester and Wilkinson 1994; Pistorius *et al.* 1999a). Pistorius *et al.* (1999a) estimated that the population declined by 2.5% annually from 1992-97, and suggested that the population may now be stabilizing.

For the period 1982-93, first-year survival was relatively high at Marion Island, averaging around 60%, while the survival of 3-year-old females and 3-4-year-old males declined significantly during this period (Bester and Wilkinson 1994; Pistorius *et al.* 1999b). The mean age at first pupping was 4 years, similar to that of South Georgia and a year earlier than at Macquarie Island, and fecundity has steadily increased since 1982 (Bester and Wilkinson 1994; Pistorius *et al.* 2001). In spite of this, high mortality rates for 3-year-old females have led to lowered recruitment to the adult population at Marion Island (Bester and Wilkinson 1994).

Îles Crozet (Possession Island)

The Îles Crozet population, located on Possession Island, declined by 70% between 1966-89, with an average annual decline of 5.8% between 1966-76 and 5.7% between 1980-89 (Guinet *et al.* 1992, 1999). The number of breeding females observed at Possession Island did not change significantly between 1990-97, and the population appears to have remained stable since then (Guinet *et al.* 1999). Compared to the population at Îles Kerguelen (see below), elephant seals at Îles Crozet had higher growth rates and weaning weights, and lower age of first pupping (Guinet 1991).

Kerguelen Island

The Kerguelen Island population declined by 48% between 1970-87. The number of breeding females decreased at an annual rate of 4.6% between 1971-77, then by 3.8% annually between 1979-84 (van Aarde 1980; Pascal 1985; Guinet *et al.* 1992, 1999). In the mid 1980s, the population stabilized, and the numbers of breeding females increased significantly at an annual rate of 1.1% from 1987-97. Thus, Kerguelen Island was probably the first location in which the population declines began to cease (Guinet *et al.* 1992, 1999).

Heard Island

At Heard Island, the population was reduced by 47% between 1949-85. Estimates of the annual rate of decline range from to 1.6 to 2.4% (Burton 1986; Slip and Burton 1999). Like the trends observed at Îles Kerguelen, the population of breeding females at Heard Island has changed little since 1985, with an intrinsic rate of increase of 0 - 1.9% annually (Guinet *et al.* 1999; Slip and Burton 1999).

4.6.1.2 Discussion of potential causes of decline for southern elephant seals

Elephant seals exhibit high levels of natal site fidelity, and both genetic and tag resighting data indicate that the declining Macquarie and Kerguelen stocks are genetically isolated, with virtually no emigration of animals out of the region. Thus, the decline of these elephant seal populations must be a result of changes in mortality or in recruitment from within the population (e.g. fecundity, juvenile survivorship and other parameters related to reproductive performance) (Hindell and Burton 1987; Pistorius 1999b).

Although a variety of causes have been hypothesized for the decline of southern elephant seal populations, certain generalizations can be made about the characteristics of the declines (Hindell and Burton 1987; Hindell *et al.* 1994). The declines are not worldwide; for the most part, only populations within the Macquarie and Kerguelen stocks appear to have been affected. Also, other marine mammal and bird species in the Antarctic region do not appear to have suffered similar reductions in numbers, and many increased during the same period (Hindell and Burton 1987). The numbers of animals fell gradually in most populations, with steady rates of decrease ranging from 2-10%, and no apparent differences between adult males and females. The majority of populations experienced declines between the 1950s and 1970s, although close comparisons of the timing of the declines are precluded by insufficient population estimates, especially in the early years. These similarities suggest that a common factor, or group of inter-related factors, may be implicated in the decline of these elephant seal populations (Hindell and Burton 1987; Guinet *et al.* 1992; Hindell *et al.* 1994; Burton *et al.* 1997; Slip and Burton 1999).

Hindell and Burton (1987) and Hindell *et al.* (1994) divided the potential underlying causes of the decline into the following categories: intrinsic population factors, predation, and reduction in prey availability. The distribution or abundance of prey resources may change as a result of trophic interactions, competition from other species or from fisheries, climatic or environmental factors, or a combination of these (Hindell *et al.* 1994).

Intrinsic population factors

Density-dependent changes in survival and fecundity have been demonstrated for several pinniped populations, especially within breeding colonies (Harwood and Rohani 1996). However, most of these changes were attributed to extrinsic factors such as prey availability (see below) and disease, for which there is no evidence in southern elephant seal populations.

Intrinsic population factors may play a role in the population declines, but there is little evidence to support this. For both southern and northern elephant seals (*Mirounga angustirostris*), pup mortality has been found to increase in very dense breeding colonies, but it is unlikely that this mortality could account for the declines of the Macquarie and Kerguelen stocks, since the stable populations at South Georgia also exist under crowded conditions (Hindell *et al.* 1994).

At Marion Island, Skinner and van Aarde (1983) noted a lack of sexually mature subordinate bulls surrounding harems, implying the possibility that not all females leaving the harems were inseminated. These observations led to the "paucity-of-males" hypothesis, which suggests that progressive declines in the number and quality of adult males would limit fertilization opportunities for available females, resulting in a decline in pupping. However, Bester and Wilkinson (1994) observed high pupping rates at Marion Island, and Wilkinson and van Aarde (1999) found that the adult sex ratio was no different from that of populations that were stable or increasing, and that although dominant males did indeed exclude subordinates from mating opportunities, dominant males were capable of inseminating all females in the breeding colony, and each female was mated on several occasions. Thus, the paucity-of-males hypothesis has been dismissed as a possible factor in the decline (Bester and Wilkinson 1994; Wilkinson and van Aarde 1999).

Predation and disturbance

Killer whales (*Orcinus orca*) are abundant at both Marion Island and Îles Crozet and may account for up to 25% of the mortality of recently weaned and juvenile elephant seals there (Condy *et al.* 1978; Guinet *et al.* 1999). In contrast, killer whales are not commonly seen at Îles Kerguelen, Heard Island or Macquarie Island, and any predation at those locations would be negligible (van Aarde 1980; Wilkinson and van Aarde 1999). Thus, the more rapid decline due to heavy predation by killer whales has been implicated as a secondary factor in the declines in elephant seal populations at Îles Crozet and Marion Island (Guinet *et al.* 1992).

Human disturbance is unlikely to play a role in the elephant seal declines, since most of the populations occur on remote islands with minimal human presence. Additionally, Wilkinson and Bester (1988) found no correlation between the rates of decline at Marion Island and elsewhere and the level of onshore human disturbance due to research activities on marine mammals and birds (e.g. tagging, census gathering, etc).

Prey depletion

The diet of southern elephant seals is poorly known, since elephant seals forage widely in the Southern Ocean on mostly benthic prey, and typically do not haul out during the foraging period, making it difficult to obtain stomach or fecal samples. It is generally accepted that southern elephant seals consume large, benthic species of squid, supplemented opportunistically with benthic or pelagic fish such as rockcod (*Notothenia* spp.) and myctophids (*Electrona* spp.) (Green and Burton 1993; Laws 1994). The foraging areas of seals from Macquarie Island and Heard Island / Îles Kerguelen do not overlap, and are likely distinct from those of other southern elephant seal populations (Hindell *et al.* 1991; Slip and Burton 1999). Therefore, widespread trophic or oceanographic changes in the Southern Ocean might have resulted in large scale changes in food availability for these populations of elephant seals, affecting survival and reproductive success (Hindell and Burton 1987; Hindell *et al.* 1994; Guinet *et al.* 1999).

<u>Effect of prey availability on reproductive performance of southern elephant seals</u>

Numerous studies have demonstrated the effect of prey depletion on various reproductive parameters of southern elephant seals. At Marion Island, Pistorius *et al.* (1999b, 2001) found that fecundity increased and age of sexual maturity (e.g. first pupping) decreased as the population declined. Indeed, estimates of fecundity were considerably higher than those reported for other pinniped populations. Pistorius *et al.* (2001) suggest that the changes in these reproductive parameters may have been caused by a density-dependent effect. An increase in per-capita prey availability as the populations of elephant seals declined would have resulted in lower intraspecific competition for food resources, leading to higher growth rates of juveniles and lower age at maturity (Pistorius *et al.* 2001). However, fecundity itself is not likely to be a factor in the population decline; instead, Pistorius *et al.* (1999b) attribute the decline to a decrease in adult and/or juvenile survival. Both pre-weaning and juvenile mortality were lower at Marion Island than at South Georgia, and adult mortality was higher, suggesting that the latter has an important role in the population decline.

Adult survival could be related to food availability, and adult males suffered higher rates of mortality than adult females, likely due to their higher energetic requirements for a larger size and for male-male competition (Pistorius *et al.* 1999b). Over the period 1982-93, the survival of 3-year-old females and 3-4-year-old males declined significantly (Bester and Wilkinson 1994; Pistorius *et al.* 1999b). Seals of this age have increased food requirements relative to older animals, as females are subjected to the physiological and energetic demands of gestation and lactation for the first time while continuing to grow in body size, while males undergo a secondary growth spurt at around this time (Bester and Wilkinson 1994).

In comparison, although adult survival was higher at Macquarie Island than at South Georgia, first-year survival was significantly lower, particularly in the mid-1960s when it decreased dramatically, resulting in the near failure of the 1965 year-class (Hindell 1991). Hindell and colleagues hypothesized that the population at Macquarie might actually be undergoing a natural equilibration process (Hindell and Burton 1987; Hindell 1991; Hindell *et al.* 1994). Since many of the populations of southern elephant seals were historically overexploited by the sealing industry, the seals' prey would have increased in abundance while seal populations were low. Once sealing operations ceased, the seal populations would have rapidly increased and surpassed their original levels, overexploiting their food resources in the process. The declines observed in the 1940s-1980s may therefore represent populations that were approaching an equilibrium level after a period of unusually high numbers; the population at South Georgia would not have been affected since sealing operations there were more carefully managed (Hindell 1991; Hindell *et al.* 1994). In other mammal populations in which a population "overshoot" and subsequent decline has been noted, the decline was principally driven by an increase in juvenile mortality, concurrent with a delay in the age at first breeding (e.g. Testa and Siniff 1987). This hypothesis is consistent with the characteristics of the declines at Macquarie Island and Îles Kerguelen, but fails to explain the rapid decline at smaller populations such as Marion Island, at which commercial sealing was never extensive (Hindell *et al.* 1994).

Burton *et al.* (1997) found that weaning mass of elephant seal pups was lowest within populations that have been in decline, and weaning mass was significantly lower in rapidly declining populations (e.g. Marion and Heard Islands) than in more slowly declining populations (e.g. Macquarie Island). Since weaning mass is directly related to maternal mass, this indicates that adult female southern elephant seals are smaller in declining populations (Arnbom *et al.* 1993). Small size of mothers may be caused by reduced food availability in the southern Indian and Pacific Oceans, although Burton *et al.* (1997) are cautious to attribute the decline of these populations to differences in prey resources, noting that there might be survival advantages to higher weaning mass at South Georgia but not in the other regions. However, the fact that higher weaning masses were recorded at Macquarie Island than at Marion and Heard Islands is suggestive of a density-dependent effect, and more research is required to investigate this possibility (Burton *et al.* 1997).

<u>Effect of competition / fisheries on prey availability for southern elephant seals</u>

Since elephant seals forage at great depth on primarily benthic prey, there is little potential for overlap of prey species with other marine mammals or birds (Hindell *et al.* 1994). However, some fisheries operating on or near the foraging grounds used by southern elephant seals may have the potential for direct or indirect competition.

A commercial fishery trawler fishery for numerous pelagic species (e.g. Antarctic icefish *Champsocephalus gunnari*, Patagonian toothfish *Dissostichus elegenoides*, marbled rockcod *Notothenia rossii* and grey rockcod *Lepidonotothen squamifrons*) has operated around Îles Kerguelen since the early 1970s, and has been implicated as a possible factor in the decline of local elephant seal populations (van Aarde 1980; Pascal 1985; Green *et al.* 1998). van Aarde (1980) suggested that prey exploitation by commercial fisheries might have caused either an increased mortality rate or a decreased reproduction rate for elephant seals at Îles Kerguelen, possibly by older or more experienced females marginalizing subadult females into areas of lower food abundance or quality. However, Guinet *et al.* (1992) rejected this hypothesis as a factor in the decline, as fish stocks continued to be depleted by fisheries after the population of elephant seals stabilized.

Like elephant seals, other species that prey mostly on squid (e.g. wandering albatrosses *Diomedea exulans*, sooty albatrosses *Phoebetria fusca*) were also found to decline sharply during the same period (Weimerskirch and Jouventin 1998). Even though some of the wandering albatross mortality could be attributed to bycatch in long-line fisheries, the stabilization and subsequent increase of the wandering albatross population in the mid 1980s, concurrent with constant fishery effort, suggest that other factors may have contributed to their previous decline. Guinet *et al.* (1992) and Weimerskirch and Jouventin (1998) proposed that a possible decrease in local squid availability may therefore be implicated in the decline in both elephant seal and albatross populations at Îles Kerguelen. In contrast, populations of other subantarctic predators, such as penguins, fur seals and baleen whales, that prey mostly on krill and small pelagic fish were found to be steadily increasing over the same period (e.g. Croxall *et al.* 1988; Weimerskirch *et al.* 1992; Boyd 1993).

In 1994, a formal proposal was made for a commercial fishery for toothfish near Heard Island, and Green *et al.* (1998) warned that since the diet of Heard Island elephant seals appears to include toothfish and grey rockcod in relatively high proportions (Green and Burton 1993), such a fishery would certainly lead to intense competition for available fish between the industry and elephant seals. As of 2000, trawl fisheries for mackerel icefish and Patagonian toothfish were operating near Heard Island, with total allowable catches (TACs) of 1150 tonnes and 3000 tonnes respectively (CCAMLR 2000). Experimental trawl and longlining fisheries have also been authorized for Elan Bank, southwest of Heard Island (CCAMLR 2000).

A commercial trawler fishery for toothfish was also developed in 1994 around Macquarie Island. Diet analysis revealed a 19% overlap in squid consumption between elephant seals and toothfish at Macquarie Island, although each predator targeted different species of squid (*Kondakovia* sp. versus *Gonatus antarcticus*, respectively) (Goldsworthy *et al.* 2001). Toothfish were not found in the diet of elephant seals. Therefore, although there were weak trophic linkages among the toothfish, its fishery, and the marine mammal populations, the fishery is currently not implicated in the elephant seal decline at Macquarie Island.

<u>Effect of environment or climate on prey availability for southern elephant seals</u>

Large-scale oceanographic changes in the Southern Ocean ecosystem may have caused a decrease in the biological productivity of the area, leading to a reduction in available prey for elephant seals. There is evidence of a decline in the extent of Antarctic sea-ice that occurred from the mid 1950s to the mid 1970s, resulting in a 25% reduction of sea-ice cover and a 2.8° shift southward of the marginal sea-ice edge (de la Mare 1997). Since the sea-ice edge has an important role in primary production, such a decline would have had dramatic effects on the biological productivity of the Antarctic ecosystem. The timing of the sea-ice decline coincided with that of declines in elephant seal populations in the region, especially those at Heard Island, Îles Kerguelen and Macquarie Island, although there are insufficient data to enable statistical correlations (Slip and Burton 1999).

Other changes in atmospheric circulation and an increase in sea temperature were observed in the southern Indian Ocean from the mid 1960s to the mid 1980s (Allison and Keage 1986). A large low pressure trough situated over the Vestfold Hills region of Antarctica was found to deepen in the late 1960s, at the same time as increases in first-year mortality were observed at Macquarie Island (Hindell *et al.* 1994). Fluctuations in atmospheric conditions in the Vestfold Hills, where elephant seals from the Kerguelen and Macquarie stocks are known to forage, may have affected oceanographic conditions and caused changes in the abundance or distribution of prey resources in that ecosystem (McCann and Rothery 1988; Gales and Burton 1989; Hindell *et al.* 1994).

Fluctuations in ice cover, sea temperature and atmospheric conditions occur periodically in the Southern Ocean, but the extent and effects of these vary from region to region (Sahrage 1988). The marine ecosystem is more productive around South Georgia than around Macquarie Island, with a more extensive continental shelf that supports larger stocks of fish and krill, a prey resource for squid, while stocks of krill- and squid-eating large whales have been reduced locally (Sahrhage 1988). Thus, elephant seal populations at South Georgia might be less limited by food availability than elsewhere (McCann 1980; Hindell *et al.* 1994; Boyd *et al.* 1996).

4.6.1.3 Summary of causes of decline for southern elephant seals

The period of rapid decline appears to have ended for all of the breeding populations in both the Kerguelen and Macquarie stocks; these populations now appear to have stabilized or are decreasing or increasing slightly. It is possible that major oceanographic or trophic changes in the Southern Ocean have resulted in large scale changes in food availability for these populations of elephant seals. Interrelated, secondary factors could include localized predation, competition with commercial fisheries, and changes in sea-ice condition altering the productivity of the Southern Ocean (Hindell *et al.* 1994; Guinet *et al.* 1999; Slip and Burton 1999; Pistorius *et al.* 2001).

If southern elephant seal populations are impacted by accessibility to food resources that are patchily distributed in space and time, then certain predictions are available for testing. Seals would be expected to adjust their foraging strategies over short time spans to compensate for changes in prey density and location, and first-year survivorship is expected to vary accordingly (Hindell *et al.* 1994). Alternatively, if the populations are declining as a result of an inherent equilibrium process, as suggested by Hindell (1991) and Hindell and Burton (1987), then growth rates and first-year survival are expected to increase as the populations return to their original levels (Hindell *et al.* 1994). In either case, few conclusions can be made without new studies of the diet and foraging behaviour of first-year seals and of long-term demographic comparisons among the declining populations that are designed to specifically identify the cause of the decline (Hindell *et al.* 1994).

4.6.2 Antarctic fur seals at South Georgia

Antarctic fur seals (*Arctocephalus gazella*) are distributed primarily in the Atlantic sector of the Southern Ocean. South Georgia, including Bird Island, supports the largest breeding population of Antarctic fur seals, representing about 96% of world-wide pup production for the species, with an estimate of 1.5 million animals in 1990 (Boyd 1993). Smaller colonies have been established at Marion, South Shetland, South Orkney, Kerguelen, Heard and Macquarie Islands, primarily as a result of emigration of pregnant females from South Georgia (Boyd 1993).

4.6.2.1 Description of the population dynamics of Antarctic fur seals

Antarctic fur seals were reduced to the brink of extinction by the sealing industry in the 18th and 19th centuries. Since commercial exploitation ceased, populations of Antarctic fur seals have been increasing rapidly, and some studies suggest that the increased availability of krill after the reduction of baleen whale populations in the area may have fueled the dramatic rise of the Antarctic fur seal population at South Georgia (Croxall *et al.* 1988). The population steadily increased at an annual rate of 16.8% between 1957-72, then at 11.5% between 1972-76 and 9.8% from 1976-90 (Boyd 1993). Because pup production generally remained high at all breeding colonies during this period, Boyd (1993) attributed the slowing annual rate of increase of the population to emigration and establishment of new colonies due to overcrowding of breeding beaches.

Although other colonies around South Georgia continued to increase, the population of Antarctic fur seals at Bird Island began to decline in the early 1990s, with a negative trend in both number of pups born (-7.3% per year) and birth mass of pups (Reid and Croxall 2001). Indices of reproductive success such as the number of pups surviving to 30 days and the weaning mass of pups (at 120 days) tended to be negative during the 1990s, although these parameters varied substantially between years (Reid and Croxall 2001).

One breeding colony of Antarctic fur seals, on Seal Island in the South Shetland Islands, has also experienced declines in pup survival and weaning rates, but this has been attributed to localized predation on fur seal pups by leopard seals (*Hydrurga leptonyx*) and the population does not appear to be food-limited (Boveng *et al.* 1998), so will not be discussed here.

4.6.2.2 Effect of prey availability on reproductive performance of fur seals

Prior to the declines at Bird Island, numerous studies had reported variation in reproductive parameters in relation to local prey availability. At South Georgia, female reproductive performance is susceptible to large-scale fluctuations in food resources because lactating females feed almost exclusively on krill and few alternative prey species are available to exploit near the breeding colonies (Lunn *et al.* 1994). Antarctic fur seals have a lactation period of around 4 months, which is considerably shorter than that of other fur seals. Thus, energy must be transferred to pups at a higher rate in the limited period available for foraging (Boyd 1993, 1999). In addition, since ovulation and implantation overlap with lactation of the previous year's pup, the nutritional requirements of reproduction are spread over two summers (Lunn and Boyd 1993).

The population at South Georgia experiences periodic reductions in krill (in particular, krill abundance was low in 1983-84, 1990-91 and 1993-94; Priddle *et al.* 1988), which affect female reproductive performance in the following ways. Female fur seals invested a significantly greater effort in foraging during periods of low prey abundance by increasing the time spent foraging to 6-7 days, compared to 3-4 days in periods of high prey availability, thereby increasing the costs of foraging by 30-50% (Croxall *et al.* 1988; Lunn and Boyd 1993; Boyd *et al.* 1994). Longer feeding trips resulted in a suppression of pup growth rate since pups were fed less frequently by their mothers (Lunn *et al.* 1993; Boyd *et al.* 1995).

Periodic reductions in krill influence pup production and weaning success, as lower birth weights of pups were correlated with low food availability (Croxall *et al.* 1988). Also, in the year following a season of low krill abundance, female fur seals were less likely to pup or gave birth later in the season (Lunn and Boyd 1993; Lunn *et al.* 1994). In the 1990-91 breeding season, pup production was reduced to 66% of the previous season (Croxall *et al.* 1988). Thus, local prey depletion has effects on pup production that are not confined to a single season (Lunn and Boyd 1993).

Reductions in prey abundance also appeared to influence adult female survival rates, but were not correlated with pregnancy rates (Lunn and Boyd 1993; Boyd *et al.* 1995). Food availability may have a greater role during the winter when adult females are pregnant; however, no data are available on winter foraging behavior or diet of females (Boyd *et al.* 1995).

4.6.2.3 Discussion of causes for the decline at Bird Island and reproductive effects elsewhere

The Antarctic Peninsula marine ecosystem that includes South Georgia is a region of exceptionally high primary productivity, supported by the transport of cold, nutrient-rich water from the Weddell Sea. The Southern Ocean is characterized by relatively simple trophic interactions and the presence of a keystone prey species, Antarctic krill (*Euphausia superba*), that is consumed by the majority of seabirds, baleen whales and pinnipeds that inhabit the region. Fluctuations in abundance and distribution of krill occur regularly in the Southern Ocean, and these have been attributed to a complex interaction of large-scale climatic and biological processes at a range of scales (reviewed in Sahrhage 1988; see also Priddle *et al.* 1988; Reid *et al.* 1999; Murphy and Reid 2001).

Priddle *et al.* (1988) suggest that the distribution of krill could be affected by periods of prolonged southwards airflow over the Scotia Sea that would cause southward displacement of warm surface water and pack ice within the Weddell Sea. This ocean-atmospheric process would result in the redistribution of krill away from its normal areas of abundance (Priddle *et al.* 1988). Similarly, Loeb *et al.* (1997) indicate that krill reproduction and survival is positively correlated with the extent of sea-ice coverage. Since the 1950s, mean annual air temperature has increased by 4-5 EC in the Antarctic Peninsula region and this warming trend has been implicated in the reduction of sea-ice cover (Sahrhage 1988; de la Mare 1997; Reid and Croxall 2001). A long-term environmental change may therefore be occurring in the Antarctic Peninsula that might have considerable consequences for populations of krill and their predators (Reid *et al.* 1999; Reid and Croxall 2001).

Since the 1990s, negative trends in reproductive performance and population size have been recorded for most of the krill-dependent predators at South Georgia, including Antarctic fur seals, macaroni penguins (*Eudyptes chrysolophus*), gentoo penguins (*Pygocelis papua*) and black-browed albatrosses (*Thalassarche melanophrys*) (Reid and Croxall 2001). This suggests that a distinct change occurred within the krill population around 1990 that appears to have brought the supply of krill close to the level of predator demand (Reid and Croxall 2001). Levels of krill harvesting in the Southern Ocean have been relatively small (about 100,000 tonnes per year) compared to the amount of krill consumed by seabirds and seals, so commercial fisheries are not currently expected to have much of an effect on Antarctic fur seal population size (Croxall *et al.* 1988; Harwood and Croxall 1988). However, several authors caution that assessment of the amount of krill available to fisheries must consider these predator-prey interactions and adopt precautionary measures accordingly (Everson and de la Mare 1996; Constable *et al.* 2000; Reid and Croxall 2001).

