Endangered Species Act — Section 7 Consultation
Biological Opinion

Activities Considered:	State of Alaska parallel groundfish fisheries for pollock, Pacific cod, and Atka mackerel Authorization of groundfish fisheries under the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area Authorization of groundfish fisheries under the Fishery Management Plan for Groundfish of the Gulf of Alaska
Agency:	National Marine Fisheries Service
Consultation by:	National Marine Fisheries Service Alaska Region
Date Issued:	
Issued by:	__________________________ Robert D. Mecum Acting Administrator, Alaska Region

EARLY DRAFT FOR
ACTION AGENCY REVIEW
(NMFS SUSTAINABLE FISHERIES)

ACRONYM LIST

The following is a list of acronyms and terms used throughout the document

ABC – Acceptable biological catch
ADF&G – Alaska Department of Fish and Game
AFA – American Fisheries Act
AKR – Alaska Regional Office
AFSC – Alaska Fisheries Science Center
BEST – Bering Ecosystem Study
CPUE – Catch per unit effort
DEIS – Draft Environmental Impact Statement
DPS – Distinct population segment
Delisting – removal from the List of Endangered and Threatened Wildlife and Plants
EBS – Eastern Bering Sea
EEZ – Exclusive Economic Zone
EIS – Environmental Impact Statement
EPA – U.S. Environmental Protection Agency
ESA – Endangered Species Act of 1973
FOCI – Fisheries-Oceanography Coordinated Investigations (NOAA)
FMP – Fisheries Management Plan
FWS – Fish and Wildlife Service
GOA – Gulf of Alaska
List – Federal List of Endangered and Threatened Wildlife and Plants
MARPOL – International Convention for the Prevention of Pollution from Ships
MMC – Marine Mammal Commission
MMPA – Marine Mammal Protection Act
MSA – Magnuson-Stevens Fishery Conservation and Management Act
MSY – Maximum sustainable yield
mt – Metric tons
mtDNA – Mitochondrial DNA
nm – Nautical Mile
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NPFMC - North Pacific Fishery Management Council
PBR – Potential Biological Removal
Plan – Steller sea lion recovery plan
PDO – Pacific Decadal Oscillation
PVA – Population viability analysis
RPA – Reasonable and Prudent Alternative
SEAK – Southeast Alaska
TAC – Total allowable catch
TDR – Time-depth recorder
UME – Unusual mortality event
USCG – United States Coast Guard
USFWS – United States Fish and Wildlife Service
VMS – Vessel monitoring system

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1 BACKGROUND AND CONSULTATION HISTORY

1.1 Purpose

The Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531-1544), amended in 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat on which they depend. Section 7(a)(2) of the ESA, requires that each federal agency shall insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species, or destroy or adversely modify critical habitat of such species. When the action of a federal agency may adversely affect a protected species, that agency (i.e., the "action" agency) is required to consult with either the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the protected species that may be affected. For the actions described in this consultation, the action agency is the NMFS Alaska Region Sustainable Fisheries Division (SFD) and the consulting agency is the Protected Resources Division (PRD).

On April 19, 2006, PRD received a written request from SFD for re-initiation of formal section 7 consultation and was accompanied by a Biological Assessment (BA). Re-initiation on the 2000 Biological Opinion was requested by SFD to address potential impacts to listed marine species related to actions associated with the groundfish fisheries in Alaska. PRD concurred with this request and formally re-initiated consultation on June 21, 2006.

This opinion and incidental take statement were prepared by NMFS in accordance with section 7(b) of the ESA, and implementing regulations at 50 Code of Federal Regulations (CFR) Part 402. It is based on an evaluation of both the direct and indirect effects of the action on listed species and their critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. The opinion presents NMFS's review of the status of the listed species considered in this consultation, the condition of the critical habitat, the environmental baseline for the action area, all the effects of the action as proposed, and cumulative effects (50 CFR 402.14 (g)). For the jeopardy analysis, NMFS analyzes those combined factors to conclude whether the proposed action is likely to appreciably reduce the likelihood of both the survival and recovery of the affected listed species. With respect to critical habitat, the following analysis relies only on the statutory provisions of the ESA, and not on the regulatory definition of "destruction or adverse modification" at 50 CFR Part 402.02.

If the action under consideration is likely to jeopardize the continued existence of an ESA-listed species, or destroy or adversely modify its designated critical habitat, NMFS must identify any reasonable and prudent alternatives for the action that avoid jeopardy or destruction or adverse modification of critical habitat and meet other regulatory requirements (50 CFR Part 402.02).

This opinion is based on information provided in the biological assessment provided by SFD for this proposed action, the June 2004 Final Programmatic Supplemental Environmental Impact Statement (PSEIS) on the Alaska groundfish fisheries, previous biological opinions and National Environmental Policy Act (NEPA) documents on council actions, and published and unpublished sources of information on the biology and ecology of listed species in the action area, the general history of fisheries in the action area, and fishery management. A complete administrative record of this consultation is on file at NMFS Alaska Regional Office (Tracking number: F/AKR/2006/02532).

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

This opinion evaluates three actions:

- Authorization of groundfish fisheries under the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area;
- Authorization of groundfish fisheries under the Fishery Management Plan for Groundfish of the Gulf of Alaska; and
- State of Alaska parallel groundfish fisheries for pollock, Pacific cod, and Atka mackerel [consultation requested by the State of Alaska on March 31, 2006; see letter from McKie Campbell, Commissioner, to Robert D. Mecum, Acting Administrator, NMFS, Alaska Region]

In the BA, SFD reviewed the status of the species and their critical habitat, the likely effects of the proposed actions, and the potential impacts to the species. For each species, SFD determined whether the species were likely or not likely to be adversely affected. NMFS has determined that the following ESA-listed species are not likely to be adversely affected by the proposed actions, and therefore do not require formal consultation: Blue whale, Bowhead whale, Northern Right whale and its critical habitat, Sei whale, fin whale, Olive Ridley sea turtle, Loggerhead sea turtle, Green sea turtle, and Leatherback sea turtle (see Table ES.1 of the BA and subsequent re-initiation letters between SFD and PRD). NMFS has determined that the following species are likely to be adversely affected by the action, and thus require formal section 7 consultation under the ESA:

(i) Western Distinct Population Segment of Steller Sea Lion (*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])

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

(iii) North Pacific Humpback Whale (*Megaptera novaeangliae*) listed as endangered upon passage of the ESA of 1973 (16 U.S.C. 1531 et seq.)

(iv) North Pacific Sperm Whale (*Physeter macrocephalus*) listed as endangered upon passage of the ESA of 1973 (16 U.S.C. 1531 et seq.)

1.2 Consultation History

On November 30, 2000, NMFS issued an FMP level biological opinion (NMFS 2000) 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 found that the FMPs jeopardized both the western and eastern distinct population segments (DPSs) of Steller sea lion and adversely modified their designated critical habitat; thus a reasonable and prudent alternative (RPA) was provided and partially implemented in 2001. However, in 2001, the action agency (SFD) proposed a replacement action for those components of the 2000 FMP-level consultation which had resulted in jeopardy and adverse modification. NMFS prepared a project level biological opinion in 2001 (NMFS 2001) which reviewed the revised action and determined that it was not likely to jeopardize or adversely modify critical habitat. In response to a Court order, NMFS prepared a supplement (NMFS 2003) to the 2001 biological opinion (NMFS 2001) which affirmed NMFS's prior conclusions of not likely to jeopardize or adversely modify critical habitat.

Since the conclusion of the 2000 and the 2001 biological opinions, all subsequent modifications to the action have been considered through informal consultations. On October 18, 2005, the North Pacific Fishery Management Council (Council) requested that NMFS reinitiate consultation on the 2000 Biological Opinion; the request was based on the acknowledgement that a substantial amount of research has been published since 2000 on Steller sea lions, and that a new evaluation of that information would be prudent. After a review of this draft opinion, the Council will consider whether the new scientific information allows for changes to the proposed action that would avoid jeopardy and adverse modification.

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 formal consultations are described below (see Table 1.1 for a complete list of formal and informal consultations):

- 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 understood.

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

- December 22, 1998 Biological Opinion on authorization of the BSAI and GOA groundfish fisheries based on TAC specifications recommended by the Council for 1999. The opinion concluded that based on the 1999 TAC specifications, the groundfish fisheries were not likely to cause jeopardy or adverse modification for listed species or their critical habitat. The opinion was also challenged in court and subsequently found to be arbitrary and capricious for failing to include a sufficiently comprehensive analysis of the groundfish fisheries and their individual, combined, and cumulative effects. Based on this finding, the court determined that NMFS was out of compliance with the ESA (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 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.

- October 19, 2001 Biological Opinion on Authorization of the BSAI and GOA groundfish fisheries under their respective FMPs, specifically the Pacific cod, pollock, and Atka mackerel fisheries and the parallel fisheries for Pacific cod, pollock, and Atka mackerel as authorized by the State of Alaska within 3 nm of shore. 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. 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).