4.6.2.4 Summary of effects of prey depletion on Antarctic fur seals

There is little doubt that Antarctic fur seals are affected by variability in abundance and distribution of krill, their primary food resource. However, some authors also suggest that Antarctic fur seals, which were harvested to low levels, may now be approaching an equilibrium point that might represent their historical population size (Croxall *et al.* 1988). Thus, the population would be expected to fluctuate considerably and then stabilize once natural limits to its population growth have been reached (Croxall *et al.* 1988; Lunn *et al.* 1993). It is possible that the recent declines at Bird Island could be indicative of an interaction between this process and local or seasonal prey depletion (Reid and Croxall 2001).

4.6.3 Grey Seals, Harbor Seals and the North Sea Industrial Sandeel Fishery

The industrial fishery for sandeel (sand lance, *Ammodytes maritimus*) is the largest single species fishery in the North Sea, with annual catches of up to 100,000 tonnes since 1990 (Gislason and Kirkegaard 1996). Sandeels are important prey for numerous species of fish, seabirds and marine mammals, and the reproductive success of some seabirds has been shown to be dependent on local availability of sandeels (Furness and Tasker 2000). Recently, concern has been raised over the potential for overexploitation of this fishery and its effect on predator species, and a precautionary approach to its management has been urged (Gislason and Kirkegaard 1996; Furness 1999).

Grey seals (*Halichoerus grypus*) in Britain breed along the northeast coast of Scotland, including the Orkney, Hebrides, Shetland and Farne Islands and the Isle of May. The population of British grey seals was estimated at over 100,000 individuals in 1994, and has been steadily increasing at 5-7% annually since the 1950s (Harwood and Prime 1978; Hiby *et al.* 1996). Grey seals forage in the Moray Firth, the Firth of Forth and the North Sea, targeting primarily sandeels as well as gadids (esp. cod *Gadus morhua*), flatfish and sculpins (Hammond and Prime 1990; Hammond *et al.* 1994).

Although grey seal populations in the North Sea are steadily increasing, Pomeroy and Duck (2000) found that for grey seals breeding at the Isle of May, availability of sandeels (estimated by CPUE of the commercial fishery) was negatively correlated with the proportion of female seals that failed to give birth in a given year, as well as with the number of puppings that failed. Individual differences in foraging strategies appeared to be a factor, as seals that shifted to an alternative prey source when sandeels were depleted locally had better reproductive success. Thus, the sandeel fishery may have a direct effect on reproductive performance of this population of grey seals, in particular for those seals that continue to target sandeels (Pomeroy and Duck 2000).

Harbor seals (*Phoca vitulina*) are sympatric with grey seals in Britain and consume similar prey species, but occur in far fewer numbers and typically forage closer to haul-out locations than grey seals do (Thompson *et al.* 2001). The British population was estimated at around 25,000 in 1994, and had experienced a reduction in numbers of about 50% in the 1988 phocid distemper epidemic (Heide-Jørgensen *et al.* 1992; Hiby *et al.* 1996).

Recent surveys have revealed a decline of 16-36% in the numbers of harbor seals at Orkney, and an absence of yearlings, suggesting a reduction in local recruitment (Thompson *et al.* 2001). These authors attribute the decline at Orkney to changes in sandeel availability related to levels of commercial harvest. Local depletion of sandeel stocks could have caused a redistribution of seals to alternative foraging areas, or harbor seals might incur competition from grey seals in the same area. In addition, alternate prey sources might be not be as abundant nor as high quality as sandeels, which would lead to changes in the reproductive performance or survival of harbor seals (Thompson *et al.* 2001). These hypotheses remain to be tested.

The study of Isle of May grey seals (Pomeroy and Duck 2000) might be the first to demonstrate a definitive link between fisheries-induced prey depletion and pinniped reproductive performance. Although the grey seal population is not currently declining, the negative trends in reproductive success coincident with the decline of a sympatric harbor seal population suggest that both species may be at risk for being negatively impacted by the sandeel fishery in the future (Pomeroy and Duck 2000; Thompson *et al.* 2001). This might represent a similar situation to that of Antarctic fur seals at South Georgia, in which changes in reproductive performance were noted over a long period of time before the population was observed to decline (Reid and Croxall 2001).

4.6.4 South American Sea Lions in Argentina and the Falkland Islands

South American sea lions (*Otaria flavescens)* are distributed widely around the southern coasts of South America, from Peru to southern Brazil, as well as on the Falkland Islands, and the worldwide population was estimated to be over 300,000 in the late 1980s (Bonner 1999). Throughout their range, South American sea lions were historically subjected to subsistence and commercial harvesting, which currently continue in Chile and Uruguay (Bonner 1999).

In the Falkland Islands, the sea lion population declined from 400,000 to 30,000 individuals between 1937-65, representing a 93% decrease in pup production and an 8.8% annual rate of decline (Strange 1979; Gerber and Hilborn 2001). Similarly, in Argentina, the populations fell from 137,000 to 14,000 from 1938-75 at Peninsula Valdez and from 33,000 to 8,800 during 1947-72 in central and southern Chubut (Ximenez 1976; Reyes *et al.* 1999). The cause of the declines is currently unknown. Harvesting occurred in both areas during this time, but was insufficient to explain the massive decline in numbers (Gerber and Hilborn 2001).

Commercial fisheries have been implicated as a potential factor in prey availability for South American sea lions in Argentina, in addition to causing incidental mortality (Crespo *et al.* 1997). Trawl fisheries for hake (*Merluccius hubbsi*) and shrimp (*Pleoticus muelleri*) overlap considerably with the foraging areas and fish sizes consumed by male sea lions, while jigging fisheries target the same size of shortfin squid (*Ilex argentinus*) as female sea lions, although the fisheries tend to operate further from the coast than the sea lions (Crespo *et al.* 1997). The large amount of hake discarded by the trawl fishery presents a concern for the future abundance of the hake stock and its subsequent availability to sea lions in the area.

Although there appear to be links between sea lion prey availability and commercial fisheries operating in Argentina and the Falkland Islands, these have not been tested. Exploration for oil in the area might have also had an affect on sea lion populations. However, since harvesting levels fail to account for the rate or extent of the declines, it is possible that fisheries or other human interactions could be implicated in the decline of the South American sea lions during the 1940s to 1970s, and may also be factors in the slower than expected recovery of the populations (Crespo *et al.* 1997; Reyes *et al.* 1999; Gerber and Hilborn 2001).

4.6.5 Short-term Catastrophic Events

Large-scale, catastrophic changes in food availability impact populations in a similar way as disease; mortality is typically wide-spread and independent of population size. Even though one or more cohorts may be completely lost or may fail to recruit, the effect on the population's long-term dynamics is usually temporary (Harwood and Rohani 1996; Geraci *et al.* 1999). Mass mortality events were caused by drastic reductions of food resources for harp seals in the Barents Sea, for many pinniped populations during El Niño events, and for Cape fur seals in Namibia.

4.6.5.1 Harp seals in the Barents Sea

Harp seals (*Pagophilus groenlandicus*) are the most abundant seal species in the Barents Sea. In the late 1970s, the population of harp seals in the Barents Sea was estimated to be 800,000 animals, increasing at a rate of 5% annually (Haug *et al.* 1991). In winter and spring, harp seals breed and molt on the pack-ice in the White Sea. After molting, the seals migrate north and northwest into the Barents Sea as the ice edge recedes, and spend the summer and fall widely dispersed in open waters along the pack-ice. In the late summer, the seals prey on the abundant pelagic amphipod *Parathemisto libellula*, then in fall begin to prey on pelagic schooling fishes, primarily capelin (*Mallotus villosus*), and herring *(Clupea harengus)* to a lesser extent. Polar cod (*Boreogadus saida*), amphipods and krill are also taken opportunistically (Lydersen *et al.* 1991; Haug *et al.* 1994; Nilssen 1995; Nilssen *et al.* 1995). The seals normally migrate back to the coastal waters of the southeastern Barents sea in early winter as the ice cover increases to the south (Haug *et al.* 1994).

Description of the harp seal decline

In the early 1980s, large numbers of seals began appearing along the northwest coast of Norway during the winter and spring; such aberrant migration patterns or "invasions" had been recorded periodically over the last century (Wiig 1988). Many seals were incidentally drowned in static fishing gear deployed along the coast, and due to damage to gear and reduced catches, the Norwegian government began to pay a compensation to fishermen who caught seals in their gill-nets (Nilssen *et al.* 1998). In the early 1980s, between 500 to 2000 seals per year were recorded as bycatch, although it is assumed that these figures are under-reported, and some sources estimate as many as 10,000 seals per year may have drowned (Haug *et al.* 1991; Nilssen *et al.* 1998)

In 1987 and 1988, the magnitude and geographical extent of the invasions increased dramatically, with seals appearing all the way to Norway's southern coastline (Nilssen *et al.* 1998). In 1987, 56,000 seals were reported as incidental bycatch, and the actual mortality that year has been estimated as high as 100,000 (Wiig 1988; Haug *et al.* 1991). In 1988, over 21,000 seals were reported, and by 1989 the seal mortality had returned to the level of the early 1980s (Haug *et al.* 1991). Most of these seals were caught in winter and spring, and the majority were immatures (younger than 4 years) of both sexes, or mature males (Haug *et al.* 1991). Many of the seals were in poor body condition (Wiig 1988; Øritsland 1990), and 8-27 % of seals sampled had empty stomachs (Haug *et al.* 1991). Stomach analyses of by-caught seals indicated that feeding had been opportunistic, consuming a variety of gadoid species such as cod (*Gadus morhua*), saithe (*Pollachius virens*), haddock (*Melanogrammus aeglefinus*) and Norway pout (*Trisopterus esmarckii*), while herring was present in much lower quantities. Capelin was present in only a few of the seal stomachs, and was absent from seals sampled in the northern Barents Sea during the same time period (Haug *et al.* 1991; Lydersen *et al.* 1991; Nilssen *et al.* 1995; Ugland *et al.* 1993). More deviations in the normal migration to the Barents Sea were also recorded in Russia, where many harp seals in poor body condition appeared along the Russian coasts of the White Sea during the summer months of 1987 and 1988 (Timoshenko 1995).

Factors causing the population changes for harp seals

The deviant migration pattern and subsequent mass mortality of harp seals in 1987-88 was likely caused by a complex interaction of environmental and ecological factors in the Barents Sea marine ecosystem (Haug and Nilssen 1995; Nilssen *et al.* 1998).

The Barents Sea is a highly productive area which sustains large populations of zooplankton (primarily copepods, krill and amphipods) and serves as a nursery area for the larvae and juveniles of several stocks of fish that spawn along the western and northwestern coast of Norway, including herring, cod, haddock and saithe (Sakshaug *et al.* 1994; Gjøsæter 1995). The zooplankton is harvested primarily by capelin, and to a lesser extent by polar cod and juvenile herring. These species are in turn predated by Arctic cod, sea birds, minke (*Balaenoptera acutorostrata*) and other baleen whales, harp seals and commercial fisheries (Gjøsæter 1995).

The Barents Sea capelin stock was historically one of the largest capelin stocks in the world. Its size has varied considerably since the early 1970s, averaging about 4 million tonnes with peaks in 1975 and 1980 of up to 8 million tonnes, with concurrent fishery catches ranging from 1.3 to 3 million tonnes (Gjøsæter 1995). In 1985-87, the Barents Sea capelin stock was reduced to less than 100,000 tonnes; this collapse was attributed to a number of environmental factors, summarized in Hopkins and Nilssen (1991) and Gjøsæter (1995). The change in oceanographic conditions in the Barents Sea appeared to originate with an inflow of Atlantic water in 1982-83 that transported in large stocks of zooplankton, providing favorable recruitment conditions for herring and Arctic cod in the Barents Sea. Predation by herring on capelin larvae caused a complete recruitment failure of the 1984 and 1985 year classes of capelin. The increased water inflow also caused a reduction in available zooplankton, and concurrent higher water temperatures in the Barents Sea lead to a decreased growth rate for maturing year classes of capelin. At the same time, large populations of juvenile cod predated heavily on the declining capelin stock after depleting the available stocks of herring (Hopkins and Nilssen 1991; Gjøsæter 1995). The capelin collapse was further compounded by commercial fishery catches that may have been too high given the concurrent reduction in capelin stocks (Hopkins and Nilssen 1991; Nakken 1998).

Fluctuations in fish populations appear to be inherent in the Barents Sea ecosystem, with periods of high capelin abundance, and low herring and cod recruitment, alternating with periods of strong herring and cod populations and concurrent reductions in capelin stocks (Hopkins and Nilssen 1991; Saksaug *et al.* 1995; Gjøsæter 1995; Nakken 1998). Capelin stocks returned to high levels by the early 1990s, but collapsed again in 1992-94, while the abundance of juvenile herring in the Barents Sea increased substantially in the early 1990s (Gjøsæter 1995).

Discussion of factors contributing to the harp seal population changes

Although researchers (e.g. Haug *et al.* 1991; Kjellqwist *et al.* 1995) were originally reluctant to attribute the 1987-88 invasion of harp seals to the 1985-87 capelin collapse, Haug and Nilssen (1995) and Nilssen *et al.* (1998) argue that observations of density-dependent responses (such as poor condition, increased age at maturity and decreased female fecundity) support the hypothesis that prey depletion may have caused seals to leave their traditional wintering areas in the Barents Sea and invade the Norwegian coast in search of food. High levels of mortality, particularly of juveniles, lead to decreased recruitment to the harp seal population in the late 1980s (Haug and Nilssen 1995).

Seal invasions into Norwegian waters occurred again when the capelin stock collapsed in 1992-94, but the levels of mortality were small compared to those of the 1987-88 event (Nilssen *et al.* 1998). There is evidence that since the early 1990s, the abundance of immature herring in the Barents Sea has provided an alternative winter food resource for the seals, thereby reducing the impact of fluctuating capelin stocks (Nilssen *et al.* 1998). Indeed, capelin appears to be largely absent from the diet of harp seals during the 1990s, while herring and polar cod predominate (Lindstrøm *et al.* 1998). However, the reduced size of the more recent invasions may have also been related to a relatively low population size as a result of the poor recruitment in the 1980s (Haug and Nilssen 1995).

Recovery of the harp seal population

The high mortality experienced during the 1987-88 seal invasions had dramatic effects on the demographics of the harp seal population (Kjellqwist *et al.* 1995). There was a gradual decline in the abundance of young seals throughout the 1980s. In 1987, at the peak of the seal invasion, the 1986 year class (e.g. one-year-olds) was absent from samples, and seals born in 1987 and 1988 were very scarce in subsequent years. Recruitment of one-year-old seals did not improve until after 1992 (Kjellqwist *et al.* 1995). The mean weight of pups on the breeding grounds in the White Sea in 1987-89 was significantly lower than in surrounding years (Timoshenko 1995).

During the 1990s, the harp seal population remained at lower levels than had been recorded in the 1970s (Haug and Nilssen 1995). Øien (1994, in Nilssen *et al.* 1998) estimated the population to be 600,000 in 1991. Harvest quotas for Norway and Russia were reduced following the harp seal invasions, and have remained at 40,000 seals per year since 1989 (Kjellqwist *et al.* 1995). However, the Barents Sea harp seal stock has since rebounded, and in 1999 the population was estimated to be 2.2 million (Nilssen *et al.* 2000).

4.6.6 El Niño

El Niño Southern Oscillation (ENSO) events occur periodically in the Pacific Ocean, causing large-scale changes in productivity in the normally rich upwelling systems inhabited by pinnipeds and redistributing prey stocks away from their foraging grounds. The effects of El Niño on pinniped populations are well documented and are summarized in Trillmich and Ono (1991). In the severe El Niño event of 1982-83, widespread mortality of pups and juveniles occurred, particularly for fur seals and sea lions in the Galapagos Islands, Peru and Chile (Trillmich and Ono 1991). In many cases, a large proportion of adult females and territorial males also died, resulting in a significant reduction in reproductive potential for species such as Galapagos fur seals (*Arctocephalus galapagoensis*) and South American fur seals (*A. australis*) (Trillmich and Ono 1991). El Niño events as recent as 1997-98 have continued to cause massive declines in some South American populations that are still recovering from previous events.

While effects were not as severe in the northern Pacific region, El Niño events caused higher than normal mortality due to starvation of juvenile age classes of California sea lions (*Zalophus californianus*), northern fur seals (*Callorhinus ursinus*) and northern elephant seals in islands off California (Trillmich and Ono 1991). In addition, heavy storms along the California coast caused separation of pups from mothers in breeding colonies and resulted in redistribution of breeding colonies and suppressed pupping rates (Sydeman and Allen 1999). Most of the populations of pinnipeds in California, with the exception of the Steller sea lion, appear to have recovered from the effects of El Niño (Barlow *et al.* 1998; Sydeman and Allen 1999). However, periodic El Niño events continue to cause strandings of emaciated or "orphaned" pups (Mair 1998; Zagzebski *et al.* 1999).

Although El Niño events are concentrated primarily in the Pacific Ocean, changes in reproductive performance were also documented for pinniped populations in other regions. Pup production of Antarctic fur seals at South Georgia and Îles Crozet was depressed during the season following El Niño, and demographic changes in Antarctic phocids were also observed (Croxall *et al.* 1988; Testa *et al.* 1991;

Boyd 1993; Guinet *et al.* 1994). A secondary El Niño effect was also noted for fur seals in Namibia (see below) (Agenbag 1996).

4.6.6.1 Cape fur seals in the Benguela System, Namibia

South African or Cape fur seals (*Arctocephalus pusillus pusillus*) occur along the western coasts of South Africa and Namibia, and are occasionally seen in Angola (Roux 1997). The population was estimated at 1.7 million (aged 1+) in 1993, and had been increasing at a rate of 3.7% annually since the early 1970s (Butterworth *et al.* 1995). Cape fur seals have historically been harvested in both South Africa and Namibia, both for commercial purposes or to manage population levels in order to protect fisheries (Punt and Butterworth 1995). Fur seals in this area forage inshore on a variety of prey, including anchovy (*Engraulis capensis*), snoek (*Thrysites atun*), pilchard (*Sardinops sagax*), Cape hake (*Merluccius capensis*) and cephalopods (Punt *et al.* 1995).

A climatic anomaly caused an intrusion of warm, poorly oxygenated water into the Benguela upwelling system off Namibia from late 1993 to early 1994 (Agenbag 1996). While it is unclear what caused the unusual oceanographic condition, it is possible that its effects magnified a significant decline in anchovy stocks that had been underway since the 1991-93 El Niño event, resulting in massive reductions of anchovy and pilchard populations from the continental shelf (Agenbag 1996).

In 1993-94, populations of Cape fur seals along the Namibian coastline experienced an episode of mass mortality affecting all age and sex classes (summarized in Roux 1997; see also Anselmo *et al.* 1995). Pup growth was very poor at the outset of the 1993-94 breeding season, and by early 1994, starvation and abandonment resulted in the highest levels of pup mortality ever recorded for this species. By May 1994, an estimated 120,000 pups had died, and emaciated adults and juveniles of both sexes began to wash up along the Namibian coastline in large numbers. Those adult females that survived were typically emaciated, and many aborted their pups later in the year; at one colony, more than 40,000 aborted fetuses were counted through October 1994. In the 1994-95 pupping season, pup production was 50-70% lower than the two previous seasons, while mass of pups at birth and early pup survival were the lowest recorded (Roux 1997).

The high mortality rates of 1994 were predicted to cause a “slight delay” in the overall trend of increasing abundance of Cape fur seals, and some speculated that the reduction in pup production was an indication that the species had approached its carrying capacity (Butterworth *et al.* 1995). Bonner (1999) lists the current population at 1.1 million but provides no other information about the population status. Commercial harvesting of pups and bulls has continued in Namibia, and the 2000 quota of 60,000 pups and 7,000 adult males was almost double that of previous years (Anon. 2000).

Recent reports suggest that a similar decline might have been occurring in Namibia during the 2000-01 breeding season (Anon. 2001). A weakening of the southern trade winds was expected to cause a redistribution of prey species into deeper waters offshore, and an estimated 150,000 pups were predicted to starve as a result. In January 2001, abortion rates and pup mortality rates were approaching those recorded for the 1993-94 mass mortality event (Anon. 2001). However, there is a lack of information on the outcome of these observations.

4.6.7 Summary

Comparative analyses of pinniped populations can be useful in identifying patterns and relationships among environmental variability, trophic interactions and anthropogenic factors that may play a role in population declines (Shima *et al.* 2001). Pinniped populations have been observed to respond to changes in food availability by moving to other areas or switching to other food resources, decreasing their growth rate, or economizing on reproductive performance (Harwood and Rohani 1996). In this review, responses of pinniped populations to local prey depletion were variable, ranging from dramatic declines in which the causative factors were relatively clear (Barents Sea harp seals, Cape fur seals), to more subtle changes in demographic characteristics and reproductive parameters such as survival, growth rates, and age-class structure that were related to a variety of factors (Southern elephant seals, Antarctic fur seals, North Sea grey seals) (Bowen *et al.* 2001). In all of the declines, juvenile survival was affected either directly or indirectly.

Of the cases present here, the primary prey of most of the pinnipeds were pelagic schooling fish, although southern elephant seals target deep-sea squid and adult female Antarctic fur seals prey exclusively on krill. The ability to switch to alternate sources of prey was variable, or unknown in some cases; the foraging behaviour of Barents Sea harp seals and North Sea grey seals appeared to be the most flexible, while the diet of Antarctic fur seals and southern elephant seals was more constrained. When catastrophic environmental perturbations occurred, such as El Niño or the Benguela current anomaly, virtually all prey disappeared and prey switching did not appear to be an option for affected pinniped species.

Phocid populations appeared to respond to prey depletion in a different way than otariids, since both southern elephant seals and Barents Sea harp seals appeared to be affected during the pelagic foraging period, while the declines of the fur seal and sea lion populations were typically linked to the breeding season. This is likely because of the difference in lactation strategies between phocids and fur seals. In phocids, mothers fast while lactating, so food availability is most important to foraging adults prior to or after the breeding season, but these adults can and do forage widely in search of prey. In contrast, fur seals and sea lions forage throughout lactation, but are limited geographically by the need to return every few days to nurse their pup; thus, when prey is patchy, mothers must either forage more widely, risking starvation of the pup, or must settle for lower quality prey, impacting weaning success. Thus, food availability appears to directly affect pup survival in species that forage throughout lactation.

Large-scale environmental variation has played a role in most of the cases profiled here, either directly (e.g. El Niño, Cape fur seals) or indirectly by causing changes in prey availability (e.g. southern sea lions, Antarctic fur seals, Barents Sea harp seals). Large marine ecosystems are inherently variable, both within and between years, and include systemic changes in physical processes that impact all levels of the food web. However, the consequences of environmental changes are not necessarily the same for each population, and are difficult to assess (Reid and Croxall 2001; Shima *et al.* 2001). Mass mortalities might increase the risk of extinction for populations that are already at very low levels, although for most otariid populations, the rate of population increase does not appear to change at low densities, indicating a resilience to the effects of population declines (Harwood and Rohani 1996; Gerber and Hilborn 2001).

Although not always implicated in the declines, commercial fisheries were also commonly associated with ecosystems that include declining populations of pinnipeds (e.g. southern elephant seals, South American sea lions, North Sea grey and harbour seals, Barents Sea harp seals). The interaction of marine predators and commercial fisheries is complicated by the fact that in most marine ecosystems, other fish species are the most important predators of prey species targeted by both pinnipeds and humans (Yodzis 2001). Thus, multi-species approaches are necessary for assessing competition between pinnipeds and fisheries for food resources (Harwood and Croxall 1988; Punt and Butterworth 1995; Bogstad et al. 1997; Yodzis 2001).