- June 19, 2003 Supplement to the 2001 Biological Opinion on Authorization of the BSAI and GOA groundfish fisheries under their respective FMPs, specifically the Pacific cod, pollock, and Atka mackerel fisheries and the parallel fisheries for Pacific cod, pollock, and Atka mackerel as authorized by the State of Alaska within 3 nm of shore. This document is a supplement to the 2001 BiOp on the pollock, Pacific cod, and Atka mackerel fisheries off Alaska in response to a remand order by the Court. NMFS presented background information on the decision making process in the 2001 BiOp as a requirement of a Court order. NMFS reaffirmed the decisions in the 2001 Biological Opinion.

- March 9, 2006 Biological Opinion on the issuance of an exempted fishing permit (EFP) to support a feasibility study using commercial fishing vessels for acoustic surveys of pollock in the Aleutian Islands subarea. Formal consultation was initiated on January 17, 2006. The permit authorized the harvest of pollock inside designated critical habitat. NMFS determined that the action would not jeopardized listed species or adversely modify their critical habitat.

2 DESCRIPTION OF THE PROPOSED ACTION

NMFS Sustainable Fisheries Division (SFD), under the authority of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and the State of Alaska propose to: (1) authorize groundfish fisheries in the BSAI under the FMP for the BSAI Groundfish; (2) authorize groundfish fisheries in the GOA under the FMP for Groundfish of the GOA; (3) authorize parallel fisheries within State-managed waters. Management of groundfish fisheries within the Exclusive Economic Zone (EEZ) off Alaska is a continuing activity which is implemented pursuant to NEPA, the ESA, Marine Mammal Protection Act (MMPA), and other applicable statutes and executive orders. As stated in Section 1, this opinion is comprehensive, including not only the fisheries covered under the FMPs, but an investigation of the overall management framework to determine if the framework contains the necessary conservation and management measures to ensure the protection of listed species and critical habitat.

The purpose of this section is to provide an overview of the MSA, the two FMPs for Alaska groundfish fisheries, and management of State parallel fisheries. The first task is to deconstruct this complicated action into its component parts (Figure 2.1). This yields four main groups of activities: (1) fisheries management policy, (2) exploitation strategy, (3) annual fisheries assessment, and (4) commercial fisheries prosecution. This break-down forms a natural approach to assessing the impacts of the action; policy on its own does not result in the removal of fish, but it does set up limitations and expectations for removals. Although choices made at the fishery removal stage seem independent, they are affected by policy choices made earlier.

2.1 Purpose

At a fundamental level, management of the groundfish fisheries has two interrelated purposes: to maximize the social and economic benefits of the groundfish resources to the people of the United States (U.S.) and to conserve the resource to ensure its sustained availability to current and future generations. The use and conservation of the fisheries need to be managed so that one objective—whether related to biological conservation or to socioeconomic well-being—does not take priority over the other, except when the resource itself is at risk of being depleted. To prevent such depletion of the resource, fisheries management strives to balance these two fundamental objectives.

The proposed action, authorization of the BSAI and GOA FMPs (NPFMC 2005a and 2005b), includes extensive mitigation measures 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 (NMFS 2000, 2001, and 2003). The mitigation measures, which were implemented in 2001, took the place of a Reasonable and Prudent Alternative (RPA) which was required as part of the jeopardy and adverse modification finding in the 2000 Biological Opinion. Thus, this proposed action is intended to meet the requirements of the MSA while specifically avoiding jeopardy and adverse modification for Steller sea lions and other listed species.

2.2 Fisheries Management Policy

When considering the impacts of commercial groundfish fisheries, it is easy to investigate the manner in which each vessel moves through the water, which species of fish are harvested, and what the harvest rate may have been. Yet, in order for this ultimate effect (fishing) to occur, a long series of guiding documents has been prepared, interpreted, and implemented. This series of documents and events is described in Figure 2.1. In this section, we focus on the first major area: fisheries management policy.

Fisheries are complex dynamic systems, involving physical, biological and human dimensions. Within those dimensions, innumerable elements inter-relate and change through time. Observing those elements and understanding the relationships between them is difficult, and being able to predict the fate of all these elements accurately is impossible (Goodman *et al.* 2002, NRC 2006). And yet, despite this complexity and limited predictability, the goal of fisheries management is, as far as possible, to make sense of the various dimensions and elements, and to make decisions on alternative policies in the face of uncertainty.