Some of the pinniped populations reviewed here continued to increase even though variation in prey availability appeared to be causing reductions in reproductive performance (Antarctic fur seals, North Sea grey seals). Other populations appeared to have recovered (Barents Sea harp seals, Cape fur seals, South American fur seals, populations affected by El Niño). Some researchers have hypothesized that populations of southern elephant seals, Antarctic fur seals and South American sea lions might be declining towards pre-exploitation levels and that these declines might be indicative of a stabilizing effect rather than tending towards extinction (Hindell 1991; Croxall *et al.* 1988; Gerber and Hilborn 2001). The opposite might be true for populations Cape fur seals and North Sea grey seals, which some studies suggest might be increasing to their natural carrying capacity and could be expected to level off in the future (Harwood and Prime 1978; Butterworth *et al.* 1995). Thus, most of these populations are exhibiting some sort of recovery from the declines, although in some cases the rate of recovery is suppressed.

Although many studies have reported changes in population size or reproductive success in response to environmental heterogeneity, few have conclusively determined the ultimate cause of a long-term decline. Similarly, although there are numerous hypotheses implicating various factors in the declines, few studies have been established to test these. In the future, detecting the effect of prey depletion in pinnipeds will benefit from both longitudinal studies of individuals to determine variation in reproductive success in relation to prey availability (Pomeroy and Duck 2000), as well as comparative analyses of populations subject to similar conditions, to identify possible relationships and patterns that could help to generate further hypotheses (Shima *et al.* 2000). Also, reliable estimates of pinniped and prey abundance, diet and foraging patterns, and factors affecting reproductive success are clearly necessary to enable these comparisons (Harwood and Croxall 1988).

5 EFFECTS OF THE FEDERAL ACTION

Pursuant to Section 7(a)(2) of the ESA (16 U.S.C. §1536), federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of their critical habitat. This biological opinion assesses the effects of NMFS' proposal to authorize amendments 70/70 and 61/61 to the BSAI and GOA FMPs and State of Alaska parallel fisheries for Pacific cod, pollock, and Atka mackerel. The fisheries for pollock, Pacific cod, and Atka mackerel authorized by the amended FMPs are likely to adversely affect the endangered western population of Steller sea lions through both direct take (gear interactions which may injure or kill individuals) and indirect take (competition for prey). In Section 2 of this biological opinion and Section 4.2 of the SEIS, NMFS provided an overview of the fisheries, particularly the distribution and timing of fisheries which are expected to negatively affect Steller sea lions.

In this biological opinion, NMFS assesses the probable direct and indirect effects of the fisheries authorized by the amended FMPs on the two populations of Steller sea lions and their designated critical habitat. The purpose of the assessment is to determine if it is reasonable to expect that the fisheries can be expected to have direct or indirect effects on threatened and endangered species that appreciably reduce their likelihood of surviving and recovering in the wild or appreciably diminish the value of designated critical habitat for both the survival and recovery of threatened and endangered species in the wild. Before beginning our analysis, we will discuss our approach to the assessment, the evidence available for our assessment, and assumptions we had to make to overcome limits in our knowledge.

5.1 Approach to the Assessment

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of federal actions to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR §402.02). Section 7 of the ESA and it implementing regulations also require biological opinions to determine if federal actions would appreciably diminish the value of critical habitat for the survival and recovery of listed species (16 U.S.C. §1536; 50 CFR §402.02).

We approach jeopardy analyses in three steps. First, we identify the probable direct and indirect effects of an action on the physical, chemical, and biotic environment of the action area. The second step of our analysis determines if we would reasonably expect Steller sea lions to experience reductions in reproduction, numbers, or distribution in response to these effects. In the third step of our analyses, we determine if any reductions in a species' reproduction, numbers, or distribution (identified in the second step of our analysis) can be expected to appreciably reduce a listed species' likelihood of surviving and recovering in the wild.

We approach adverse modification of critical habitat analyses in a qualitative manner. First we identify which aspects of critical habitat are most likely to be affected by the proposed action. Then we qualitatively determine if the action is likely to diminish the value of critical habitat.

Human activities can reduce a species' reproduction by reducing the number of adults that reproduce in a population, reducing the number of young an adult will produce in a time interval or a lifetime, increasing the time it takes for an adult to reproduce, increasing the number of years that pass before an adult females returns to breed, reducing the survival of young, or decreasing the number of young that recruit into the adult population (Andrewartha and Birch 1954, Ebert 1999, Caughley and Gunn 2000). Human activities can reduce a species' numbers by killing them immediately or over time, reducing the numbers of individuals born into a population, reducing the number of individuals that immigrate into a population, or increasing the number of individuals that emigrate from a population (Burgman *et al.* 1993, Caughley and Gunn 2000). Human activities can reduce a species' distribution by reducing its population size or density in ways that cause the species to abandon parts of its range (Fowler and Baker, 1991). A species' reproduction, numbers, and distribution are interdependent: reducing a species' reproduction will reduce its population size; reducing a species' population size will usually reduce its reproduction, particularly if those reductions decrease the number of adult females or the number of young that recruit into the breeding population; and reductions in a species' reproduction and population size normally precede reductions in a species' distribution.

The final step in our analysis — relating reductions in a species' reproduction, numbers, or distribution to reductions in the species' likelihood of surviving and recovering in the wild — is the most difficult step because (a) the relationship is not linear; (b) to persist over geologic time, most species' have evolved to withstand some level of variation in their birth and death rates without a corresponding change in their likelihood of surviving and recovering in the wild; (c) our knowledge of the population dynamics of other species and their response to human perturbation is usually too limited to support anything more than rough estimates. Nevertheless, our analysis must distinguish between anthropogenic reductions in a species' reproduction, numbers, and distribution that can reasonably be expected to affect the species' likelihood of survival and recovery in the wild from other (natural) declines.

5.1.1 Types of Decision Making Error

As scientists we have two points of reference available when we consider data, information, or other evidence to support our analyses (1) we can analyze the information available and subsequently conclude that an action has an affect, when in fact it does not (false positive), or (2) we can analyze the information available and subsequently conclude that an action does not have an affect, when if fact it had (false negative). In statistics, these two points of reference are called "errors": the first point of reference is designed to avoid what is called Type I error while the latter is designed to avoid what is called Type II error (see Cohen 1988). Although analyses that minimize either type of error are statistically valid, most biologists and ecologists still focus on minimizing the risk of concluding that there was an effect when, in fact, there was no effect (Type I error) and tend to ignore Type II error.

To comply with direction from the U.S. Congress to provide the "benefit of the doubt" to threatened and endangered species [House of Representatives Conference Report No. 697, 96th Congress, Second Session, 12 (1979)], our analyses are designed to avoid concluding that actions had no effect on listed species or critical habitat when, in fact, there was an effect (Type II error). This approach to error may lead us to different conclusions than scientists who take a more traditional approaches to avoiding error, but we consider our approach to be more consistent with the purposes of the ESA and direction from Congress.

Jeopardy and adverse modification analyses must look into the future to identify the effects of activities conducted today on the future of threatened and endangered species. Some human activities have delayed effects on plant and animal populations, either because a species' population takes time to respond to an effect, because the population only responds when effects accumulate, or a combination of these two. The classic example of a combined response is bald eagle population's response to DDT, which became apparent only after many years of population declines. These responses pose the challenge of choosing how far into the future we must look to (1) detect a population's response to an effect or (2) detect a change in a species' likelihood of surviving and recovering in the wild (Crouse 1999). If we do not look far enough into the future, our analyses will not detect a population's response to a human activities and we are more likely to falsely conclude there was no effect when, in fact, an effect occurred. If we look too far into the future, our analyses can mask short-term collapses in a population and, again, we increase our likelihood of falsely concluding there was no effect when, in fact, an effect occurred.

5.1.2 Evidence Available for the Assessment

Detailed background information on the status of the species and critical habitat has been published in a number of documents including the Steller Sea Lion Recovery Plan (NMFS 1992); the draft SEIS for this action (Section 3.1.1); the draft SEIS for the FMPs (NMFS 2000); the marine mammal stock assessments (Ferrero *et al.* 2000); the FMP biological opinion (NMFS 2000); and the numerous white papers described in Section 1.3 of this document. Despite the published and unpublished information, our knowledge of the biology and ecology of Steller sea lions, including their life history, population dynamics, and their response to environmental change and other variation is still rudimentary. Numerous reports have also noted the lack of available information to make educated, scientifically sound determinations (SSC 2001 [Review of the FMP biological opinion]; Bowen *et al.* 2001 [Review of the November 30, 2000 Biological Opinion]; ASSLRT 2001; DeMaster *et al.* 2001 [Summary of the Is It Food? II Workshop]). As a result of these limits, we cannot quantify the effects of changes in abundance, reproductive success, and other vital rates on a Steller sea lion's likelihood of surviving and recovering in the wild.

In previous opinions and conservation actions, NMFS has utilized four types of management measures or tools to reduce the likelihood that fisheries were competing with Steller sea lions:

1 Areas and periods when and where fisheries for pollock, Pacific cod, and Atka mackerel were prohibited (i.e., rookery and haulout closures),
2 Temporal distribution of TAC (disperse catch throughout the year),
3 Spatial distribution of TAC (fish according to the distribution of biomass),
4 A mechanism for reducing TACs at a faster rate than status quo when biomass falls below the target biomass level ($B_{40\%}$).

There has been some debate in the scientific community about the extent to which competition with fisheries is currently contributing to the decline of Steller sea lions. As previously mentioned, the majority of participants in a recent workshop on Steller sea lions agreed that competition was not the leading hypothesis (DeMaster *et al.* 2001). However, at this time, the hypothesis that fisheries cause adverse impacts cannot be ruled out. This information, although very rough and without peer review, provides NMFS with an opportunity to look closer at critical habitat and make determinations about the relative importance of different areas. In the Federal Register notice dated August 27, 1993 (58 FR 45269) NMFS points out that as new, more refined, telemetry data become available, interpretations on the foraging behavior and needs of Steller sea lions may change. We feel that a more refined approach to looking at the effects of fishing on Steller sea lion survival and recovery in the wild is now possible given these new telemetry data.

5.2 Information on Steller Sea Lion Movement Patterns Using Satellite Telemetry

The new satellite telemetry information that is most beneficial is the detailed accounts of the locations of Steller sea lions. Discussions in prior biological opinions relied heavily on the published reports by Merrick *et al.* (1994), Merrick and Loughlin (1997), and Loughlin *et al.* (1998). Summaries of recent and continuing Steller sea lion telemetry research were presented at a telemetry workshop sponsored by the Steller sea lion recovery team on December 8-10, 1997 (NMFS 1997). This information was used to determine appropriate buffer areas for sea lions and trawl closures, and was utilized again in the FMP biological opinion. In that document, NMFS also incorporated some of the more recent research, however the level of analysis at that time was very coarse.

A detailed discussion on the historical and current status of sea lion research using satellite telemetry is provided in Section 3.1.1 of the SEIS. In the following two sections, we summarize the results of two unpublished papers which provide initial results on telemetry research since the last published paper in 1997.

5.2.1 Summary of Steller Sea Lion Research Using Satellite Telemetry

In a white paper by ADF&G and NMFS (2001), the authors provide an excellent overview of satellite telemetry research on Steller sea lions in Alaska. The following section borrows heavily from that paper which was a collaborative effort between ADF&G and NMML.

5.2.1.1 Deployment Background and History

A satellite-linked time-depth recorder (SDR) is composed of a small package of electronics which is glued to a sea lion's back. The purpose of the SDR is to transmit depth information from the unit up to orbiting satellites which then triangulate the source beam to estimate a location of the animal. To do this, the instrument must be above the water, or dry. A conductivity sensor determines whether the SDR is wet or dry, and a pressure transducer estimates the depth of the animal. The SDR makes a reading every 10 seconds, and attempts to transmit a signal to the satellite about every 40 seconds if the sensor determines that the instrument is above the surface (or "dry"). If the instrument is not dry, then it attempts to send a signal the next time it does read dry. Satellites are only overhead for limited periods each day. The instruments are programmed to send signals during the time of day when success is most likely. However, most of the time satellites are not in the right position, and transmissions are not successful. Due to limitations in the amount of data that can be transmitted, depth data are collected and stored in bins. Generally, three types of dive data are collected: (1) maximum depth, (2) duration, and (3) time-at-depth. The specific type of data collected can be programmed by the researcher, and a variety of information can be gleaned from combining the wet/dry sensor and the depth transducer to determine if the animal has been hauled out or is on a long foraging bout. Further details of the types of data collected are provided in ADF&G and NMFS (2001).

Between 1990 and March 2001, 98 SDRs were deployed on Steller sea lions in the western stock, and 84 had been deployed on animals from the eastern stock. Early deployments were focused on adult females with pups during the breeding season, whereas since 1994 the majority of deployments have been on animals less than 2 years of age, during both the breeding and non-breeding periods. Nearly equal numbers of male and female pups and juveniles have been tagged. However, for the 70 adults tagged, only 4 have been males. Mean deployment duration has been about 60 days, with a substantial number of units providing data sets that were too small for analysis. Recent deployments have lasted substantially longer (see ADF&G and NMFS 2001, their Table 1, Appendix 1). The geographic distribution of tags extends from Russia through Washington State. In Alaska, SDRs have been deployed in all subregions of both stocks: (1) Gulf of Alaska, (2) Aleutian Islands (except western Aleutians), and (3) Southeast Alaska (see ADF&G and NMFS 2001, their Figures 1 and 2). Although sea lions tagged in the western GOA and Aleutian Islands are known to range into the Bering Sea, SDRs have not yet been deployed on sea lions from sites in the Pribilof Islands or further north in the Bering Sea.

Given the current leading hypothesis that reduced juvenile survival has been at the center of the decline of the western stock of Steller sea lions, satellite telemetry research has focused on this life stage since 1998 (ADF&G and NMFS 2001). Although low juvenile survivorship may be at least partially responsible for the current decline, little information is available on life history traits on either stock of Steller sea lions. ADF&G has developed a SCUBA technique to capture pups and juveniles in the water, which has proven to be an effective method that avoids disturbing an entire sea lion colony, as with previous beach captures. The overall research objective has been to document the development of diving and movement patterns throughout the first year of life, with the intent of distinguishing differences in the biology and habits of juveniles between the western and eastern stock. To date, 57 juveniles in the eastern stock (Southeast Alaska) and 14 in the western stock (Prince William Sound) have been instrumented. Two manuscripts summarizing this work are being prepared (ADF&G and NMFS 2001). Additionally, Dr. Russ Andrews from the University of British Columbia is collaborating with ADF&G to compile a manuscript describing the movement patterns of adult females with dependent pups from a rookery in Southeast Alaska.

The habits of nutritionally dependent and independent young sea lions are closely linked to their food source, and many species typically show an increase in juvenile mortality rate post-weaning. If the decline in the Steller sea lion population hinges on juvenile survival, it follows that the period of greatest vulnerability to juveniles may occur at the transition to nutritional independence. Thus, a critical component for describing juvenile life history is the ability to distinguish between weaned juveniles and nursing pup/ juveniles still dependent on their mothers for nourishment.

5.2.1.2 Previous Use of Telemetry Information

Since the early 1990s, satellite telemetry information has been used in a variety of situations. The satellite telemetry data considered when the spatial extent of critical habitat and the early no-trawl zones were determined was a result of studies conducted during 1990-1993 on adult females in the Gulf of Alaska and eastern Aleutian Islands during the breeding seasons (Loughlin and Spraker 1989; Merrick *et al.* 1994; Merrick and Loughlin 1997). Results from these studies were summarized, in part, by the distance from the rookery from which a female departed to the subsequent location furthest offshore from that site during an at-sea trip. During the breeding season, adult female Steller sea lions traveled a mean distance of about 9 nm (17 km) from the rookeries with a range of 2-26 nm (3-49 km). The maximum distance recorded during an individual at-sea trip was 26 nm. Similar distances were observed in the Kuril Islands, Russia, during June 1991 (Loughlin *et al.* 1998) and in Southeast Alaska in the early and mid 1990s (Calkins 1997, Swain and Calkins 1997). However, due to the limited number of transmissions sent to the satellites while animals are at sea, sea lions likely traveled further offshore than indicated by the calculated distance (i.e., these are minimum distances, not necessarily maximum ranges).

These distances were the only data of this type available when the spatial extent of no-trawl zones and critical habitat was being determined. The size of the no-trawl zones was based on the mean distance traveled by adult females with pups during the breeding season (i.e., approximately 9 nm). The first closures prohibiting fishing with trawl gear was based on the average distance traveled by sea lions, and was therefore out to 10 nm from specific haulout or rookery sites. Later, some of the closure areas were extended to 20 nm in order to protect a greater percentage of the trips by sea lions. This was based on information on maximum distances traveled offshore from a rookery by an adult female during the breeding season on a feeding bout during the summer. This same maximum distance of 20 nm was then used in the 1993 critical habitat designation.

Studies conducted after critical habitat designation suggested that juveniles and adult females in winter travel substantially greater distances (i.e., greater than 60 nm) during feeding bouts and during transits within their home range (Merrick and Loughlin 1997, Swain and Calkins 1997). In general, the distance traveled away from the rookery during the breeding season appears to reflect the width of the continental shelf near the rookery. In those areas where the shelf is near the rookery females tend to travel shorter distances, and where it is farther offshore, they travel further. However, the variation among individual animals was large. Also, as a female's pup grows and becomes less dependent on frequent nursing bouts, the distance traveled by the female tends to increase as does the duration of time at sea. After the breeding season, females tend to travel greater distances away from the rookery or haulout site because they are not obligated to return to the rookery frequently to suckle their pup. Total distance traveled was greater than 500 km for adult females in winter and greater than 320 km for young of the year in winter.

In the FMP biological opinion, NMFS provided an analysis of the current telemetry information available at the time. For the analysis, NMFS used locations from animals instrumented only by NMML, and determined the percentage of hits inside and outside of critical habitat, split out by breeding and non-breeding aged animals. The level of detail for the analysis was at a fairly broad level of critical habitat, and provided little information for treating different parts of critical habitat in different ways. This information was crucial in making the determination that all of critical habitat should be protected in a substantial way.

5.2.1.3 Telemetry Information Provided During the RPA Committee Process (Spring 2001)

In February 2001, the RPA committee requested a summary of at-sea locations, which was presented in March 2001 by Dr. Robert Small as (1) the distance to the nearest landmass and (2) the distance to the capture site. The request provided committee members with an overview of the distribution of the at-sea locations for sea lions in an attempt to evaluate the spatial overlap with fisheries. All locations within the filtered database were sorted into two groups of bins, representing the distance (nm) to the nearest landmass and the distance to the capture site. The percentage of the total number of locations in each bin was displayed in graphic form as a frequency distribution, including the cumulative percentage across bins on the 2nd (right) y-axis (ADF&G and NMFS 2001). Frequency distributions were generated for both summer and winter periods in the three main geographic regions (BSAI, GOA, and Southeast) by age (pup, juvenile, and adult). In general, the large majority of at-sea locations occurred close to shore (less than 10 nm) across regions and seasons (ADF&G and NMFS 2001, their Appendix 2). More distant locations were observed for adult females in winter, and in some cases juveniles in summer.

Several important caveats were noted when these data were presented to the RPA Committee:

1. Due to a larger proportion of time spent at the surface when animals are nearshore, there is a higher probability of obtaining at-sea locations near haulouts and rookeries than when animals are farther at-sea and are likely to be diving to greater depths,

2. At-sea locations only describe where an animal was at a given time, it does not necessarily indicate whether the animal was foraging,

3. The large majority of pups instrumented, and perhaps most juveniles, were likely to still be nursing, and thus not were not foraging independently from their mom, and

4. Telemetry data are lacking for subadults and females without pups.

These caveats were presented and discussed at the RPA committee meeting. The author pointed out the danger of using the telemetry data to estimate the percentage of time the instrumented sea lions may have spent at specific distances from shore, and then further inferring from that information the spatial distribution of foraging bouts.

Additional figures prepared by NMML (ADF&G and NMFS 2001, their Appendix 2) were presented at the March RPA committee meeting which included 2- and 3-dimensional figures of individual foraging bouts by 11-month old male sea lions off Long Island (GOA) and Seguam Island (BSAI). The duration of these two foraging bouts were approximately 4 and 14 days, with mean dive depths (greater than 4 m) of about 23 and 18 m, and maximum depths recorded to 152 and 252 m. These figures represent results from the on-going analysis that integrate at-sea locations and concurrent dive behavior of individual at-sea trips to estimate the foraging behavior of sea lions. Additional figures (ADF&G and NMFS 2001, their Appendix 2) prepared by NMML displayed the low fidelity of sea lions to the site where they were captured and the SDR was deployed. Preliminary results indicate that pups make extensive movements along the nearshore area, but do not make extensive offshore movements, until perhaps 11 months of age. Once pups and juveniles arrive at a new site, they appear to remain relatively close and make short distance movements until they move to the next site (ADF&G and NMFS 2001, their Figure 14).

In May 2001, Dr. Russ Andrews of the University of British Columbia gave a presentation for the RPA committee on his research into the foraging behavior and energetics of adult female Steller sea lions. The primary focus of this research was to test the hypothesis that the continued population decline is due to nutritional stress. Dr. Andrews had provided some preliminary results at a foraging ecology workshop convened by the Recovery Team in 1999. His collaborative research integrated three electronic devices that provided detailed fine-scale information on sea lion foraging: (1) a stomach temperature transmitter (STT) that indicates when the animal ingests prey, (2) a data logger that records depth, velocity, and water temperature, and (3) an SDR to determine the locations of the animal. The combination of data collected from these instruments provides an insight into the spatial and temporal aspects of sea lion foraging coupled with the knowledge of whether their efforts were successful or not. This is crucial in understanding how fisheries and other factors may influence sea lion foraging success, and thus their survival and recovery in the wild.

Based on results from adult females in summer at Forrester Island (SE) and Seguam Island (BSAI) in 1994 and 1997, nearly all prey ingestion occurred when animals repeatedly exhibited dives deeper than 10 m. Prey was ingested during all at-sea trips during which such ‘foraging dives’ occurred. However, long periods of time often elapsed and large distances were covered between successful foraging events (Recovery Team 1999). This preliminary study demonstrated that observations of where sea lions travel and dive do not necessarily allow one to distinguish productive feeding areas from unproductive ones (Recovery Team 1999). Adult females began “foraging dives” >10 m within 8-26 minutes after departing a rookery, yet the first prey was not ingested until 0.9 to 5.1 hours after departure (ADF&G and NMFS 2001).

Further information was presented to the RPA committee by NMML and is being developed into a manuscript for publication (Loughlin *et al.* unpublished). Results from this analysis of recent deployments by Loughlin *et al.* (unpublished) obtained from juvenile sea lions, indicate three types of movements at-sea:

1. Long-range trips greater than 8 nm (15 km) offshore and lasting more than 20 hours,

2. Short-range trips less than 8 nm (15 km) offshore and less than 20 hours duration, and

3. Nearshore transits among land sites (i.e., haulouts and rookeries).

Long-range trips were foraging trips based on preliminary examination of concurrent dive data, and began when sea lions reached about 9 months of age in March, possibly when the animals were weaned and began foraging independently from their mother. For long-range trips, the mean distance from the haulout site at which a sea lion began a trip to the location furthest from that haulout site was 26.3 nm (SD=30.1 nm; max=129.9 nm), and they represented 6% of all trips to sea. The most numerous trips (87%) were short-range foraging trips that occurred almost daily (0.9 trips/day, n=328 trips) with a mean distance of 1.9 nm (3.6 km; SD=0.2 nm; max=11.3 nm). Transit trips were characterized as the straight line distance from one haulout site to another and began as early as 7 months of age, but occurred more often after 9 months of age when animals were likely weaned. Transit trips represented 6 % of all trips to sea and had a mean distance of 35.9 nm (SD=45.2 nm; range 3.5-184.5 nm). In summary, Loughlin *et al.* (unpublished) found the majority of trips (87%) were short-range trips with a mean distance of 1.9 nm and a maximum of 11.3 nm, with only 6% of the trips with a mean distance of 26.3 nm and a maximum of 129.9 nm. Overall, about 93.8% of the at-sea locations for juveniles were within 10 nm of land, only 2.2% were in the 10-20 nm zone, and only 4% were outside of 20 nm.

The general discussion during the RPA committee regarding telemetry focused on these new preliminary reports. There was a great deal of discussion on the associated caveats and limitations of the data at hand. With those understandings, most committee members concluded that roughly 75% of the at-sea locations were within 10 nm miles from shore and that 25% were greater than 10 nm from shore (RPA Committee, minutes from March 26-29, 2001 meeting in Anchorage, AK). The interpretation was also made that areas within 10 nm from shore were about 3 times as important as those areas beyond 10 nm from shore (based directly on the at-sea distributions). Further, since observed pups and juveniles tended to stay within 10 nm from shore more than the adults, and assuming that pups and juveniles are the most likely part of the sea lion population affected by nutritional stress, localized depletions, and predation, that the areas beyond 10 nm were less important factor in the current decline of the species, and would therefore be less likely to be adversely affected by competition with fisheries.

The critical assumption that must be made here is that the observed at-sea distributions are indicative of sea lion foraging. At this point we can still say very little about the foraging success of these animals while at sea, and therefore do not know if there are areas of ocean, a time of day or distance from land that is more or less important or effective for a foraging Steller sea lion. However, NMFS has no indication that disproportionate benefits would accrue from foraging at various distances from land, therefore drawing from the information above that roughly 75% of the at-sea distributions occur within 10 nm from shore, we can then speculate that about 75% of the foraging effort occurs within 10 nm from shore, and that most of the observed activity by pups and juveniles occurs in this area.

5.2.1.4 Further Discussion on Satellite Telemetry Information

The results from current telemetry analyses by NMML, ADF&G, and Dr. Andrews provide a basis to begin evaluating sea lion foraging ecology at a level of detail not previously possible. Although most of this data was available during the drafting of the FMP biological opinion, the analyses described here were not. As described above, NMFS previously considered all critical habitat to be equally as important to sea lion foraging. In other words, we knew animals spent a lot of time close to shore, but weren't able to quantify that amount. Preliminary analyses of the frequency and distribution of sea lion locations is described in ADF&G and NMFS (2001), which provides a rudimentary attempt to relate sea lion distribution with foraging effort in order to estimate competitive overlap with fisheries.

However, one of the most confounding potential biases of the raw telemetry data are the number of locations close to shore. Steller sea lion at-sea behavior is considered to be different near haulouts and rookeries than it is further offshore (Small, pers. comm., Bowen *et al.* 2001). For example, nearshore activity can include resting, sleeping, and social interactions that could result in them spending a large proportion of their time at the surface. In contrast, offshore activity is composed of a greater proportion of deep dives, resulting in a larger proportion of the time that the instruments are unable to transmit data. Therefore, various sea lion behavior types will influence the data transmission rate, and the probability of obtaining at-sea locations near haulouts and rookeries will be higher than when the animals are further offshore. Additionally, the existing data from stomach temperature transmitters (adult females in summer), as presented by Dr. Andrews, indicates the first prey ingestion event occurs at least 0.9 hours after departure from a rookery (their study). Assuming that sea lions travel away from the rookery during some portion of the time prior to the first prey ingestion event, a portion of nearshore at-sea locations do not represent successful foraging.

This information suggests that some portion of the number of locations obtained near shore may not represent successful foraging. To further explore the potential effect of these biases through a sensitivity analysis, ADF&G and NMFS (2001) reduced the number of at-sea locations in the first distribution bin (i.e., the 0-2 nm bin) by 90% (their Figure 3). This was an exercise intended to show an alternate range of possibilities based on the biases described in Section 5.2.1.3, and investigate the robustness of the data. These biases, if realized, would inflate the number of near shore locations as compared to those offshore. There is currently no available data for NMFS to accurately estimate this factor, therefore, 90% was used as a proxy for discussion purposes only and should not be viewed as the appropriate factor. Further analysis is necessary to determine what actual biases may be occurring and how they may affect our interpretation of the data. As pointed out by Bowen *et al.* (2001), further exploration of this complex data set may reveal different conclusions which may need to be acted on in the future.

Table 5.1 (a,b) displays the at-sea observations for sea lions instrumented between 1990-2000 (from the NMML database [i.e., does not include animals instrumented in Southeast Alaska in the eastern population] ADF&G and NMFS 2001, their Table 1). Table 5.1a represents the full database, and Table 5.1.b reflects the 90% reduction of the observations between 0-2 nm from shore. Using the full data set (Table 5.1.a), the vast majority of observations were within 10 nm from shore, with some pups/juveniles in summer ranging offshore (20.4%; beyond 20 nm) and some adults in the winter (16.7%). Very few observations were made in the 10-20 nm zone in either season (0-5.1%).

Using the modified database (Table 5.1b), during the winter (non breeding period) about 95% of pups and juveniles were within 10 nm of shore, yet during the summer they ranged more widely; 37% of the observations occurred inside 10 nm, yet 63% were beyond 10 nm. One plausible explanation for this pattern of behavior is that since most of the pups/juveniles instrumented during the fall and winter were still nursing, they would be less likely to travel too far form shore. Later in their first year, by spring and early summer, some of these animals are weaned and they begin to forage on their own further from shore, perhaps in attempt to avoid competing with older sea lions (Bowen pers. comm.). In the winter, adults (primarily females with pups) were distributed 41% inside 10 nm and 59% offshore; during the summer they were 80.5% inside 10 nm, and 19.5% beyond 10 nm.

During the summer, 80% of the adult observations were within 6 nm and the remaining 20% occurred beyond 100 nm (ADF&G and NMFS 2001; their Figure 3). These results suggest that adult females exhibit two behaviors during the summer breeding season: (1) short range foraging trips (less than 6 nm) in which they are limited in the time that they can be away from their pup without the pup beginning to starve, and (2) longer range trips (greater than 100 nm) perhaps due to the lack of suitable prey nearshore, or possibly to capture specific offshore prey. Although a majority of both pup and juvenile locations were also nearshore, sea lion locations were distributed in all distance bins suggesting that some of the younger animals, possibly the juveniles that have been weaned (the age class likely to be a critical factor in the current decline of the western population), had begun to make more extensive off-shore foraging trips.

During the winter about 35% of adult locations (a period when adult females are less likely to be nursing a pup) were within 6 nm of shore, and about 40% of the locations were greater than 50 nm from shore, suggesting that adult females are more likely to make off-shore trips during the non-breeding season (ADF&G and NMFS 2001). Pups and juvenile locations were distributed among all distances from shore, except no trips were recorded beyond 100 nm, and 95% recorded within 10 nm (Table 5.1b). This suggests that pups and juveniles make shorter at-sea trips than do adults in the winter. Pups and juveniles spent only about 1.9% of their time beyond 20 nm (0.4% in the full database) indicating that these animals are highly attached to nearshore areas.

Under both data scenarios (full database and the 90% filter), the greatest fraction of at-sea observations occurred within the 0-3 nm and the 3-10 nm zones (except for adults in winter and pups and juveniles in summer [Table 5.1b]). Although NMFS cannot unequivocally equate these observations to foraging rates, it is reasonable to conclude that the 0-10 nm zone represents an important foraging area for Steller sea lions, and thus may require the greatest protection from potential disturbance, such as competition with fisheries. There are notably fewer observations in the 10-20 nm zone, especially for pups and juveniles, which are the age classes currently of most concern (DeMaster *et al.* 2001). However, the greatest discrepancy between the two methods is found in the fraction of observations in the areas beyond 20 nm from shore (Table 5.1a,b). Granted, the filtered method is highly theoretical, but it does provide a possible upper bound to help us consider the importance of offshore areas to foraging Steller sea lions.

Table 5.1. At-sea locations for Steller sea lions in summer and winter. Percentages reflect the proportion of locations obtained within certain distances from shore. Sample sizes refer to the total number of locations received for pups and adults (not the total number of animals tracked). Although this information does provide some guidance regarding where the animals are located, this information cannot be used to determine precisely where the animals are foraging as noted in the text above. Table 5.1a reflects the raw database of NMML deployments from 1990-2000. In Table 5.1b 90 percent of the observations in the 0-2 nm areas were deleted to show one method for approaching potential biases in the data.

Table 5.1a	**Summer (Apr–Sept)**		**Winter (Oct–Mar)**	
Zone	**Pups/Juveniles (*n=274*)**	**Adults (*n=201*)**	**Pups/Juveniles (*n=1062*)**	**Adults (*n*=96)**
0-3 nm	68.4 %	89.6 %	92.8 %	74.0 %
3-10 nm	6.0 %	6.0 %	6.3 %	5.2 %
10-20 nm	5.1 %	0 %	0.6 %	4.2 %
beyond 20 nm	20.4 %	4.5 %	0.4 %	16.7 %

Table 5.1b	**Summer**		**Winter**	
Zone	**Pups/Juveniles (*n=111*)**	**Adults (*n=46*)**	**Pups/Juveniles (*n=205*)**	**Adults (*n=34*)**
0-3 nm	22.1 %	54.5 %	62.7 %	26.3 %
3-10 nm	14.9 %	26.0 %	32.4 %	14.7 %
10-20 nm	12.6 %	0 %	2.9 %	11.8 %
beyond 20 nm	50.4 %	19.5 %	1.9 %	47.2 %

5.2.1.5 A Zonal Interpretation of the Available Satellite Telemetry Information

There is considerable information contained in the telemetry data already collected, and more coming in daily from recent deployments. Numerous manuscripts are in preparation, which reflect a range of hypotheses and opinions on the utility of such data. In many ways this biological opinion is on the leading edge, utilizing all of the newly available data to make the best determination we can to provide for the survival and recovery of Steller sea lions. NMFS recognizes alternative interpretations to those put forth by the agency, many of these discussions took place in the RPA committee meetings, yet NMFS must use the best available scientific and commercial data to determine whether the proposed action is likely to jeopardize the continued existence of Steller sea lions or destroy or adversely modify their critical habitat. With this in mind, NMFS has developed a qualitative scale for rating the importance of foraging areas for Steller sea lions based on their at-sea observations and known foraging ecology as discussed above (see Table 5.2).

Again, the telemetry information and analyses currently available indicate that the 0-3 and 3-10 nm zones (distance from shore) are the most heavily used by Steller sea lions (Table 5.1), and are the areas in which pups and lactating females rely heavily on during the fall and winter periods; hence we rated this as a high level of concern with possible adverse interactions with fisheries (Table 5.2). We rated the 10-20 nm zone as being a low to moderate concern for sea lions, because relatively few at-sea observations have been collected in these areas (Table 5.1; ADF&G and NMFS 2001, Loughlin *et al.* unpublished). Although some locations have been observed in this zone, NMFS has no indication that foraging in this zone is any more important to the species than areas closer to shore, therefore each at-sea observation will be weighted the same by area. The low fraction of at-sea observations in this zone reflects the low concern rating. However, this zone does contain important prey species which are likely to move through this area into the nearshore zones (which are of higher concern because of the intensity of the presumed foraging from 0-10 nm). This uncertainty is reflected in the low to moderate rating for this zone. Although research is currently either underway or planned in order to estimate some of these factors (e.g., fish and sea lion movement patterns, and the possibility of localized depletions from fishing), NMFS currently has little information to describe the small scale movement patters of sea lion prey species within critical habitat.

A relatively high percentage of at-sea locations were observed in the zone beyond 20 nm , up to 50.4% for pups and juveniles in the summer, and 47.2% of adults in the winter (Table 5.1b), or 20.4% and 16.7% respectively for the full database (Table 5.1a) . Loughlin *et al.* (2001) found that about 93.8% of the at-sea locations for juveniles were within 10 nm of land, only 2.2% were in the 10-20 nm zone, and only 4% were outside of 20 nm. Given the significant size of the area beyond 20 nm, the pattern of dispersal of the fishing vessels in these zones, and the fact that it is outside most of the areas of critical habitat (except for the foraging areas), NMFS is rating this as a low concern when compared with the 0-3 nm zone.

Spatial dispersion outside 10 nm is considered to be a low priority given the frequency of at-sea locations observed from 10 nm offshore and beyond. For example, critical habitat catch limits were required in the RPA for the FMP biological opinion, which was based on the available biomass for all critical habitat areas that were open to fishing. Fishing in the so called "green areas" however was allowed up to 3 nm from a haulout or rookery. Since our current interpretation of the telemetry data indicates a higher concern for areas inside 10 nm, the previous approach to fishing inside critical habitat is no longer fully appropriate. Given the current information, areas inside 10 nm should be limited to minimal fishing for pollock, Pacific cod, and Atka mackerel (see the discussion above for these areas). This leaves critical habitat areas outside of 10 nm and the three foraging areas. Although spatial dispersal is still considered to be an important tool to minimize the possibility of competition with fisheries, the use of closure areas in the most important foraging zones alleviates the need for small catch limits in areas outside of 10 nm from shore that were previously considered to be integral to the RPA in the FMP biological opinion. However, other tools such as differential gear closures to areas inside critical habitat from 10-20 nm or in the foraging areas, or other critical habitat limits (i.e., harvest limits in the SCA) would strengthen the conservation measures, and further insure that competition was unlikely to occur between fisheries and sea lions.

Temporal dispersion outside 10 nm is considered to be a low to moderate priority given the frequency of at-sea locations observed from 10 nm offshore and beyond. Again, as described above, the most important areas for foraging sea lions are 0-10 nm from shore. Outside of this zone, competition is less likely, although impossible to quantify. A tool that has been used in the past (i.e., in the RPA for the FMP biological opinion), is to disperse the fishery into 4 separate seasons inside critical habitat areas and 2 seasons outside. The current interpretation of the telemetry information has allowed NMFS to partition these areas such that the zone previously thought to be most important for sea lions (0-20 nm) has now been reduced to 0-10 nm due to the level of specificity in the new analyses. Therefore, since most of the 0-10 nm zone should have only minimal fishing, the need for 4 seasons (as opposed to 2) is no longer necessary. In other words, the area beyond 10 nm from shore will be treated in the same manner as the area beyond 20 nm in previous conservation actions for sea lions. Special consideration should be given to the 3 foraging areas however, as they do represent areas of intense historical fishing and high concentrations of fish, such that the possibility of localized depletions could be theoretically higher. More seasonal splits in the foraging areas would certainly reduce the risk of causing localized depletions in these areas considered to be important to the conservation of the species.

Fishery effects at the global or regional level were thoroughly considered in the FMP biological opinion. The conclusion of that document was that a revised Global Control Rule was necessary to insure that fishing could not occur below a certain biomass level for pollock, Pacific cod, and Atka mackerel. There is a moderate concern that if the biomass level for these species was to fall below 20% of its theoretical unfished biomass amount, that sea lions would be adversely affected, and that fishing could not occur without increasing that adverse impact.

Table 5.2. Specific zones of concern for possible adverse effects from fisheries on Steller sea lions based on current telemetry information and known foraging ecology of the species.

ZONE	LEVEL OF CONCERN	RATIONALE
0-3 nm	High	• High density of sea lions, presumably foraging • High potential for competitive interaction • Moderate potential for disturbance
3-10 nm	High	• High density of sea lions, presumably foraging • High potential for competitive interaction • Moderate potential for disturbance
10-20 nm	Low to moderate	• Few at-sea observations of sea lions in this zone • Potential to serve as a "buffer" area between nearshore closures and offshore fishing
beyond 20 nm	Low	• Although sea lions are known to forage here, most sea lions in this area are older juveniles or adults, which have advanced diving/foraging capabilities • Assumption is that animals in this age class can find adequate forage even if there is local competition (supported by the fact that animals in these age classes appear to be healthy)
Spatial Dispersion (outside 10 nm)	Low	• Roughly 25-40% of the at-sea observations of sea lions are in this zone (beyond 10 nm) • High level of concern for areas from 0-10 nm, and expected minimal fishing in those zones where the majority of sea lion foraging is presumed to occur • Harvest limits based on biomass are not necessary in this zone if minimal fishing occurs from 0-10 nm, and there is adequate temporal distribution of the fishery as described below
Temporal Dispersion (outside 10 nm)	Low to moderate	• Roughly 25-40% of the at-sea observations of sea lions are in this zone (beyond 10 nm) • High level of concern for areas from 0-10 nm, and expected minimal fishing in those zones where the majority of sea lion foraging is presumed to occur • Two seasons are considered appropriate, with roughly 50% of the harvest occurring in each season to minimize the possibility for localized depletions, four seasons would be more conservative, and further reduce the likelihood of competition between fisheries and Steller sea lions • No target harvest rate is available as a guide
Global Fishing Effects	Moderate	• Directed fishing for pollock, pacific Cod, and Atka mackerel when the biomass level is below 20% of its theoretical unfished biomass level is likely to adversely affect sea lions

5.3 Effects of the Action on Steller Sea Lions and their Critical Habitat

5.3 General Effects of Fisheries for Pollock, Pacific Cod, and Atka Mackerel

The BSAI and GOA Groundfish FMPs, as modified by proposed Amendments 61/61 and 70/70, and State parallel fisheries, have the potential to affect Steller sea lions and their critical habitat in a variety of ways depending on the methods, seasons, quantities, and locations of harvest. This section describes the types of effects the fisheries may cause and highlights the effects of greatest potential concern for Steller sea lions and their critical habitat. The following sections will discuss the direct and indirect effects of the proposed actions, other ecosystem effects, and the analysis of those effects relative to needs of foraging Steller sea lions.

The SEIS for Steller sea lion protection measures summarizes the operation of the BSAI and GOA Groundfish FMPs. In summary, the groundfish fisheries are prosecuted with trawl, pot, hook-and-line, and jig gear. The amount of allowable harvest is determined annually by setting catch specifications known as the total allowable catch (TAC). The groundfish fisheries are open access fisheries, and the existing BSAI and GOA fleets exceed the minimum capacity required to catch the TAC. Therefore, the TAC setting process is a significant determinant of the magnitude of the effects of the fisheries on the target species, listed species, critical habitat, and other ecosystem components. Time and area management measures limit the fisheries as well to address concerns for prohibited species, bycatch, habitat protection, and catch dispersion. Vessel size and processing capacity also affect the location and timing of the catch.

The principal types of effects these groundfish fisheries may inflict on sea lions and their critical habitat include entanglements of sea lions in fishing gear, removal of sea lion prey, harvests that are concentrated in time and in space. Other effects may include changes to the bottom habitat and/or to the fish community that in turn may lead to changes in community structure, biodiversity, and other elements of the ecosystem upon which sea lions depend.

5.3.1.1 Entanglement in Fishing Gear

Steller sea lions occasionally become entangled in fishing gear and are injured or killed. These incidental takes occur when sea lions are feeding in or swimming through the same waters where fishing gear is in use, and the sea lions inadvertently become trapped in the gear. Entanglement can cause sea lions to drown or to become injured in ways that make them susceptible to other sources of mortality.

5.3.1.2 Large Overall Removals of Fish That Are Prey for Sea Lions

By design, fishing reduces the available biomass of target species. At the ecosystem level (i.e., at the scale of the entire BSAI or GOA region), large scale removals of fish can reduce substantially the available stocks of target species, changing the relative abundance of different fish species in the ecosystem, and altering the prey base that is available for animals such as sea lions that feed on those same species of fish. In the present case, the BSAI and GOA groundfish fisheries target walleye pollock, Pacific cod, and Atka mackerel, all of which are important prey for Steller sea lions (Sinclair and Zeppelin submitted).

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. This strategy supposes that there is surplus fish production beyond that required to ensure that successive generations of a species will replace themselves. Fisheries models predict that surplus production is maximized at intermediate stock sizes because high stock densities result in more competition for available resources, reducing the reproductive rate of the population

(Ricker 1975). In a single species context, fishery managers generally consider that this surplus production can be removed without adversely impacting the target fish stock or the ecosystem. Multi-species models can help to identify areas of needed research and identify possible responses of the ecosystem to fishing, but their predictions are still relatively uncertain for use in management. For sea lions, the relevant question is whether fishing under the prevailing exploitation strategy (the global control rule) results in such large overall removals of fish that sea lions are unable to forage at levels that prevent starvation. High levels of fishing effort can reduce the prey available for sea lions by decreasing the biomass of the entire stock of fish, or by changing the age distribution of the stock such that the area occupied by the fish stock changes (e.g., favoring the habitats used by younger fish).

5.3.1.3 Harvests That Are Concentrated in Time

High levels of harvest during particular seasons may adversely affect sea lions even if the total annual harvest level is not a threat. For example, during the winter months sea lions may have relatively infrequent foraging opportunities and may be less able to travel large distances in search of food. Similarly, juvenile sea lions may rely on easy feeding opportunities during periods when they are learning to forage independently. Substantial harvests of sea lion prey during these times may lead to nutritional stress, even if ample food is available at other times of the year. Particular levels of TAC, even when divided into seasons, can result in a race for fish that concentrates fishing effort in a short period of time until the TAC is caught and the fishery must be closed.

5.3.1.4 Harvests That Are Concentrated in Particular Locations

Competition for available fish between the BSAI and GOA groundfish fisheries and sea lions can occur at a variety of spatial scales. At the macro-scale, potential impacts of fishing include competition for a common resource and/or shifts in predator-prey relationships that may change the carrying capacity of the ecosystem. Observation of these effects is complicated by natural variability of the ecosystem. At the meso-scale, fisheries can affect the distribution and abundance of groundfish in a region such as Shelikof Strait or Bristol Bay that is important to local groups of sea lions. Finally, at a micro-scale fishing vessels can affect the distribution and abundance of groundfish in specific locations, making it harder for sea lions to prey upon groundfish in those areas. The effects of fisheries on the distribution and abundance of fish species have shorter duration as the spatial scale of impact decreases. Nevertheless, localized depletions of fish that are prey for sea lions can be important for the affected individuals, especially during vulnerable life stages (e.g., juveniles or nursing mothers) and near important habitat areas (e.g., haulouts).

5.3.1.5 Fisheries Effects on the Environment

Commercial fisheries can have other ecosystem effects that may influence Steller sea lions, in addition to the direct and indirect effects discussed above. These other effects may include ecological change resulting from the removal of large numbers of target species and non-target species (bycatch), or from habitat alteration caused by fishing and the industrial infrastructure that processes the catch and delivers it to markets. These types of ecosystem effects are discussed in the SEIS for Steller sea lion protection measures (NMFS 2001b) and are summarized briefly here insofar as they relate specifically to sea lions and their critical habitat.

The BSAI and GOA groundfish fisheries affect fish population structure through changes in the growth, mortality, production, and recruitment of populations of target fish species and bycatch. Removing target species and bycatch could also affect other parts of the marine ecosystem by changing predator/prey relationships and community structure. However, evaluation of the present fishery management regime in the last 20 years does not show the types of dramatic reductions of individual populations that occurred previously. Most of the work evaluating predator/prey relationships in the BSAI 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) suggests 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. Models have shown that although cannibalism can explain a large part of the decline in recruitment observed at high spawner biomasses for pollock, most of the overall variability in stock and recruitment for pollock appears to be more linked to climate events (Livingston and Methot 1998). 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, which has been relatively steady over the last 20 years and does not indicate successive depletion of populations or food web effects observed in more heavily fished ecosystems of the world. Likewise, while localized extirpations or declines in diversity of marine species due to fishing have been observed in some areas of the world under conditions where management was not precautionary, under the current regime in the action area, such effects on biodiversity are not likely to occur.

The effects of fishing on marine habitat have received increased attention is recent years, primarily because of concern that the impacts of certain fishing practices on designated Essential Fish Habitat (EFH) could lead to reduced yields of commercially and recreationally important species, reduced biodiversity, and other ecosystem effects. This concern has focused primarily on the effects of mobile fishing gear such as trawls and dredges on benthic habitats. To the extent that adverse effects to EFH may reduce the recruitment, productivity, and survival of various fish species, the effects of fishing on EFH could lead to reductions in prey for Steller sea lions. However, there is very limited available scientific information to link physical changes to EFH with resulting decreases in the value and productivity of those habitats for federally managed species of fish (Auster and Langton 1998). Potential effects to sea lions are therefore difficult to assess, but probably are not significant compared to other factors. NMFS and the North Pacific Fishery Management Council are presently developing an SEIS that will evaluate in more detail the effects of fishing on EFH (NMFS 2001c).

Most of the groundfish caught in the fisheries will be processed in seafood processing facilities in the action area. Discharges from fish processing facilities can affect water quality in coastal areas. However, the adverse effects tend to be localized and usually depend on flushing rates and dispersal patterns 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, and produce noxious smells. The waste can cause receiving waters to become anoxic, elevate ammonia levels, and smother benthic organisms. Seafood processing discharges are subject to Federal and state regulation, so even these localized effects have become less common than in the past. Thus, the effects of seafood processing on water quality in the action area are not likely to cause measurable effects to Steller sea lions or their critical habitat.

5.3.1.6 Fisheries Effects by Gear Type

Numerous gear types are used for fishing under the proposed action including jig, pot, hook-&-line, bottom trawl, and pelagic trawl gear. Also numerous vessel classes are used including everything from small skiffs, catcher boats, freezer longliners, and large catcher processors. Descriptions of these fisheries are outlined in detail in the SEIS for this proposed action. A reasonable question arises is whether these fisheries are more likely to adversely affect sea lions than another one? Unfortunately, just like many of the other hypotheses which may contribute to the sea lion decline such as localized depletions and nutritional stress, we have little scientific evidence which indicates whether hook-&-line gear is more or less likely to locally deplete prey than trawl gear.

Empirically, from observer data, we can review data describing fishing locations and timing of harvests, concentration in time and space, and from those analyses speculate on how they might affect sea lions. A recent unpublished analysis by the AFSC attempted to look at the spatial and temporal concentration of various fisheries (Figures 5.1 and 5.2). In this analysis, we looked at the timing of catch in relation to spatial and temporal concentration of fishing effort. Looking at the percentage of catch that was caught in areas with high catch rates, trawl fisheries were noted in the BSAI Pacific cod fishery to have the highest proportion of their catch in these dense aggregations. Pot gear had less of a proportion in those high catch rate bins, whereas hook-&-line gear had the highest proportions in the lowest catch rate bins (Figure 4.3). These data suggest that the hook-&-line fishery in the BSAI Pacific cod fishery is more dispersed than the trawl fishery, and may be less likely to cause localized depletions of prey for Steller sea lions. However, to stress again, the critical link between fisheries removals (time, rate, location, etc.) and the effects on sea lions is so poorly understood that we cannot un-equivocally say that these gear types do or do not adversely affect Steller sea lions. Some published papers (Lokkeborg et al. 1989, Lokkeborg 1998, and Lokkeborg and Ferno 1999) have begun to look at the effects of gear such as hook-&-line on the distribution and abundance of fish species. Yet, it appears that the nature of hook-&-line gear is a more dispersed fishery in both time and space - one of the major qualitites identified in recent biological opinions that could help avoid jeopardy and adverse modification of critical habitat. Certainly, the chance of causing localized depletions with jig gear is considered extremely low, yet there are few scientific data to support this (i.e., the link between removals of fish and adverse impacts to sea lions) except for extremely low catch rates (NMFS, blend data). Figure 5.2 shows a similar pattern for trawl fisheries for Atka mackerel and pollock in the BSAI, where the largest percentage of the catch comes from the bins with the highest catch rates.

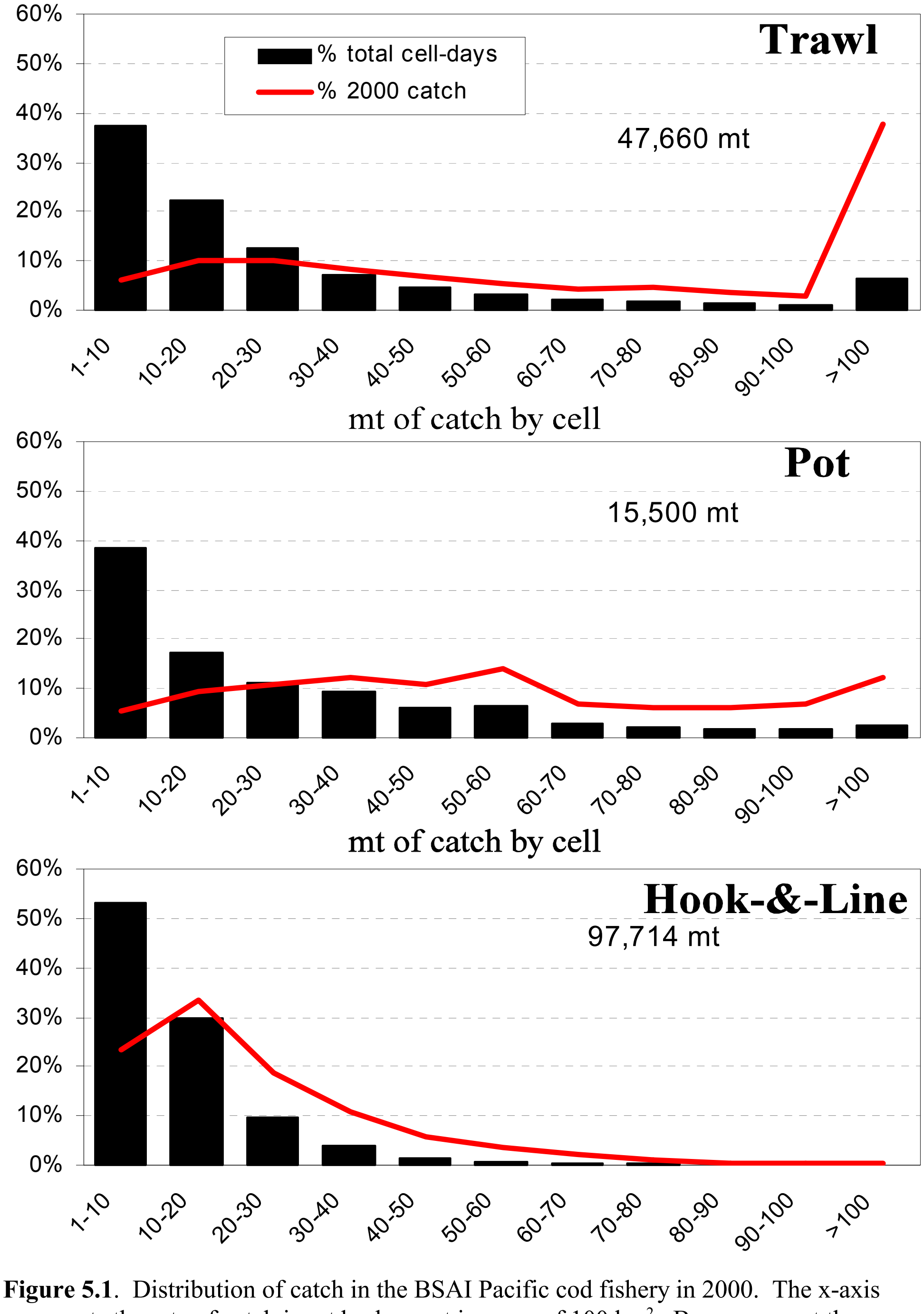

Figure 5.1. Distribution of catch in the BSAI Pacific cod fishery in 2000. The x-axis represents the rate of catch in mt broken out in areas of 100 km^2. Bars represent the relative amount of days in which 100 km^2 cells had a particular catch rate. The line graph represents the cumulative percentage of the total catch in each bin.

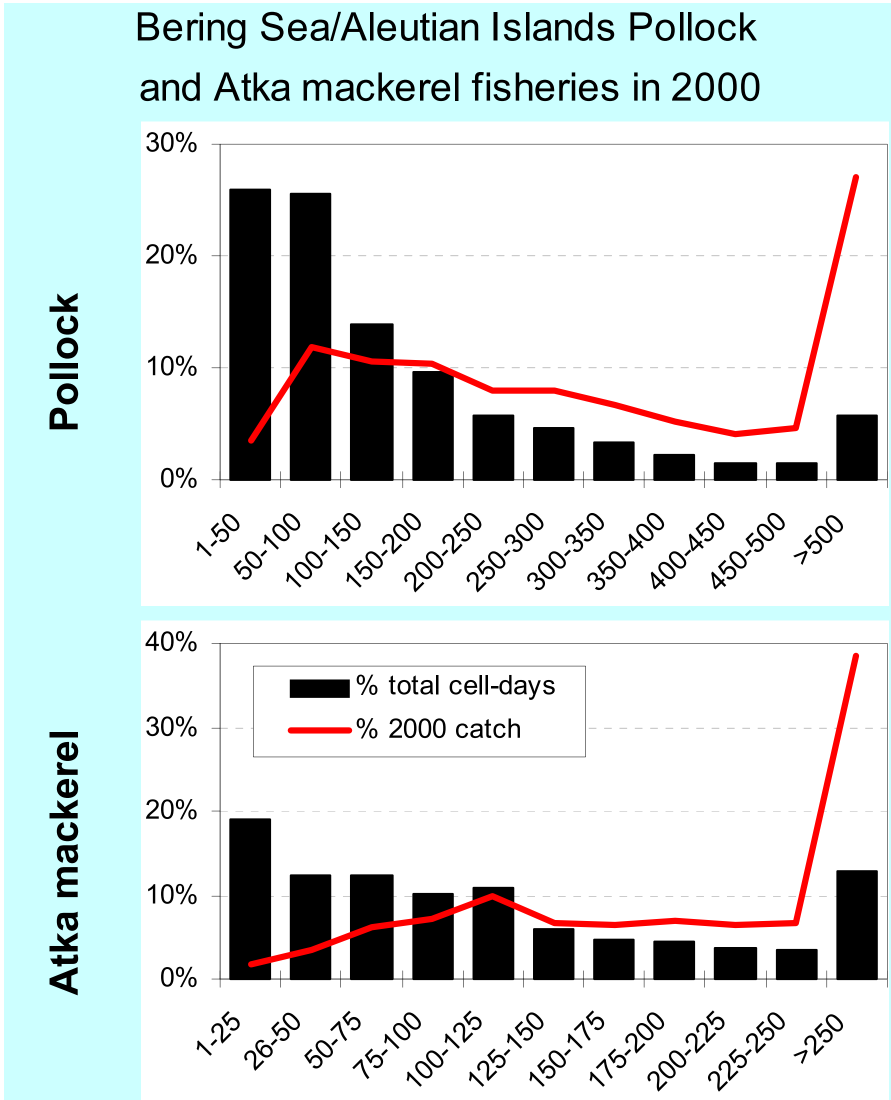

Figure 5.2. Distribution of catch in the BSAI pollock and Atka mackerel fisheries in 2000. The x-axis represents the rate of catch in mt broken out in areas of 100 km^2. Bars represent the relative amount of days in which 100 km^2 cells had a particular catch rate. The line graph represents the cumulative percentage of the total catch in each bin.

5.3.1.7 Discussion of Effects

In a comment received on the draft biological opinion, GIS mapping technology was used to map data from a tagged sea lion and pollock trawl locations in the BSAI and GOA (Figure 5.2). This figure is useful in that it illustrates a number of interesting points discussed throughout this document. First of all it shows the general pattern of hits within 10 nm from shore, and that the overlap with fisheries (if prohibited from inside 10 nm) would be limited based on the information available from satellite telemetry. The figure shows the outline of the proposed protection areas for pollock for 2002 and beyond - yet it also shows where those protection measures existed before 2000, you can tell by the location of trawls, and specifically by the lack of trawl locations in a very good fishing area off from Sea Lion Rock (Amak). It also depicts the new boundary of 10 nm and overlays that with the data from a foraging pup which spent a bit of time around the island in 2000. The image (as well as others provided in the comment and produced by NMFS) comports with the raw data previously reported - that pups generally spend the majority of their time around a rookery or a haulout, and probably don't venture too far out to sea.

At Cape Sarichef (next to the number 30), you can see a heavy concentration of pollock trawling, which

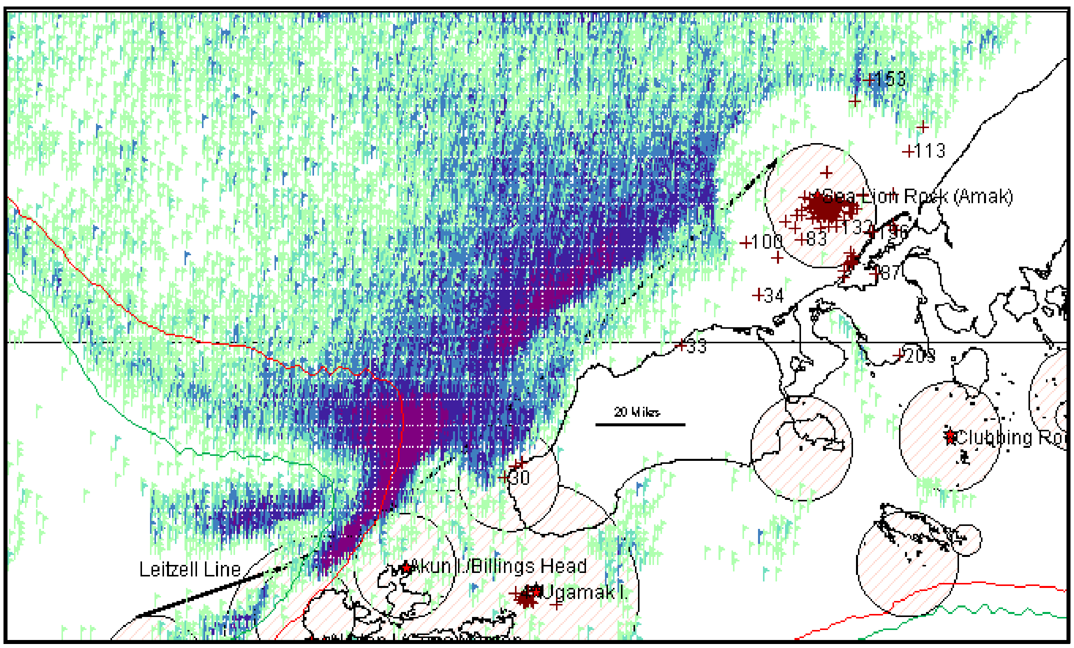

Figure 5.2. Observations of a 9 month old sea lion pup tagged on March 8, 2000 on Aiktak displayed against tows for pollock in the BSAI and GOA (figure provided to NMFS in a comment on the opinion).

was restricted in 1999, and would be restricted under the proposed action out to 10 nm - but you can see the historical dependence and fishing patterns at this site which go very close to shore. This figure also illustrates NMFS concern for heavy fishing right on the boundary of closed areas. We can speculate that a border between 10-20 nm around Sea Lion Rocks may help protect the prey field within the 10 nm boundary - the question then arises, are there adverse impacts of fishing right up to that boundary? For species such as Atka mackerel, which appear to have a high affinity for a specific location (Fritz unpublished data), this may not be as important as for pollock and Pacific cod which move more rapidly and across greater distances. Conversely, rapid and large scale movement may dampen out any "downstream" effects that might be possible by fishing around areas such as Amak. Information from current and expected research projects should help elucidate some of these questions over the next 2-5 years. At this point, most of these questions are unanswerable, and we can only speculate as to the merits of each hypothesis.

5.3.2 Comparison of the Proposed Action to the RPA (FMP Biological Opinion)

Table 5.4 below describes the differences between the proposed action and the RPA contained in the FMP biological opinion. This section and the analysis provides an overview of the types of changes in conservation management for Steller sea lions and the expected relative affect on the sea lion population.

Table 5.4. Comparison of the use of management tools under the RPA (FMP biological opinion) and the proposed action.

	Action	
Management Tool	***RPA from 2000 Biological Opinion BiOp SEIS Alternative 3***	***Proposed Action BiOp SEIS Alternative 4***
Fishery Exclusion Zones	(1) All critical habitat (0-20 nm from rookeries and haulouts and foraging areas) in areas 2, 4, 6, 8, 9, 10, 11, and 13 closed to all three fisheries and gear types (2) No fishing within 3 nm of haulouts and rookeries west of 144°W	(1) Portions of critical habitat in areas 1-13 closed to one or more fisheries and gear types; more restrictions in area 0-10 nm from rookeries and haulouts than in the rest of critical habitat (2) No fishing within 3 nm of rookeries west of 144°W
Temporal Dispersion and Allocation	Dispersion 4 seasons inside critical habitat 2 seasons outside critical habitat Allocation of TAC by season Inside: 20% 20% 30% 30% Outside: 40% 60%	Dispersion No reference to critical habitat No directed fishing for AI pollock 2 seasons: EBS pollock and cod, AI cod and Atka mackerel, and GOA cod 4 seasons: GOA pollock Allocation of TAC by season EBS pollock: 40% 60% EBS and AI cod: ~ 70% 30% AI Atka mackerel: 50% 50% GOA cod: 60% 40% GOA pollock: 30% 15% 30% 25%
Spatial Dispersion	Catch limits assigned to critical habitat areas open to fishing based on seasonal proportion of target species biomass in area	Catch limits for pollock in the SCA (75% in the A season) and critical habitat limits of 70% for Atka mackerel in the Aleutian Islands (areas 542 and 543).
Global Control Rule	Linear reduction in fishing mortality rate below $B_{40\%}$ to F=0 at $B_{20\%}$	Linear reduction in fishing mortality rate between $B_{40\%}$ and $B_{20\%}$ as in status quo; at $B_{20\%}$, F=0

5.3.2.1 Qualitative Model for Evaluation of Different, Complex Conservation Programs

This portion of the discussion was provided in large part in a white paper by DeMaster (2001). This information was used in the RPA committee process in determining the relative effects of the proposed action on the survival and recovery of the western population of Steller sea lion. The following is an overview of that paper, with further discussions on the sensitivity of the model.

In the FMP biological opinion, NMFS established 13 distinct management areas from Prince William Sound west to the end of the Aleutian Chain to apply area-specific conservation measures. These 13 areas were essential to the adaptive management program required by the RPA, but did not necessarily represent areas that should specifically be managed based on sea lion trends or needs based on foraging requirements. One of the tools that NMFS used to evaluate whether the RPA removed jeopardy, was a population trajectory model that predicted how the sea lion population would respond to the implementation of the RPA. NMFS recognized that the approach adopted in the opinion was a "worst case" scenario, because areas that were open to fishing, with extensive fishing restrictions such as catch limits and 4 seasonal apportionments, were not given any positive credit towards the population trajectory. NMFS' opinion was that there would be a positive result when fishing under these conditions, but did not feel comfortable guessing at what level of change might be expected. The expected population trajectory was between 0-2% (FMP biological opinion).

The following assumptions were made for the analysis in the previous opinion:

1. The sea lion subpopulation in areas closed to all directed fishing for pollock, Pacific cod, and Atka mackerel would benefit by an amount equal to the average rate of decline in the western Steller sea lion population between 1991 and 2000 (e.g., 4% per year as estimated by DeMaster 2001),

2. The positive effect of a specific management action in a given area on the sea lion population would remain constant for the period over which the population dynamics were simulated (i.e., 8 years),

3. The area-specific trend in abundance, as determined from census data from 1991 to 2000, would remain constant for the period over which the population dynamics were simulated,

4. The maximum benefit of management actions in a given area would not exceed 0.04, and

5. The underlying population rate of change following the implementation of a given management regime in a given area would equal the sum of the observed trend between 1991 and 2000 and the benefit assumed for that particular area (based on the conservation measures implemented in that area, in the previous opinion there was either a 4% increase for closed areas or no increase at all for areas with restricted fishing [i.e., green areas]).

The proposed action in consideration in this opinion is a complex set of management measures for the pollock, Pacific cod, and Atka mackerel fisheries in the BSAI and GOA which is intended to be in lieu of implementing the RPA from the previous opinion. Therefore, NMFS has attempted to evaluate the proposed action in a similar manner as it did the RPA (FMP biological opinion). The proposed action uses an approach similar to that taken in the RPA, a series of 13 management areas, but instead of implementing large blocks of closed areas for fishing for pollock, Pacific cod, and Atka mackerel (as in the RPA), the proposed action would implement zones of closures based on distance from a sea lion haulout or rookery. Therefore, NMFS was required to alter the method used from the previous opinion to account for areas with limited closures. This resulted in area specific models or population trajectories based on the cumulative impact of various closure zones, seasonal distributions, and spatial distribution in those specific areas. NMFS notes that this method over the 8 year period for which the population was simulated added a good degree of subjectivity to the analysis that wasn't present in the analysis in the FMP biological opinion. However, staff scientists at NMFS conclude that this is a reasonable approach for comparing the relative effects of the groundfish fishery on sea lions.

The rationale for zone-specific conservation measures, and subsequent analysis, was based on the premise that sea lions appear to spend approximately 75% of their time at-sea within 10 nm of shore and 25% of their time at-sea beyond 10 nm (ADF&G and NMFS 2001, and Table 5.1 of this document). Therefore, conservation measures were weighted by zone, a closure of directed fishing for pollock, Pacific cod and Atka mackerel within 10 nm of rookeries and haulouts in a given area (e.g., the 13 areas) would result in an increase in the underlying population trend in that area of 75% of the maximum allowable increase (i.e., 0.03).

This approach to modeling the population trajectory has some substantial differences to the original method used in the previous opinion. In that analysis, no benefits were assigned to the areas that were open to restricted levels of fishing (e.g., the green areas). Under this scenario, virtually all of the 13 areas are open to restricted amounts of fishing with some areas close to shore closed to various gear types at various times of the year. Using the method from the previous opinion, NMFS would not have given an increase to the trajectory for any of the zones that would have restricted fishing. However, in this method, the agency has chosen to estimate the incremental benefit to sea lions of various aspects of the proposed action, such as trawl closures, fishing seasons, platooning, and other methods to minimize the possible impact on sea lions. The result is that this method is no longer a "worst case" scenario as in the previous opinion.

The population trajectory for the RPA from the FMP biological opinion was determined to be minus 0.77%, or decreasing at a very low rate. However, NMFS reasoned that the rate of decline was overestimated because it did not account for the mitigation measures inside the open, yet restricted, fishing areas inside critical habitat. To be able to compare the two actions, NMFS has since re-evaluated the RPA, using a 2% expected increase in the annual trend for the green areas, described in the FMP biological opinion. The result was a trend of minus 0.37% and plus 0.05%, respectively. The maximum rate of change that could be expected from this population if all areas were increased by 4% would be an annual increase of about 0.95%. Therefore, for the RPA, NMFS expected the population to be stable or increasing at an undeterminable rate (e.g., recovering).

The following is a discussion of the conservation effects in each of the 13 areas, and its effect on the overall population trajectory, as well as a comparison to the RPA in the previous opinion (Table 5.6).

Table 5.6. Summary of area-specific management effects for both the RPA from the 2000 biological opinion and the proposed action considered in this biological opinion. The modified 2000 RPA represents a scenario where a 2% increase was given to each of the green areas to simulate how NMFS may have interpreted those limited fishing zones in order to compare the RPA to the proposed action.

Area	*Abundance (2000)*	*Trajectory Effect 2000 RPA*	*MODIFIED Trajectory Effect 2000 RPA*	*Trajectory Effect Proposed Action*
1	2134	0.00	0.02	0.03
2	2935	0.04	0.04	0.02
3	779	0.00	0.02	0.02
4	1262	0.04	0.04	0.04
5	2033	0.00	0.02	0.03
6	2398	0.04	0.04	0.0275
7	1204	0	0.02	0.0175
8	624	0.04	0.04	0.0275
9	884	0.04	0.04	0.04
10	1105	0.04	0.04	0.0325
11	1316	0.04	0.04	0.0325
12	4925	0.00	0.02	0.0275
13	3588	0.04	0.04	0.03
Total	25187	(-0.77%)	0.05%	(-0.25%)

The following is a description of the predicted effects of area-specific management under the proposed action:

	Description
Area 1	Closed to cod and pollock trawling out to 20 nm, except for Middleton Island where trawling would not be allowed inside 10 nm. Fixed gear fishing for cod would be allowed outside of 3 nm.
Effect	0.03
Rationale	An area closed to all gear types for pollock, cod and Atka mackerel out to 10 nm would be expected to have a positive effect on the expected population change of 0.03 (hereafter referred to as the base case). Here, pollock trawling is prohibited inside of 20 nm (with one exception to 10 nm), while pot and longline gear are allowed outside of 3 nm. The effect on this subpopulation of sea lions of fishing was therefore considered similar to the base case.

	Description
Area 2	Closed to cod and pollock trawling out to 10 nm around haulouts. The Pye Island and Sugarloaf rookeries are closed out to 20 nm for trawling and 10 nm for fixed gear. For Marmot Island - in the first half of the year the trawl fishery is open from 15 nm, which extends to 20 nm in the second half of the year. The Marmot closure for fixed gear is 10 nm year-round.
Effect	0.02
Rationale	One point (0.01) was subtracted from the base case effect due to the allowance of fixed gear fisheries outside of 3 nm.

	Description
Area 3	Closed to cod and pollock trawling out to 10 nm around haulouts. Cape Barnabus and Cape Ikolik are open to all cod and pollock gear from 3 nm out. Gull Point and Ugak Island are open to trawl (outside 3 nm) in C+D season pollock and B season trawl cod.
Effect	0.02
Rationale	One point (0.01) was subtracted from the base case effect due to the allowance of fixed gear fisheries outside of 3 nm.

	Description
Area 4	Closed to pollock, cod, and mackerel fishing out to 20 nm (all gears except jig).
Effect	0.04
Rationale	No fishing within critical habitat except for jig gear.

	Description
Area 5	Closed to trawling out to 20 nm, except Mitrofania/Spitz where trawling, longlining, and pot fishing are allowed from 3 nm out.
Effect	0.03
Rationale	Same as area 1.

	Description
Area 6	Closed to fishing out to 10 nm except that trawling, longlining, and pot fishing are allowed from 3 nm at the Whaleback, Sea Lion Rocks, Mountain Point, Caton, Castle Rock, the Pinnacles.
Effect	0.0275
Rationale	The allowance of trawling, longline, and pot gear outside of 3 nm in 6 areas make this management regime less conservative than the base case. One-quarter point (0.0025) was subtracted from the base case.

	Description

Area 7	Establish a 10 nm "Leitzell line" for the pollock fishery A season; 0-3 nm of all rookeries would be closed to all groundfish fishing, 0-3 nm of major haulouts would be closed to pollock, cod, and mackerel fishing, except with jig gear, 3-10 nm of rookeries and major haulouts would be closed to pollock, cod, and mackerel fishing except with jig, longline, and pot gear. All trawling for pollock, cod, and mackerel within 0-10 nm of all rookeries and major haulouts would be prohibited; 0-20 nm closure of the 5 northern haulouts to all groundfish fishing; close CVOA to trawl c/ps fishing for pollock (June 10 - Dec 31) as per current regulations; the Pribilof haulouts would be closed only to 3 nm; prohibit fishing with longline and pot gear inside of 7 nm of Amak rookery.
Effect	0.0175
Rationale	Fishery management in this area is approximately 50% less conservative than the base case as trawling for cod is authorized outside of 3 nm. In addition, the seasonal restrictions on cod trawling and longlining are less severe than in the base case. One and one-half points (0.015) were subtracted from the base case.

	Description
Area 8	Same as area 7.
Effect	0.0275
Rationale	Same as area 7.

	Description
Area 9	Closed to pollock, cod, and mackerel fishing out to 20 nm (all gears except jig or fixed gear catcher vessels under 60 ft.).
Effect	0.04
Rationale	No fishing within critical habitat except for jig gear or fixed gear catcher vessels under 60 ft.

	Description
Area 10	Closed to pollock, cod, and mackerel fishing with trawls or pots out to 20 nm (all gears except jig). Longlining closed out to 10 nm.
Effect	0.0325
Rationale	Fishery management in this area is more conservative than the base case as trawling and pot gear for pollock, Pacific cod and Atka mackerel are prohibited out to 20 nm. One-quarter point (0.0025) was added to the base case.

	Description
Area 11	Same as area 10.
Effect	0.0325
Rationale	Same as area 10.

	Description
Area 12	**Atka mackerel:** Temporal Measures: A&B Seasons (January 20 and September 1). Season TAC allocations: 50/50 per A&B seasons Measures to reduce catch rates on localized basis: Platoon management in Areas 542 and 543. Vessels wishing to participate would register with NMFS to fish scheduled A or B seasons and would be randomly assigned to one of two teams. The teams would start in either 542 or 543. Area Restrictions: No CH fishing in Seguam foraging area and Area 518 (Bogoslof). No CH fishing for mackerel east of 178 West longitude. Rookeries west of 178 West longitude closed out to 10 nm except 15 miles at Buldir. Haulouts: closed 0-3 nm. CH Apportionment: 60% inside and 40% outside. **Pacific cod:** Seasons: Trawl: January 20 - June 10 (80%), June 11 - October 31 (20%) Longline, jig: January 1 - June 10 (60%), June 11 - December 31 (40%) Pot: January 1 - June 10 (60%), September 1 - December 31 (40%) Pot CDQ January 1 - December 31 Note: the harvest of cod by the <60' pot vessels should account towards the 1.4% quota when the 18.3% season is closed. Area Restrictions: Longline and Pot: no CH fishing east of 173 degrees West to western boundary of Area 9, Buldir closed inside 10 nm, Agligadak closed to 20 nm. Trawl: East of 178 west: rookeries closed at 10 miles except 20 nm Agligadak, haulouts open from 3 miles and out; west of 178 west: no fishing within 10 miles at haulouts and rookeries until the Atka mackerel fishery inside CH A or B season, respectively, is completed, at which time trawling for cod can occur 3 nm outside of haulouts and 10 nm of rookeries. All gear types: Seguam foraging area is closed to all gear types. **Pollock:** One season with January 20 opening. No fishing for pollock in CH. Other applicable allocation splits (AFA)
Effect	12 = 0.0275
Rationale	Fishery management in this area is less conservative than the base case as trawling and longlining for Atka mackerel and Pacific cod is authorized outside of 3 nm from rookeries and haulouts (with some exceptions). Further, seasonal restrictions on trawling for cod is less conservative than the base case. One quarter point was subtracted from the base case.

	Description
Area 13	The conservation measures in area 13 are more restrictive than in area 12, as the Atka mackerel fishing effort will be spread out due to the establishment of two groups (i.e., platoons) of fishing vessels and the cod fishery will be excluded from critical habitat areas until the Atka mackerel fishery has been completed.
Effect	0.03

Rationale	Fishery management in this area is less conservative than the base case. The platoon approach for the Atka mackerel fishery should reduce daily catch rates by roughly 50% relative to the 1999 fishery. In addition, the cod fishery is prohibited while the Atka mackel fishery is being prosecuted. One-quarter point (0.0025) was subtracted from the base case.

The results of the population trajectories for all 13 areas are presented in Figure 5.3 for the RPA and for the proposed action considered in this biological opinion. The average trend in abundance for the proposed action is -0.25%, and +0.05% for the RPA (as modified by adding a 2% increase to each of the green areas).

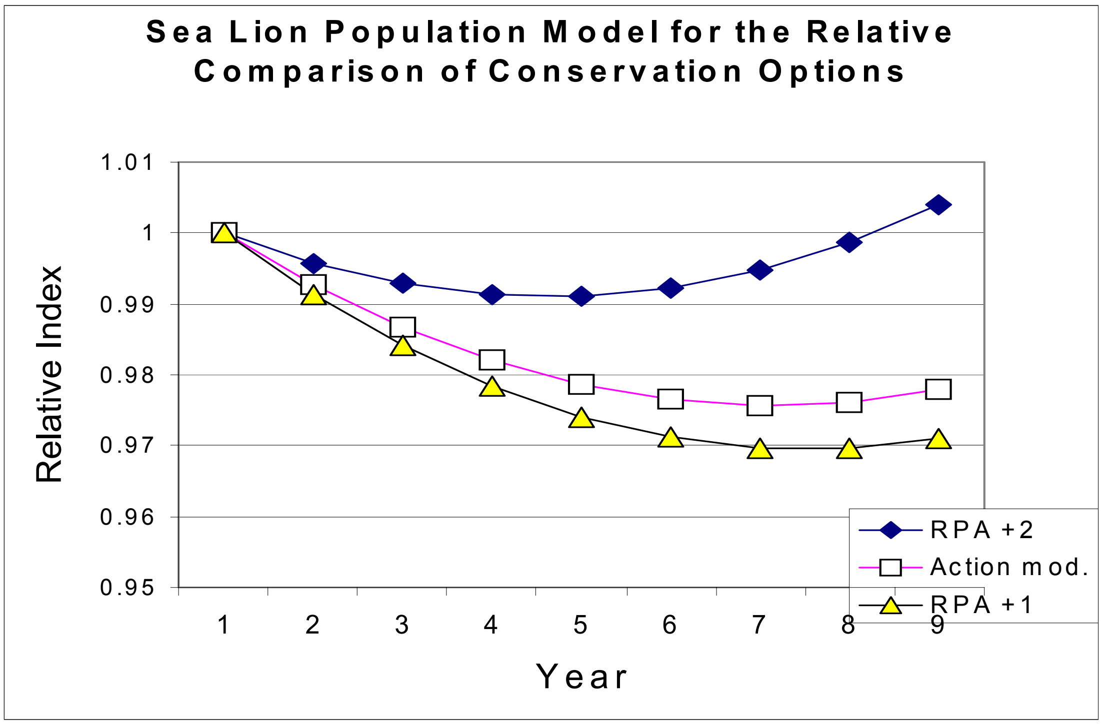

Figure 5.3. Estimated theoretical population trajectories associated with the area-specific management effects for both the RPA from the FMP biological opinion (with a 2% increase in the green areas) and the proposed action considered in this biological opinion. The rate of change is the average rate of change over the 8 year trajectory based on an exponential model (See DeMaster 2001 for details). The model is highly subjective and should be considered only as an additional tool to compare various complex management measures.

5.3.2.2 Discussion of the Two Conservation Approaches

The population trajectories presented here in this document, and those calculated for the RPA committee are not intended to accurately predict population trends over the next eight years. Rather, given the assumptions discussed above, the predicted trajectory was intended for use as an index of the effectiveness of the proposed action relative to the RPA from the FMP biological opinion. Furthermore, no level of uncertainty was assigned to the model or the trajectory estimates because of the subjectivity and qualitative nature of the model. After a preliminary review of this analysis by the Council's SSC and the Bowen Report (Bowen *et al.* 2001) the following additional analyses were performed to investigate the robustness of the conclusions to one or more of the assumptions described above.

The proposed action was considered to be as conservative as the worst case scenario from the RPA (Table 5.6) because the resulting trend was less negative than the RPA (and was very close to zero). However, the modified analysis which added a 2% increase to each of the green areas which were open to limited fishing resulted in a trend rate of plus 0.05%. The proposed action would then be considered to be not as conservative as the RPA under this scenario when comparing the two trends. Further, there are other numerous assumptions that have been explored further since the RPA committee meetings in an attempt to determine the robustness of the model:

> ***What would be the effect if the inner 0-10 nm zones were equal to the importance of the area beyond 10 nm (the assumption was made that 0-10 nm was three times as important as the area beyond 10 nm)?***
>
> An analysis was done that recalculated the assumed increases in the underlying trend in abundance, where the relative importance of the inner 10nm was set equal to the outer 10nm. In this case, the conclusion reached was that the proposed action would not be as conservative as the worst case scenario from the RPA (FMP biological opinion).
>
> ***What would be the effect of looking at the trend over only 1 year as opposed to 8 years?***
>
> An analysis was done that projected the population forward one time step and then compared the overall trend in abundance for the 13 areas. Under this scenario, the proposed action was considered to be as conservative as the worst case scenario from the RPA because the resulting trend was less negative than the RPA (FMP biological opinion).
>
> ***What would be the effect of using the underlying trend rate in each of the 13 areas instead of the 4% overall trend rate?***
>
> That is, what would be the results of the model if the increase in the area-specific trends were not limited to 0.04, but were set equal to the product of the area-specific trend in abundance and the percentage of the area-specific increase in the trend in abundance previously used. An analysis was done that assumed the area-specific increase in abundance was proportional to the percent increase in the trend relative to the maximum increase allowed. For example, in area 1, the assumed increase in the trend in abundance was 75% of the maximum allowed increase. Because the underlying trend in area 1 was –0.096, the resulting increase in the trend in abundance was 0.072. Therefore, the new trend in abundance under this scenario was –0.024 (-0.096+0.072). A similar calculation was made for each of the other 12 areas, except that in the two areas that were increasing, no increase in the population trend was assumed. Again, under this scenario, the proposed action was considered to be as conservative as the worst case scenario

from the RPA because the resulting trend was less negative than the RPA (FMP biological opinion).

As noted in the FMP biological opinion, the worst case trajectory over an 8 year period was found to be a negative trend of 0.77% per year. However, as noted earlier, the areas referred to as "open" to fishing, were actually subject to a variety of restrictions (e.g., seasonal and spatial limits on removals). Therefore, a new analysis of the expected trajectory for the conservation measures described in the FMP biological opinion was done, where sea lion numbers in the open areas were assumed to increase 2% points or 50% of the maximum allowable increase. The result of this analysis was a trajectory that was slightly increasing. As noted previously, the trajectory for the action described in this biological opinion was slightly negative (i.e., -0.25% per year). Such a rate of decline, if realized over an 8 year time period, would result in a population decline of approximately 2%. Given the uncertainty in the available data and the qualitative nature of this analysis, NMFS has determined that the difference in the expected trajectories is insignificant and that it is reasonable to conclude that the proposed action in the FMP biological opinion (i.e., the RPA) and the action considered in this biological opinion are approximately equal in avoiding adverse effects with Steller sea lions.

These additional analyses indicate that the conclusion reached regarding the relative conservatism of the proposed action, in relation to the RPA from the FMP biological opinion, is robust to conclusions about the independence of the 13 areas or the time period over which the trajectories are simulated. However, it appears that the results are sensitive to assumptions regarding the relative importance of the 0-10 nm zones relative to the area beyond 10 nm. At this point, while the telemetry data indicate that the inner 10 nm may be more important to lactating adult females in the summer and to young-of-the-year in the first winter and spring, additional data are needed to evaluate the relative merits of the 0-10 nm zone to one and two year old animals and to adult females during the winter. As described in the Bowen Report, if in the future NMFS has data to show that the inner 10 nm may not be three times as important as 10-20, then the analysis will not be as conservative as expected. However, at that time, when the data is available, NMFS will re-evaluate the conservation measures and work with the Council and the public to craft new measures which are appropriate given the data available at that time.

5.3.3 Analyses of the Availability of Forage for Steller Sea Lions in Critical Habitat

One method for determining whether a fishery management measure is likely to adversely affect critical habitat of the Steller sea lion is to determine whether there is adequate forage within critical habitat available to support the sea lion population and the commercial fishery. Appendix 3 of the FMP biological opinion provided one possible approach: compare the ratio of biomass currently consumed by Steller sea lions to the biomass of groundfish available within critical habitat, and compare this ratio to the theoretical ratio of biomass consumed by a "healthy" stock of Steller sea lions to the biomass of an unfished groundfish complex.

In the FMP biological opinion, NMFS made an attempt to use this approach to first determine quantitatively whether the global control rule for the two existing FMPs was adequate in providing sufficient biomass for Steller sea lion foraging throughout the year. In both cases, NMFS generally concluded that the approach was conservative, and correctly erred on the side of the species. This is in large part due to the fact that the sea lion consumption estimates were based on the following assumptions: (1) the species consumes only pollock, Pacific cod, and Atka mackerel (while sea lions are known to eat a variety of prey), and (2) sea lions forage exclusively in critical habitat. Thus, NMFS concluded that current fishing practices as authorized by the FMPs were unlikely to cause adverse modification of critical habitat at a spatial scale equal to the size of critical habitat. However, it was also recognized that this spatial scale is too large to be important to an individual sea lion attempting to forage. Unfortunately, data are not available on a spatial or temporal scale that would allow further refinement of this method at the current time.

The forage ratio approach provides some very general guidance - at a larger geographic scale and at the population level - regarding whether the current FMP allows for sufficient biomass in critical habitat in each region in which to support the current population of Steller sea lions. This approach may even be useful as a benchmark to which proposed management actions could be compared in a very gross sense. However, NMML recommends that this approach only be used to compare management actions at a spatial scale equal to or larger than the smallest unit for which the necessary fishery information can be estimated (e.g., Gulf of Alaska, Bering Sea, and Aleutian Islands). The complete forage ratio evaluation prepared by NMFS is contained below. However, this approach was not used in the decision making process because it cannot be used to evaluate fishery management on a small spatial or temporal scale.

In order to evaluate the impacts of fishery management measures at a smaller spatial scale, NMFS has elected to examine the management of the groundfish fishery within critical habitat and zones outside critical habitat, and to qualitatively describe the likely benefits to Steller sea lions of complete or partial closures of these areas. This is the spatial scale in which the fishery is prosecuted, it is the spatial scale which is likely most important to Steller sea lions, and until better data are obtained on forage availability, it seems the most appropriate approach to determining "adverse modification". This "zonal approach" to evaluating the effects of the proposed action on critical habitat is described in section 5.3.4.

5.3.3.1 The Analysis – Assumptions

Several assumptions were necessary in order to estimate the availability of forage in critical habitat. Concerns about the validity of these assumptions will be identified and discussed later in this document.

- The amount of biomass is the only factor that affects whether or not Steller sea lions can forage successfully.
- Steller sea lions eat only pollock, Atka mackerel, and Pacific cod.
- Steller sea lions forage exclusively in critical habitat
- A "healthy" stock of Steller sea lions (184,000; Loughlin *et al.* 1984) occurred at the same time as the "theoretical" level of an unfished groundfish complex.

There are significant concerns about the assumptions inherent in this approach. Concerns regarding each assumption are outlined as follows:

- Amount of biomass is the only factor that affects whether or not Steller sea lions can forage successfully.
  The "availability of forage" is likely not related only to the biomass present. Instead, "availability" will likely depend on a combination of biomass, geographic location of the forage species, vertical location of the forage species within the water column, what age-class(es) dominates the forage species, and the behavior of the forage species (i.e., aggregation behavior). This approach does not incorporate any of these other factors, and it's not clear how incorporation of these other factors (even in a qualitative sense) would affect the historical forage ratio calculation, or any determination regarding whether a particular management regime would cause the current forage ratio to increase or decrease

- Steller sea lions eat only pollock, mackerel, and Pacific cod
  There is abundant information which indicates that these species make up only a portion of SSL diet. The importance of these species to Steller sea lions varies both seasonally and

geographically. Some species, such as herring and salmon, are very important during some seasons and in some areas. Obviously, violation of this assumption is less of a concern in those areas where groundfish are the primary prey species year round, and more of a concern in those areas where species other than groundfish are a major prey species at least seasonally (e.g., Gulf of Alaska).

- Steller sea lions forage only in critical habitat.
  Existing satellite tagging data document that Steller sea lions forage extensively outside of critical habitat. In addition, although the most recent satellite tagging data show a preponderance of locations within critical habitat (in fact, within 10nm of shore), Steller sea lion biologists point out that focusing only on the number of nearshore locations - particularly with the most recent data - will likely overestimate the importance of the nearshore areas. Additional information on this important issue can be found in Section 5 of the Biological Opinion.

- A "healthy" stock of Steller sea lions (184,000; Loughlin *et al.* 1984) occurred at the same time as the "theoretical" level of an unfished groundfish complex.
  This assumption is required in order to develop the initial metric for comparison with the "historical" levels of forage available. However, although we do have some evidence that the Steller sea lion population was at an estimated 184,000 animals, we are less certain about the precision of the "theoretical" level of an unfished groundfish complex, and we are even less certain that the "healthy" population size of 184,000 and the "theoretical" level of unfished groundfish occurred simultaneously.

5.3.3.2 Estimating a Measurement for "Adequate Forage"

In order to estimate whether the current amount of forage available in critical habitat is adequate for the current population of Steller sea lions, we must define the term "adequate". Unfortunately, there have been no studies that have attempted to address what constitutes "adequate" forage availability. Thus, NMFS must use the best available information to hypothesize what level of forage availability might constitute "adequate". NMFS proposed two approaches to address this issue: first, compare current annual forage ratios to an estimated historical, theoretical level; second, compare current forage ratios to those reported in the scientific literature.

<u>Determining an estimated historical forage ratio</u>
Based on the approach reported in Winship (2000) and used in NMFS (2000), the estimated annual consumption of forage by 43,000 sea lions is 399,700 tons of fish. An estimate of the historical population size of Steller sea lions is 184,000 (Loughlin *et al.* 1984), which would be expected to consume 1.7 million tons of fish. An estimate of the theoretical, unfished biomass of groundfish is 37.6 million tons (FMP biological opinion); thus, if Steller sea lions ate only groundfish, a "healthy" stock of Steller sea lions feeding on an unfished groundfish resource could require an estimated 4.5% of the groundfish resource each year. An alternate way of stating this is that a "healthy" stock of Steller sea lions requires an estimated 22 times more forage than it is capable of consuming in a single year.

Another estimated consumption rate is reported by Fowler (1999), who extracted the information from Perez and McAlister (1993). In this report, Perez and McAlister (1993) indicated that 32,000 Steller sea lions would consume 140,700 tons of forage each year. If this is extrapolated to a "healthy" stock size of 184,000 Steller sea lions and the result compared to the theoretical, unfished biomass of groundfish, the percent "needed" by Steller sea lions is 2.2%. An alternate way of stating this is that, using this lower consumption rate, a "healthy" stock of Steller sea lions requires an estimated 46 times more forage than it is capable of consuming in a single year.

At present, we have no information that will allow us to evaluate whether it is more likely that a "healthy" stock would require an estimated 4.5% or 2.2% of a theoretical, unfished groundfish resource (22 times or 46 times more forage than consumed in a single year, respectively). There are two ways to move forward. First, one could use an average of the two estimates as a metric and state that if there is currently at least 34 (22+46/2) times more forage available in critical habitat than consumed in a year, this can be considered "adequate". Second, one could use the more conservative value as a metric, and state that if there is currently at least 46 times more forage available in critical habitat than consumed in a year, this can be considered "adequate".

There are two concerns regarding a comparison between the forage needed for a "healthy" stock size of 184,000 Steller sea lions to a theoretical unfished groundfish biomass. First, we are reasonably certain that the Steller sea lion population once included approximately 184,000 (or approximately 200,000) animals. In contrast, the theoretical unfished groundfish biomass is, by definition, theoretical. We have no way of knowing the precision of that estimate, thus, the actual ratio could be substantially higher or lower than that estimated here. In addition, this approach assumes that a "healthy" stock of Steller sea lions existed at the same time as the theoretical unfished biomass of groundfish; given that there have been multiple regime shifts, and the responses of both the groundfish population and the Steller sea lion population to these shifts are not well understood, it is not clear that this assumption is valid.

Forage ratios in the literature

The forage ratio discussed here is analogous to "consumption efficiency" or "ingestion efficiency" presented in ecology texts. Levels of consumption/ingestion efficiency for an entire trophic level (including all predators) range from ~20% for trophic levels 3-4 in freshwater ecosystems (Krebs 1978), to 10-100% or 50-100% for vertebrate carnivores of vertebrates in general (Ricklefs 1973, Begon *et al.* 1990 respectively). Begon *et al.* (1990) further states, however, that little is known about the consumption efficiencies of predators and calls any estimate "speculative". There is no general "rule of thumb" for typical consumption efficiencies for individual predators.

Synthesis

Not surprisingly, a consumption ratio estimated at 4.5% or 2.2% (forage ratio of 22-46) for a single predator is lower than the range of consumption efficiencies expected for an ecosystem of predators at a given trophic level. It may be possible to determine the average number of predators in the literature referenced above, but the nature of these references (i.e. textbooks) indicates this will not be straightforward. Another approach might be to derive values from existing ecosystem models. This approach has not yet been pursued.

Finally, concerns have been raised about the fact that the forage ratio of 22-46 (2.2-4.5% consumption of the total forage) is derived from annual estimates of consumption, while there is a desire to manage commercial fisheries on a seasonal or monthly basis. However, because the forage ratio is essentially dimensionless, the threshold value of 22 or 46 for a healthy prey field could be used to assess the amount of groundfish available on a monthly basis even though it was calculated based on an annual rate. Clearly, at some point, using different temporal scales will create problems (i.e., daily vs annual consumption), because of the ability of these animals to a maximum of 5-8 days. However, comparing consumption efficiency estimates based on monthly or annual data seems reasonable.

5.3.3.3 Evaluation of Possible Forage Ratios using Three Spatial and Temporal Scales

The following describes the estimation and attempts to interpret the forage ratio at the following four combinations of spatial and temporal scales:

1. Annual, Gulf of Alaska, Bering Sea, and Aleutian Islands combined
2. Annual, Gulf of Alaska, Bering Sea, and Aleutian Islands separate
3. Monthly, critical habitat only, Gulf of Alaska, Bering Sea, and Aleutian Islands

<u>Annual estimate of prey availability for the Western stock of Steller sea lions in critical habitat in the Gulf of Alaska, Bering Sea, and Aleutian Islands combined</u>

Estimation

The largest scale for which the ratio of prey required to prey available can be reliably estimated is at the regional scale (i.e., critical habitat within the Gulf of Alaska, Bering Sea, and Aleutian Islands combined). As previously stated, based on the approach reported in Winship (2000) and used in NMFS (2000), the estimated annual consumption of forage by 43,000 sea lions is 399,700 tons of fish. Given that there is an estimated 21.8 million tons of groundfish in this area, the proportion of prey available to the entire population of Steller sea lions is 1.8%, or a forage ratio of 55.

Possible Interpretation

The estimated current ratio of 55 is higher than the estimated ratio of 22-46 for a theoretical, unfished groundfish complex, which could lead one to conclude that there is sufficient forage in the Gulf of Alaska, Bering Sea, and Aleutian Islands, combined, to support a healthy stock of Steller sea lions. It should be noted that this spatial scale is considerable larger than the spatial scale important to foraging by Steller sea lions.

<u>Annual estimate of prey availability for the portion of the western stock of Steller sea lions in the Gulf of Alaska, Bering Sea, and Aleutian Islands</u>

Estimation

An estimate of the forage required in each area was calculated by estimating the total number of Steller sea lions in a given area based on non-pup counts from June and a published correction factor. The consumption required was then estimated by assuming that each Steller sea lion eats, on average, 0.77 tons of forage per month.

Using the annual estimate of forage required in a give area and estimates of biomass of pollock, Pacific cod, and Atka mackerel available in the Eastern Bering Sea, Aleutian Islands, and Gulf of Alaska (NMFS 2000), it is possible to calculate the ratio of prey required to prey available within critical habitat separately for the three main areas of Steller sea lion abundance (Table 5.7). Based on this calculation, there is 446 times more forage available than required in the Bering Sea, compared with 11 and 17 times more forage available than required in the Aleutian Islands and Gulf of Alaska, respectively. Alternatively, it could be stated that Steller sea lions require 0.2 - 9% of the forage available in the Eastern Bering Sea, Aleutian Islands, and Gulf of Alaska.

Table 5.7. Forage required by Steller sea lions and groundfish biomass in Critical Habitat for the Eastern Bering Sea, Aleutian Island, and Gulf of Alaska

	Annual estimate of forage required (metric tons)	Groundfish biomass estimates in 2000	Percent required (multiplier) [theoretical 22-46]
Eastern Bering Sea	41,508	18,517,619	0.2% **(446)**
Aleutian Islands	130,296	1,468,608	9% **(11)**
Gulf of Alaska	213,695	3,630,482	6% **(17)**

Possible Interpretation
Clearly, the forage ratio for the Eastern Bering Sea is higher than the ratio for a "healthy" stock of Steller sea lions foraging on a theoretical, unfished groundfish population. Although the other forage ratios are substantially lower, the interpretation of these ratios is not straightforward, as Steller sea lions do forage on species other than groundfish in these areas.

Estimates of prey availability for the western stock of Steller sea lions in critical habitat in the Gulf of Alaska, Bering Sea, and Aleutian Islands combined at time scales smaller than yearly

A method for evaluating whether the amount of forage available for Steller sea lions is adequate at scales other than annual (e.g., monthly) is desirable. Estimates of the proportion of pollock, Atka mackerel and Pacific cod biomass inside critical habitat each month were made (NMFS 2000). Similarly, estimates of the monthly groundfish consumption of sea lions can also be made. While it would appear to be simple enough to make a ratio of the two, it would be inappropriate to do so because of the differences in the underlying scale of the two data sets. The monthly estimate of pollock, Pacific cod, and Atka mackerel biomass in NMFS (2000) is an estimate of the standing stock inside critical habitat. The estimates for each month sum to more than the total biomass of the three species in the management areas. The sea lion consumption estimates are true monthly estimates that when summed, yield annual consumption. Computing a forage ratio for each individual month using these two vectors, and then comparing it to an annually-derived number (annual consumption/annual total biomass) would be inadvisable because of the differences in temporal scale used in the two analyses.

5.3.4 Direct and Indirect Effects of Fisheries on Sea Lions

In this section we will be evaluating the expected direct and indirect effects of fishing under the proposed action on the two stocks of Steller sea lions and their critical habitat. A detailed description of the spatial and temporal aspects of the pollock, Pacific cod, and Atka mackerel fisheries as well as the possible impacts to the environment are described in detail in the SEIS. This section evaluates those fisheries in terms of the 7 zones outlined above in Section 5.2.1.5 of this document.

Table 5.3 below describes the proposed action in reference to the zonal evaluation system that we will be using for this analysis. This analysis combines qualitative and quantitative methods to derive the relative fraction of critical habitat closed to each sector of the fisheries in the proposed action. The fraction of closed critical habitat was calculated proportional to the TAC for each gear type and vessel size class specified in the proposed action. For example, the TAC allocated to jig, fixed (hook-&-line and pot), and trawl gear is .02, .47, and .51, respectively, for Bering Sea cod. The amount of critical habitat closed to each gear type was calculated by dividing the number of rookeries and/or haulouts closed to that gear type by the total number of rookeries and haulouts designated as critical habitat in an area. The fraction of area closed to each gear type was multiplied by the respective TAC and the resulting product was summed across all gear types to yield the relative fraction of closed critical habitat by fishery and area. Given the complexity of the proposed action, this table merely acts as a guide to help us understand and interpret the likely impacts.

Table 5.3. Fraction of critical habitat closed, and the spatial and temporal dispersion of the proposed action as described in various zones.

Aleutian Islands	**0-3nm**	**3-10nm**	**10-20nm**	**20nm+**	**Spatial**	**Temporal**
Pollock	1.0	1.0	1.0	Seguam foraging area	Closed to directed fishing	Closed to directed fishing
Atka mackerel	.99	.71	.43	Seguam foraging area	Limited to 60% of TAC inside critical habitat and platoon management to disperse fleet	Two seasons and TAC apportionments: January 20 (50%), September 1 (50%)
Pacific cod	.98	.30	.11	Seguam foraging area	Area restrictions by gear type	Seasons with TAC apportionments by gear type (e.g. trawl, January 20- June10 (80%), June - October 31 (20%))
Bering Sea	**0-3nm**	**3-10nm**	**10-20nm**	**20nm+**	**Spatial**	**Temporal**
Pollock	1.0	.81	.05	*small area in the Bering Sea Pollock Restrict. Area	Limit pollock taken from within the SCA to 30% of the TAC prior to April 1 A season: No fishing out to BSPRA Boundary (~10nm) B season: CVOA closed to trawl catcher-processors	Season and TAC apportionments: January 20 - June 10 (40%), June 11 - October 31 (60%)
Pacific cod	.98	.44	.05	0		Season and TAC apportionments by gear (i.e. trawl, January 20- June10 (80%), June - October 31 (20%))
Gulf of Alaska	**0-3nm**	**3-10nm**	**10-20nm**	**20nm+**	**Spatial**	**Temporal**
Pollock	1.0	.80	.48	0		Season and TAC apportionments, 4 seasons (25% in each season)
Pacific cod	.77	.59	.32	0	Three options for allowing fishing from 0-20nm based on gear type and/or vessel size.	Two seasons, 60% of TAC: Jan. 1 fixed gear, Jan. 20 trawl, 40% of TAC Sept. 1 all gear types

*Closed to Trawling in the Pribilof Habitat Conservation Area

5.3.4.1 Zone: 0-3 nm from shore

The area of critical habitat from 0-3 nm from shore is considered to be one of the highest areas of concern for foraging Steller sea lions (see Section 5.2.1.5 and Table 5.2). The proposed action would close most of this zone (from 0-3 nm around rookeries and haulouts) to directed fisheries for pollock, Pacific cod, and Atka mackerel, including State parallel fisheries. There is an exception for jig gear fishing for Pacific cod, and multiple exceptions for pot and hook-and-line gear in various areas in the GOA, which amounts to about 77% of the area being closed on average (Table 5.3; 100% for trawl and 54% for fixed gear). The proposed action would effectively minimize adverse impacts within 0-3 nm from shore (due to complete closures), except for the Pacific cod fishery in the GOA. However, the exception is for fixed gear fisheries only, which NMFS considers to be less likely to cause localized depletions than trawl (see Section 5.3.1.6). Fishing with jig gear is also not expected to adversely affect sea lions through competitive interactions for prey due to the small vessel sizes, extremely low rate of harvest, and relatively low numbers of vessels. The proposed action would be very effective at avoiding any adverse impacts in this zone.

5.3.4.2 Zone: 3-10 nm from shore

The area of critical habitat from 3-10 nm (from shore) is considered to be one of the highest areas of concern for foraging Steller sea lions (see Section 5.2.1.5 and Table 5.2). The proposed action would close a substantial portion of this zone (from 3-10 nm around rookeries and haulouts) to directed fisheries for pollock, Pacific cod, and Atka mackerel. For pollock and Atka mackerel, at least 75% of the 3-10 nm zone is closed to directed fishing. For Pacific cod, about 30% of the area is closed in the AI, 40% in the EBS, and 59% in the GOA (in the GOA, trawl is closed in 86% of the area and fixed gear is closed in 33%). We can speculate that trawl gear, due to its higher catch capacity than fixed gear types, would have a greater likelihood in causing localized depletions which could adversely affect sea lions (see Section 5.3.1.6).

Limited trawling for pollock and Atka mackerel would be allowed in this zone; roughly 75-100% of the area would be closed. For Pacific cod, closures areas average between 30% to 59% across management areas. We expect that roughly half of the fishing that will occur in this zone would be with fixed gear fisheries, which are considered to be less likely to cause localized depletions compared to trawl gear. Additionally, analysis of scat data has indicated that Pacific cod may be a less important prey species for Steller sea lions than Atka mackerel or pollock, as measured by the percent frequency of occurrence (Table 3.3; Pacific cod = 11.9%, pollock = 46.4%, and Atka mackerel = 39.6% range wide).

Given this relatively small amount of overlap between fisheries and Steller sea lions, it is unlikely that the proposed action would result in competitive interactions with sea lions. Of course, additional closures, especially for trawl gear in the Pacific cod fisheries would strengthen these conservation measures and would provide a more risk-averse approach to minimizing competition. Additional fixed gear closures for Pacific cod in this zone would also presumably be beneficial, although since this gear type may be less likely to cause localized depletions, it may not have the same effect as a trawl closure described above.

5.3.4.3 Zone: 10-20 nm from shore

The area of critical habitat from 10-20 nm from shore is considered to be of low to moderate concern for foraging Steller sea lions (see Section 5.2.1.5 and Table 5.2). This information was taken into account by the Council and its RPA committee when designing their proposed action. Table 5.3 reflects the lower concern for this zone, as substantially less area of critical habitat is closed. Roughly 5-50% of the area is closed by fishery and area. The largest closure area is for pollock in the Aleutian Islands, which may provide little protection for sea lions as pollock isn't a key item in their diet in this area (Sinclair and Zeppelin submitted; Table 3.3 of this document).

For pups and juveniles instrumented in the winter, only about 0.6% of the at-sea locations were in this zone (Table 5.1a). Pups and juveniles did occur at a higher rate in this zone during the summertime (about 5.1%, Table 5.1a). However, this reflects only limited usage by these animals, as determined from at-sea observations.

Given the limited use of this zone by pups and juvenile sea lions, some level of fishing would be appropriate. Because many of the areas of concern, such as important rookeries and haulouts are closed and trawling is limited either by critical habitat limitations or temporal restrictions, the proposed action would be effective in minimizing competitive interactions in this zone (see the discussion in Section 5.2.1.5).

5.3.4.4 Zone: Beyond 20 nm from shore

The area of critical habitat beyond 20 nm from shore is considered to be of low concern for foraging Steller sea lions (see Section 5.2.1.5 and Table 5.2). This low level of concern was also taken into account by the Council and its RPA committee when designing their proposed action. Table 5.3 reflects the lower concern for this zone with little area closed to fisheries beyond 20 nm. In the EBS, A small portion of the area would be closed beyond 20 nm (distance from the nearest haulout or rookery) just north of Unimak Island in the Bering Sea Pollock Restriction Area (BSPRA). Although sea lions are known to forage in these areas (Figure 4.1), most sea lions in this zone are presumed to be older juveniles or adults which are likely to have advanced diving and foraging capabilities. Pups and juveniles were less likely to range into this zone in the winter (0.4%) than in summer (20.4%; Table 5.1a). The assumption is that animals in this age class can find adequate forage even if there is local interaction or extractive competition (supported by the fact that animals in these age classes appear to be healthy). Also, given that winter is considered to be the most critical time for pups and juveniles, protecting the zones from 0-10 where roughly 95% of the observations occurred (Table 5.1b) would be an appropriate conservation measure given the available information and understanding of sea lion foraging. Therefore, in this zone, the proposed action is unlikely to compete with Steller sea lions in a manner which would reduce their foraging success.

5.3.4.5 Zone: Spatial Dispersion (beyond 10 nm from shore)

Spatial dispersion (beyond 10 nm from shore), is considered an area of low concern for foraging sea lions (see Section 5.2.1.5 and Table 5.2). As described above, this is primarily due to the lack of estimated foraging effort in this area (i.e., 1.9% of the at-sea observations for pups in winter were beyond 10 nm; Table 5.1b). It is also a vast area in which the likelihood of causing localized depletions of important prey species that would measurably result in adverse impacts to sea lions is less likely than those areas close to shore. The proposed action has elements of spatial dispersion within the zone from 10-20 nm which is considered an area of lower concern.

For pollock, the spatial dispersion elements in the proposed action are: (1) a harvest limit on the amount of pollock taken within the SCA would be established at no more than 28% of the annual TAC prior to April 1 each year. The remaining portion of TAC available prior to June 10, or 12% of the annual TAC, may be harvested outside of the SCA before April 1 or inside SCA after April 1, and (2) a restriction on catcher processor fishing in the CVOA during the B season. The A season limit of 75% in the SCA is an arbitrary amount which more reflects the fleet's historic catch distribution in this area. It would have marginal benefits to limiting possible adverse impacts and is not related to the fraction of biomass in the

SCA (i.e., roughly 50% in the A season; FMP biological opinion). The second element is more important to sea lions as it forces a relatively large fraction of the fishing effort further offshore, especially important during the B season where NMFS has shown in past biological opinions that the fraction of pollock biomass within the SCA is very low, roughly 5-10% in most years (FMP biological opinion). The third element may also provide beneficial effects, although as noted above under the discussion of the 10-20 nm zone, pollock is not a highly occurring prey in the diet of sea lions in the Aleutians, and would therefore have marginally beneficial results. Conversely, a low frequency of occurrence of pollock in sea lion scat in the Aleutian Islands may indicate the scarcity of the prey, and given the dependence of sea lions on this prey item in the Bering Sea and GOA, we could speculate that a closure might be very important. However, we are extremely limited in being able to determine what prey species are more or less likely to be essential to the survival and recovery of the species.

Because there are virtually no limits on catch in critical habitat (the exception is a limit of about 70-75% of each seasonal allowance in the SCA and Atka mackerel harvest limits of 60% in the AI), it is likely that the majority of the harvest will be concentrated within these zones. Previous experience with pollock in the GOA in 1999 and 2000 reminded us that even though most of the 0-10 nm areas of critical habitat were closed, that the overall fraction of the catch in critical habitat remained relatively the same as before. Granted, the intent of the previous closures were not necessarily to minimize the fraction of critical habitat catch, it only serves as a guide that for this action, the result will be similar.

The Atka mackerel fishery would be conducted in a manner not previously attempted in the Aleutian Islands. First of all, there would be a harvest limit of 60% of each seasonal TAC which could be caught in critical habitat. This reflects fraction of biomass which is likely to be within critical habitat (see the FMP biological opinion). However, a number of preferred fishing grounds were opened under this action that have been previously closed. To counter this possible adverse affect, the Atka mackerel fishery will split the fleet into two groups and fish concurrently in NMFS management areas 542 and 543. This will effectively reduce the daily harvest rate in half, largely alleviating NMFS' major concern of possible localized depletion due to high daily catch rates.

Under this proposed action, the three foraging areas would be in large part open to directed fishing (with the exception of the Seguam Foraging Area and marginal limitations in the SCA). However, these areas were never considered to be important based on satellite telemetry (see Section 3.2.1). These areas were known to contain high abundances of prey species known to be important for Steller sea lions, and were therefore designated as critical habitat so that the agency and the public would be aware of their possible importance to the survival and recovery of Steller sea lions. Since the designation of these areas as critical habitat, satellite telemetry information has indicated that these areas may not be extensively used by sea lions, especially pups and juveniles which are the age classes of most concern. About 10 animals have been instrumented in the Bering Sea area and most of them were pups (Robert Small pers. comm.).

This action is likely to avoid adverse impacts to foraging Steller sea lions in this zone of low concern. However, under a more risk averse approach (i.e., to minimize type II error), fishing could be limited in critical habitat areas to the amount of biomass found in the specific area during a particular season. This would minimize the chance for localized depletions, and would insure local harvest rates similar to the global harvest rate. However, NMFS cannot presently quantitatively determine the effectiveness of this approach, except to say that it would be more risk-averse than the proposed scenario.

5.3.4.6 Zone: Temporal Dispersion (beyond 10 nm from shore)

Temporal dispersion (beyond 10 nm from shore), is considered an area of low to moderate concern for foraging sea lions (see Section 5.2.1.5 and Table 5.2). This is in part due to two considerations: (1) sea lions are thought to be more susceptible to competition for prey during critical seasons, and (2) localized depletions are more likely when catch is concentrated in one season. It is difficult to summarize the proposed action under this element. Table 5.3 outlines the various temporal dispersion elements of the action. The most risk-averse approach would be similar to that taken in the FMP biological opinion. Under that scenario, there were 4 equal seasons inside critical habitat, and two outside of critical habitat with catch percentages of 40/60% for each season. The purpose for this element was to minimize impacts during the winter/spring period when pups may be most susceptible to competition with fisheries, at this time they may be foraging on their own, and due to their inexperience and limited diving ability are more at risk than adults. The fall season may also be a critical time period for sea lions as lactating females with pups are limited to the distance they can travel from shore. This is when closures within the 0-3 and 3-10 nm zones may be most important, especially around rookeries.

Under this proposed action, most of the fisheries are temporally dispersed similarly to the risk-averse approach outlined above, especially the pollock fishery in the GOA. However, the trawl fishery for Pacific cod in the Bering Sea has two seasons with an 80/20% apportionment. Pacific cod is found in the highest frequency in sea lion diet during the winter/spring season (Table 3.3). Yet, this is also a time when Pacific cod are considered to be in high concentrations in the SCA (82%; FMP biological opinion). Additionally, the pollock fishery would change from 4 seasons inside critical habitat in 2000, to two seasons in this proposed action. Yet, a major consideration when evaluating the pollock fishery is the effectiveness of the AFA in slowing harvest rates and dispersing the pollock fishery. Unfortunately at this time, NMFS does not have a specific harvest rate which we can confidently assert is appropriate (i.e., what is the effective difference between an 80/20 split season or 60/40, or even 40/60), the available data to us at this time does not allow that fine of an understanding of the requirements of foraging sea lions or the effects of trawling on prey availability. Therefore NMFS has modified its approach to close the areas known to be important to sea lions, and open those with conservative harvest approaches in areas considered to be less important.

Given the information currently available, this action is likely to avoid competing with Steller sea lions in this zone. Certainly, other risk-averse approaches exist, such as a 60/40% seasonal split for the trawl Pacific cod fishery in the Bering Sea, or 4 seasons inside the 10-20 nm zone. However, NMFS has no quantitative method for determining the marginal benefit to sea lions that might accrue from those changes.

5.3.4.7 Zone: Global Control of Fishing Effort

Global control of fishing effort is considered a zone of moderate concern for foraging sea lions (see Section 5.2.1.5 and Table 5.2). Under the proposed action, a slightly modified control rule from the RPA from the FMP biological opinion would be implemented. The revised control rule meets the intent of the previous one in stopping all directed fishing for pollock, Pacific cod, and Atka mackerel, if the biomass was to drop below 20% of the theoretical unfished level.

6 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 4 of this Biological Opinion.

Loughlin and York (2001) provide the most recent accounting of the various sources of Steller sea lion mortality, including anthropogenic sources and predation. The sources of mortality they identify are likely to remain as threats to sea lions for the foreseeable future. The cumulative effects of future state, tribal, local, and private actions on Steller sea lions, including both lethal and nonlethal effects, are considered below.

6.1 Subsistence Harvest of Sea Lions

The subsistence harvest of sea lions by Alaska Natives results in direct takes that are expected to continue into the foreseeable future. These takes represent the highest level of known direct mortality from an anthropogenic source (Loughlin and York 2001). ADF&G conducted studies to estimate subsistence use of Steller sea lions statewide from 1992-1999 (Wolfe and Mishler 1997; Wolfe and Hutchinson-Scarborough 1999) and estimated mortality levels from a high of 549 in 1992 to a low of 164 in 1997, with a mean of 353 per year (Loughlin and York 2001). The primary areas of subsistence harvest are the Pribilof Islands, Kodiak Island, and the Aleutian Islands. The overall impact of the subsistence harvest on the western population depends upon the number of animals taken, their sex and age class, and the location where they are taken. As with other sources of mortality, the significance of subsistence harvesting may increase as the western population of sea lions decreases in size unless the harvesting rate is reduced accordingly. The future subsistence harvest may contribute to localized declines of sea lions and/or impede recovery if the harvest is concentrated geographically.

6.2 State Managed Commercial Fisheries

Section 4.4.3.3 of this Biological Opinion discusses the effects on Steller sea lions of commercial fisheries managed by the State of Alaska. In summary, state managed fisheries affect sea lions through both direct and indirect mechanisms. Direct impacts include sea lions killed inadvertently in trawls, seines, or gill nets, as well as short term nonlethal effects such as disturbance of sea lion haulouts, vessel noise, entanglement in nets, and preclusion from foraging areas due to active fishing vessels and gear. Indirect impacts include the hypothesis that fisheries may compete with sea lions for common prey. In particular, walleye pollock, Pacific salmon, Pacific cod, and Pacific herring are consumed with relatively high frequency by the western population of sea lions. State managed groundfish harvesting can cause dense schools of fish to scatter, reducing sea lion prey density and decreasing the value of foraging habitat. Similarly, short term intensive fishing effort targeted on spawning aggregations of herring and on high densities of salmon at stream or river outlets may decrease the opportunities for sea lions to forage efficiently. As a result, individual sea lions may have to expend more time and energy to consume the same quantity of fish.

How do the effects of state managed fisheries on Steller sea lions compare to the effects of federally managed fisheries? The size of the state managed groundfish fishery is small when compared to the

Federal groundfish fishery and thus could have relatively less impact on sea lions with respect to competition for prey and long term ecosystem effects. The state managed herring and salmon fisheries are short in duration and relatively small in scale. However, despite the smaller scope and scale of these state managed fisheries relative to federally managed fisheries, interactions with state managed fisheries may be a more important factor for Steller sea lions than previously realized. The November 30, 2000 Biological Opinion noted that the available information suggested that adult females remain within 20 nm of shore during the breeding season, as well as other seasons if they are nursing a pup (NMFS 2000). However, recent information on sea lion foraging patterns indicates that pups, juveniles, and breeding aged adults spend the majority of their time in areas within 10 nm of shore, suggesting that they may rely more heavily on near shore prey than previously thought (ADF&G and NMFS 2001; Loughlin *et al*. unpublished).

Telemetry results through March 2001 indicate that the majority of at-sea observations of sea lions occurred within 10 nm of shore across all the regions examined, yet observations further offshore were more common in winter (ADF&G and NMFS 2001). This general pattern is consistent with the description of sea lion foraging referenced in the FMP biological opinion (Merrick and Loughlin 1997) insofar as the previously available data suggested that foraging around rookeries and haulouts was crucial for adult females with pups, pups, and juveniles, while foraging may occur over much larger areas once sea lions are no longer tied to rookeries and haulouts. However, the more recent telemetry data suggest that sea lions occur most commonly in habitats within 10 nm of shore, as opposed to the 20 nm zone suggested by information available previously ((ADF&G and NMFS 2001; Loughlin *et al*. unpublished). Preferential use of near shore habitat by foraging sea lions implies that they are more susceptible to interactions with state managed fisheries than they appeared to be previously.

NMFS expects the existing state managed fisheries to continue into the foreseeable future. Likewise, NMFS expects the direct and indirect effects of state managed fisheries on Steller sea lions to continue into the foreseeable future. It is unclear whether the state will develop new fisheries, such as the recent Pacific cod fishery near Adak. With regard to direct effects, state managed fisheries are likely to continue to account for an annual mortality of approximately 30 Steller sea lions, based on current levels of direct mortality (Ferrero *et al.* 2000). There are no available estimates of the frequency or severity of nonlethal takes in state managed fisheries, but presumably nonlethal takes will continue at current levels. Regarding indirect effects, NMFS concludes based on available information that state managed fisheries for pollock, cod, herring, and salmon are likely to continue to compete for fish with foraging Steller sea lions. Given the importance of near shore habitats to sea lions, this competition for fish may have consequential effects. Specifically, these interactions may contribute to nutritional stress for sea lions, and may reduce the value of the marine portions of designated sea lion critical habitat. State managed fisheries will continue to reduce the abundance of preferred sea lion prey within these marine foraging areas and may alter the distribution of certain prey resources in ways that reduce the foraging effectiveness of sea lions. Therefore, state managed fisheries (particularly for herring, salmon, and groundfish) may contribute to the continued decline of the western population of Steller sea lions and may reduce the prospects for survival and recovery. However, as noted earlier in the document with regard to the effects of federal fisheries, and in Loughlin and York (2001), the causes of the current decline, and the extent that the contributing factors play in the decline are largely unknown. More data on the foraging habits of Steller sea lions expected over the next few years in combination with further discussions between ADF&G and NMFS scientists will help to better understand the type and extent of interactions between fisheries and sea lions.

6.3 State Managed Sport Fisheries

Meeting public demand for recreational fishing opportunities in Alaska while at the same time maintaining and protecting fishery resources has become a significant challenge for ADF&G (Howe et al.

1996). Increasing tourism and continued population growth lead to increased pressure on existing sport fisheries and development of new fisheries. At the core of sport fisheries management is the ADF&G onsite creel surveys. ADF&G 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, ADF&G 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. 1996).

Of the 469,436 anglers who fished in Alaska in 1995, about 51% were Alaska residents and 49% were nonresidents, resulting in about 3 million angler-days fished. This effort 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. Abundance of species such as halibut and rockfish has 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 Alaska total fish harvests, while the commercial fisheries accounted for 97% (900,000 mt) of the annual harvest in 1998. Sport fishery harvests would be expected to continue in relatively low amounts in the future. It is likely that increased levels of tourism will also increase the amount of fish taken for sport. However, this additional harvest would likely result in a comparatively small amount of fish taken. 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) take place upriver outside of foraging areas for Steller sea lions. For these reasons, future state managed sport fisheries will not contribute measurably to the total cumulative effects of state, tribal, local, and private actions on Steller sea lions.

6.4 Subsistence Harvest of Groundfish

Subsistence hunting and fishing are important to the economies of many families and communities in Alaska, and subsistence uses are central to the customs and traditions of many cultural groups, including the Aleut, Athabaskan, Alutiiq, Euroamerican, Haida, Inupiat, Tlingit, Tsimshian, and Yup'ik. NMFS expects that this traditional way of securing necessary resources will continue. About 20% of Alaska's population participates in the subsistence harvest (124,367 people in 270 communities in 1998). Most of the harvest is composed of fish (about 60% by weight). For perspective, the subsistence fishery harvests about 2% (8,000 mt) of the annual Alaska total fish harvest, while commercial fisheries accounted 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 will remain very small compared to the commercial catch of fishery resources (ADFG 1998 "Subsistence in Alaska: 1998 Update") and will not contribute measurably to the total cumulative effects of state, tribal, local, and private actions on Steller sea lions.

6.5 Illegal Shooting of Sea Lions

Loughlin and York (2001) speculate that the mortality level from illegal shooting of sea lions is at least 50 animals per year. Despite education and enforcement efforts, NMFS expects this level of mortality to continue for the foreseeable future.

6.6 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 south central 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. 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 that would fall within the action area.

6.7 Vessel and Aircraft Activity

As discussed in section 4 of this Biological Opinion, disturbance from vessel and aircraft traffic has variable effects on sea lions ranging from no reaction at all to temporary departure from haulouts and rookeries and even abandonment of haulouts and rookeries (Johnson et al. 1989; Calkins and Pitcher 1982; Thorsteinson and Lensink 1962; Kenyon 1962). These effects stem primarily from noise emanating from cruise ships, ferries, small boats, and aircraft. The consequences of such disturbance to the overall sea lion population are difficult to measure. Disturbance may have contributed to or exacerbated the decline of Steller sea lions, although it likely has not been a major factor in the decline. NMFS expects disturbance from vessels and aircraft to continue in the future at levels comparable to the present.

6.8 Population Growth

The effects of human population growth in Alaska, past and present, were discussed in section 4 of this Biological Opinion. 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 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 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 populations may increase or decrease based on their ability to exploit resources such as fisheries and secure necessities to live in these remote areas. Many rural villages have experienced population declines, mostly in the Aleutians. To bolster these communities, the state has begun to develop local fisheries. For example, 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 state waters (out to 3 miles), and focuses the dependance of specific coastal communities on fisheries. This system may put severe pressure on fishery managers in the future to enact regulations that provide for near-shore fisheries, leading to conflicts with measures to limit adverse impacts to critical habitat for sea lions.

In general, as the size of human communities increases, there is an accompanying increase in habitat alterations and impacts on landscapes and biota. As areas are modified for the construction of housing, roads, commercial facilities, and other infrastructure, native plants and animals are displaced and waste disposal needs increase.

7 ANALYSIS AND CONCLUSIONS

7.1 Analysis for Jeopardy and Adverse Modification of Critical Habitat

A description of the ESA standards, pertinent definitions, and a description of this analysis was presented in Section 1.7 of this document. Again, the two standards that NMFS must insure that any federal action avoid are:

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

7.1.1 Jeopardy

The first step of the jeopardy analysis is to identify the probable direct and indirect effects of the proposed action on the physical, chemical, and biotic environment of the action area. This information was discussed in Sections 5.2 and 5.3 above. In this section we examine steps 2 and 3 of the analysis:

> **Step 2:** we will determine if we would reasonably expect the western or eastern populations of Steller sea lions to experience reductions in reproduction, numbers, or distribution in response to these effects, and
>
> **Step 3:** we will determine if any reductions in a species' reproduction, numbers, or distribution (identified in the second step of our analysis) can be expected to appreciably reduce a listed species' likelihood of surviving and recovering in the wild.

7.1.1.1 Step 2 of the Jeopardy Analysis

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 4-5 percent per year (Loughlin and York 2001). The pertinent question now is what is causing this current decline?

At present, in the scientific community, there is no clear leading hypothesis to explain the continued decline of the western population of Steller sea lions (DeMaster *et al.* 2001). Nutritional stress, predation, and natural environmental changes are all considered to be factors in the decline. The age groups most likely affected by these factors is primarily juveniles and to a lesser extent adult females (Merrick *et al.* 1987, Pitcher *et al.* 1998, Rosen *et al.* 2000a, Alaska Sea Grant 1993).

There is sufficient evidence that supports the hypothesis that sea lions were nutritionally stressed during the first phase of the decline (roughly mid-70s through 1990; DeMaster *et. al.* 2001). Comparisons of adult female body measurements and masses from three time periods, 1958, 1975-1978, and 1985-1986, showed reduced growth and an increased level of abortions in the 1980s (Calkins *et al.* 1998). Analyses of samples collected from 1975-1978 and 1985-1986 showed that in 1985 animals were smaller, maturity was later, there were fewer adult females with offspring, adult females that did have pups were older, and there were Steller sea lions with reported signs of anemia (York 1994, and Calkins and Goodwin 1998). Calkins *et al.* (1998) also noted that the harbor seal, which feeds on similar prey as Steller sea lions, declined rapidly at a major rookery in the Gulf of Alaska during the late 1970s (Pitcher 1990) indicating that changes to the prey base may have caused this sympatric species to suffer from nutritional stress. Factors such as disease and predation may have had an influence on the population during the rapid decline, but there is not sufficient information to evaluate their possible impact (NMFS 1992).

Direct evidence for the nutritional stress hypothesis in the second phase of the decline is lacking. Nutritional stress could result from decreased foraging success due to competitive interactions with fisheries through a modification in the availability of prey and/or through environmental change. Additionally, the diet of Steller sea lions in the 1990s has had a lower caloric density than it did in the 1970s (DeMaster *et al.* 2001). Presumably, sea lions would be required to increase the amount of prey they consume in order to receive the same energetic benefit from prey with lower caloric densities. The diet of Steller sea lions may have shifted from one with relatively large amounts of forage fish such as sandlance and herring to one that is dominated by pollock, which has a lower caloric density than these fatty forage fish. It was estimated that Steller sea lions would need to consume 56% more pollock than herring for the same net energy intake (Rosen and Trites 2000).

The lack of information on the nutritional stress of juveniles (suspected to be a key population segment in the decline) is problematic (Loughlin and York 2001). NMFS is required to insure that the groundfish fisheries do not jeopardize Steller sea lions or adversely modify their critical habitat - but this does not mean going to the extreme of having to prove all negatives in order to do so. The question remains is whether nutritional stress is likely to be contributing to the continued decline of the western stock? Clearly, there is scientific uncertainty over the issue, yet it is likely that nutritional stress is playing a role as part of the decline (DeMaster *et al.* 2001). This could take many forms since NMFS cannot insure that nutritional stress is not occurring, especially in juveniles, we will then make the assumption that it is likely, adhering to our mandate to insure that fisheries do not jeopardize listed species. Such nutritional stress would indicate 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 may reduce prey availability in several zones important to sea lions. 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 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 Section 3 on the Status of the Species, we have seen clear evidence that the reproductive effort and success of adult females has been compromised.

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.

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 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.

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 due to a variety of causal factors (Loughlin and York 2001). 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 the likelihood of jeopardy and adverse modification from the effects of the commercial fisheries. Currently the western population of Steller sea lions is declining at 4% per year. Avoidance of any fishery contribution to this decline is significant, will enhance the recovery of the species, but may not, necessarily reverse the decline.

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 less 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, DeMaster *et al.* 2001). There is 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 (DeMaster *et al.* 2001). 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.

Under normal circumstances, 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 lion 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.

Because of the reasons stated above, Steller sea lions are expected to decline at least into the near future. Conservation measures have been implemented incrementally since 1991 (i.e., trawl closures around rookeries, etc.), and yet the population has continued to decline at a nearly constant rate. In part this may be due to our inability to detect a small change in the population trajectory. It is expected that NMFS would not be able to detect a change of 1% until about 6-8 years from the time of the change (FMP biological opinion). Given the projected continued decline of the species, and our inability to detect changes in population trajectory quickly, it is reasonably likely that the western population of Steller sea lions will experience reductions in reproduction, numbers, and distribution in response to the proposed action and those effects described in the Baseline (Section 4) and Cumulative Effects (Section 6). As described in the Baseline, the effects of massive foreign fisheries, intentional shooting of thousands of

Steller sea lions, incidental catch of thousands of sea lions, historic harvest of pups, and seemingly constant environmental change from regime shifts to ENSO, creates such a dynamic environment that is extremely difficult to understand and predict how those effects may have, or are, affecting the Steller sea lion population. Additionally, fisheries within 3 nm under State of Alaska management may compete with Steller sea lions for prey in areas very close to shore where sea lions have been found to spend the majority of there time, and presumably foraging effort. Although NMFS cannot quantify the magnitude of all of these effects, they are likely to combine in such a way as to reduce the foraging success of Steller sea lions.

Given that the eastern population of Steller sea lions is increasing and appears to be robust, it is unlikely that it will experience reductions in reproduction, numbers, and distribution in response to the proposed action.

7.1.1.2 Step 3 of the Jeopardy Analysis

The final step is to determine if any reduction in a species' reproduction, numbers, or distribution (identified in the second step of our analysis above) can be expected to appreciably reduce a listed species' likelihood of surviving and recovering in the wild. Since these reductions are not expected for the eastern population, it is unlikely that the eastern population will not survive and recover in the wild.

When looking at the baseline effects due to predation by killer whales and adverse effects on the species' environment due to climate change and the decadal oscillation, NMFS concludes that this proposed action is not likely to appreciably reduce the western population of Steller sea lions' likelihood of surviving and recovering in the wild. A detailed zonal description of the areas of most concern for Steller sea lions is found in Section 5.2.1.5 and Table 5.2. A description of the action in relation to these zones is described in Table 5.3. Then in Sections 5.3.2.1-5.3.2.7 we explore the possible impacts expected in each zone from fisheries authorized by the proposed action, and relate this back to the level of concern raised in Table 5.2. In summary, the proposed action will successfully avoid negative interactions with Steller sea lions in the areas and times most important to the key age classes in the population. Competitive interactions are likely in the zones from 10 nm and beyond, however these areas are not used as extensively by sea lions as those zones closer to shore (i.e., 0-10 nm), and the animals foraging beyond 10 nm are likely to be older juveniles or adults which have advanced diving and foraging abilities. Further, NMFS explored possible population trajectories in Section 5.3.2.8 (DeMaster 2001). Although this action may not be as risk-averse as the scenario proposed by the RPA from the FMP biological opinion, this action is likely to minimize adverse impacts with Steller sea lions. In all likelihood however, this species may continue to decline for some time due to adverse environmental factors described in the Baseline (Section 4).

7.1.2 Adverse Modification of Critical Habitat

NMFS explored two different methods for evaluating whether adverse modification of critical habitat would occur as a result of the proposed action. First, NMFS evaluated whether a ratio of forage available to forage consumed could be used as a metric to determine whether there is adequate forage for Steller sea lions. The analysis provided some interesting results. Although the overall biomass in critical habitat for pollock, Pacific cod, and Atka mackerel for the combined BSAI and GOA was at a scale far beyond what Steller sea lions may need to successfully forage, the area specific analysis showed something quite different. The ratio of forage available to forage consumed was only 11 in the Aleutian Islands and 17 in the Gulf of Alaska, as compared to a theoretical ratio of 22-46 (Table 5.7). The ratio in the Bering Sea was much higher at 446, well above the expected needs of Steller sea lions. Interestingly enough, the sea lion population in the vicinity of the Bering Sea is nearly stable while sea lion populations in the eastern GOA and Aleutian Islands have experienced dramatic declines since 1991 (Loughlin and York 2001) .

However, numerous difficulties arise when trying to interpret this information, as described in section 5.3.3. Because of these complications, the forage ratio approach does not allow analysis of the spatial or temporal scales of interest to a foraging Steller sea lion as described in Bowen *et al.* (2001).

Thus, to evaluate the adverse impacts of the proposed actions on critical habitat, the likely impacts from the overlap of fisheries and foraging Steller sea lions in critical habitat through the zonal system will be used.

As discussed in the Status of the Species chapter of this biological opinion (Section 3), 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 (Section 4), 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.

The forage ratio approach provides some very general guidance - at the largest geographic scale and at the population level - regarding whether the FMP allows for sufficient biomass to support the current population of Steller sea lions. This approach may even be useful as a benchmark to which proposed management actions could be compared in a gross sense. However, NMML has recommended that this approach only be used to compare management actions at a spatial scale equal to or larger than the smallest unit for which the necessary fishery information can be estimated (e.g., Gulf of Alaska, Bering Sea, and Aleutian Islands). In this case, there may be more concern for fisheries impacts in the Aleutian Islands and Gulf of Alaska, where biomass ratios are below the theoretical level necessary for successful foraging.

In order to evaluate the impacts of fisheries at a smaller spatial scale, we will use a qualitative approach which evaluates the likely adverse impacts to critical habitat for Steller sea lions in 5 different zones. This is the spatial scale in which the fishery is prosecuted, and it is the spatial scale which is likely to be most important to foraging Steller sea lions. The evaluation of the 5 zones is found in Section 5.3.2 of this document. The discussion revealed that there was adequate avoidance of competitive interactions in all five zones, as determined in the analysis by DeMaster and a qualitative look at overlap between trawl and fixed line fisheries with Steller sea lions. NMFS determined that trawl gear was more likely to cause localized depletions, or other prey field effects, that could adversely affect a foraging Steller sea lion (see section 5.3.1.6). Additionally, three foraging areas which are also critical habitat are outside these zones. Here, the action was considered to be unlikely to compete with sea lions in a way which would affect their foraging success (Table 5.6).

The effects described above indicate that the fisheries as proposed, are not likely to reduce the abundance of prey within local foraging areas and alter the distribution of groundfish prey in ways that could reasonably be expected to reduce the foraging effectiveness of sea lions, therefore, it would not reduce the likelihood of their survival and successful reproduction nor their likelihood of recovery in the wild.

7.2 Conclusions

The analysis in the preceding sections of this biological opinion forms the basis for conclusions as to whether the proposed action, the ongoing fisheries for Pacific cod, Atka makerel, and pollock in the BSAI and GOA as modified by amendments 61/61 and 70/70 satisfy the standards of ESA Section 7(a)(2). To do so, the Action Agency must ensure that their proposed action is not likely to jeopardize the continued existence of any listed species or destroy or adversely modify the designated critical habitat of such species. Section 3 of this opinion defines the biological requirements of the two populations of listed Steller sea lions. Section 4 evaluates the relevance of the environmental baseline to the status of Steller sea lions. Section 5 details the likely effects of the proposed action, both on individuals of the species in the action area and on the listed population as a whole, across its range and life cycle. Section 6 considers the cumulative effects of relevant non-Federal actions reasonably certain to occur within the action area. On the basis of this information and analysis, NMFS draws it conclusions about the effects of the pollock, Pacific cod, and Atka mackerel fisheries on the survival and recovery of the two listed populations of Steller sea lions.

In this section NMFS must determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the proposed action, the environmental baseline, and cumulative effects. The information available to NMFS is both quantitative and qualitative. For Steller sea lions, although significant research has been funded over the past 6 months, little qualitative information is currently available on the habitat requirements of the species. NMFS expects that over the next 3-5 years a significant amount of new information will be available for future decision making, however, much of the available information today is based on the professional judgement of knowledgeable scientists. Despite an increasing trend toward a more quantitative understanding of the habitat requirements of Steller sea lions, critical uncertainties limit NMFS’ ability to project future conditions and effects. As a result, no hard and fast numerical indices are available for any of these stocks on which NMFS can base determinations about jeopardy or the adverse modification of critical habitat (Section 7(a)(2) standards). Ultimately, NMFS’ conclusions are qualitative judgments based on the best quantitative and qualitative information available for Steller sea lions.

7.2.1 Western Population of Steller Sea Lions

After reviewing the current status of the endangered western population of Steller sea lions, the environmental baseline for the action area, the proposed action 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 not likely to jeopardize the continued existence of the western population of Steller sea lions.

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 proposed action 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 not likely to adversely modify its designated critical habitat.

7.2.2 Eastern Population of Steller Sea lions

After reviewing the current status of the threatened eastern population of Steller sea lions, the environmental baseline for the action area, the proposed action 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 not likely to jeopardize the continued existence of the eastern population of Steller sea lions.

After reviewing the current status of critical habitat that has been designated for the eastern population of Steller sea lions, the environmental baseline for the action area, the proposed action 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 not likely to adversely modify its designated critical habitat.

8 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.

8.1 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 in both the federal and Alaska State managed parallel fisheries for pollock, Pacific cod, and Atka mackerel. 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. The scope of this incidental take statement extends to the parallel fisheries authorized by the State of Alaska in accordance with the requirements contained below.

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 the conservation measures contained within this proposed action are likely to reduce these events. 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 proposed action 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 and Associated Terms and Conditions in Italics

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. These terms and conditions are non-discretionary.

1. **NMFS will monitor the take of Steller sea lions in the pollock, Pacific cod and Atka mackerel fisheries.**

    NMFS-trained observers on vessels in these fisheries will be deployed under the existing program for observer coverage based on vessel size and sector.

    NMFS will use observer data to make minimum estimates of mean annual mortality for each fishery.

    NMFS will evaluate the observer coverage that results from existing regulatory requirements to determine if changes in coverage are warranted to better assess take of Steller sea lions.

2. **NMFS will monitor vessel location and compliance with gear and directed fishing restrictions for the pollock, Pacific cod and Atka mackerel fisheries.**

    NMFS will implement a Vessel Monitoring System for all vessels in the pollock, Pacific cod and Atka mackerel fisheries that are subject to restrictions on directed fishing in rookery, haulout, or foraging area zones.

    NMFS will require electronic vessel logbooks or other recordkeeping and reporting measures necessary to monitor directed fishing.

3. **NMFS will monitor harvest of pollock, Pacific cod and Atka mackerel.**

    Monitoring of harvest of these species will be sufficient to account for the amount of fish harvested and to determine appropriate fishery closures by sector, gear type or area.

4. **NMFS will manage critical habitat harvest limits using conservative management strategies to minimize the likelihood of exceeding a critical habitat harvest limit.**

    Conservative management strategies shall include:

    If any part of an observed haul or set, or an unobserved vessel trip, occurs inside critical habitat, the entire catch will be counted against the critical habitat harvest limit.

If VMS data are missing for a vessel in a fishery subject to a critical habitat harvest limit, the catch will be counted against the critical habitat harvest limit.

If critical habitat harvest limits are small relative to the amount of fishing effort, NMFS will calculate the fishery closure date based on estimates of maximum harvest capacity, and pre-announce the closure date.

9 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 has determined that the following conservation recommendations should be implemented by the appropriate entities in order to facilitate the recovery of listed Steller sea lion populations. 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.

9.1 Conservation Programs for State Managed Fisheries

New information available since the FMP biological opinion indicates that Steller sea lions may depend on areas closer to shore. This new information, along with other new information outlined in section 1, has resulted in a revised set of conservation measures proposed by the Council and NMFS. Analysis of this new data has also highlighted the concern that fisheries managed by the State of Alaska, within 3 nm of shore, may adversely affect sea lions through both indirect and direct mechanisms. That State of Alaska has been very supportive in providing information to NMFS in order to evaluate potential areas of concern (i.e., Kruse *et al.* 2000). However, further study is needed to evaluate these areas of concern to determine with greater confidence the potential types of adverse effects and their magnitude. The State of Alaska should further explore these issues and determine whether any conservation measures are necessary in order to avoid adversely affecting the survival and recover of Steller sea lions. Numerous options are available for further informal and formal consultations between the State of Alaska and NMFS depending upon the appropriate course of action. The goal should be continued cooperation in minimizing adverse impacts to Steller sea lions in order to facilitate their recovery and remove them from listing under the Endangered Species Act.

9.2 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).

9.3 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 assembled a new recovery team to revise the plan. NMFS and the new recovery team should begin this process within the next 6 months. Both industry and environmental organizations should have an opportunity to provide input.

9.4 Co-management of Steller Sea Lions with Alaska Native Organizations

Over the past few years, NMFS has initiated efforts to develop co-management agreements with Alaska Native Organizations for the purpose of managing populations of beluga whale, harbor seal, northern fur seal, and Steller sea lion. Co-management agreements have been finalized for four western stocks of beluga whales in Alaska, for the Cook Inlet beluga whale population, and for populations of harbor seals in Alaska. NMFS working with the appropriate Alaska Native Organization will continue to strive to develop a co-management agreement regarding the western population of Steller sea lion, which would include the development and implementation of a joint policy regarding subsistence harvests of the endangered western population.

10 LITERATURE CITED

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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
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CDQ	Community Development Quota
CFR	Code of Federal Regulations
CH	Critical Habitat
CPUE	Catch Per Unit Effort
CVOA	Catcher Vessel Operational Area
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 Agency
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
SSC	Scientific and Statistical Committee to the NPFMC
TAC	Total Allowable Catch
USFWS	U.S. Fish and Wildlife Service