2.2.1 The MSA and other applicable law

The MSA (16 U.S.C. § 1851) is the primary domestic legislation governing management of marine fishing activities in federal waters (those waters extending seaward from the edge of coastal state waters to the 200-mile limit). This area became known as the EEZ in 1983. First passed in 1976, the MSA was reauthorized in 1996 by the United States Congress to include, among other things, a new emphasis on the precautionary approach in U.S. fishery management policy. The MSA contains ten national standards, with which all FMPs must conform and which guide fishery management. Besides the MSA, U.S. fisheries management must be consistent with the requirements of other regulations including the MMPA, the ESA, the Migratory Bird Treaty Act, and several other Federal laws.

The MSA created eight regional fishery management councils that are primarily charged with preparing fishery management plans and plan amendments. The Councils are authorized to prepare and submit to the Secretary of Commerce for approval, disapproval or partial approval, FMPs and any necessary amendments, for each fishery under their authority that require conservation and management. The Councils conduct public hearings so as to allow all interested persons an opportunity to be heard in the development of FMPs and amendments, and review and revise, as appropriate, the assessments and specifications with respect to the optimum yield from each fishery (16 U.S.C. 1852(h)).

To date, the Councils have prepared, and NMFS has approved and implemented, 47 FMPs, most now with numerous amendments. These FMPs not only must comply with the MSA, but with the requirements of other federal laws, such as the ESA. The MSA contains provisions for taking into account the requirements of other laws, as well as the protection of marine ecosystems and the environment, some of which are contained in the definitions of “optimum yield” (OY) and “conservation and management”:

> “The term “optimum”, with respect to the yield from a fishery, means the amount of fish which–
>
> (A) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;
>
> (B) is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and
>
> (C) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield of such fishery” (16 U.S.C. § 1802(3)(28)) (emphasis added).

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

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

> (ii) <u>irreversible or long-term adverse effects on fishery resources and the marine environment are avoided</u>; and
>
> (iii) there will be a multiplicity of options available with respect to future uses of these resources" (16 U.S.C. § 1802(3)(5)) (emphasis added).

The Councils have considerable autonomy but most prepare FMPs, create regulations, and generally make decisions that are consistent with the provisions of the MSA (Goodman *et al.* 2002). Section 301(a) of the MSA sets forth national standards for conservation and management with which FMPs and regulations must be consistent. In addition, NMFS established 10 National Standard Guidelines to assist in the development and review of FMPs, amendments, and regulations prepared by the Councils and the Secretary (50 CFR 600 Subpart D). The National Standards are as follows:

1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.
2. Conservation and management measures shall be based upon the best scientific information available.
3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.
4. Conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be A) fair and equitable to all such fishermen; B) reasonably calculated to promote conservation; and C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.
5. Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.
6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.
7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
8. Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to A) provide for the sustained participation of such communities, and B) to the extent practicable, minimize adverse economic impacts on such communities.
9. Conservation and management measures shall, to the extent practicable, A) minimize bycatch and B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.
10. Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

National Standard 1 is undoubtedly the most influential in decisions made by the Council on fisheries management. National Standard 2 ensures that science plays a key role in determining how fisheries are prosecuted (Goodman *et al.* 2002).

2.2.2 The FMPs and Implementing Regulations

The FMPs govern groundfish fisheries of the Gulf of Alaska and Bering Sea and Aleutian Islands Management Areas (NPFMC 2005a and 2005b). Coverage of species and locations of fisheries under these plans are detailed in Section 1.1 of the BSAI and GOA FMPs.

The BSAI groundfish FMP was approved by the Secretary of Commerce on October 27, 1979, and implemented by regulations published on December 31, 1981 (46 FR 63295, corrected January 28, 1982, 47 FR 4083; NPFMC 2005a). As of September 2006, it has been amended over seventy times, and its focus has changed from the regulation of mainly foreign fisheries to the management of fully domestic groundfish fisheries. The geographical extent of the FMP management unit is the U.S. EEZ of the Bering Sea, including Bristol Bay and Norton Sound, and that portion of the North Pacific Ocean adjacent to the Aleutian Islands which is between 170° W. longitude and the U.S.-Russian Convention Line of 1867 (Figure 2.2). The BSAI groundfish FMP covers fisheries for all stocks of finfish and marine invertebrates except salmonids, shrimps, scallops, snails, king crab, Tanner crab, Dungeness crab, corals, surf clams, horsehair crab, lyre crab, Pacific halibut, and Pacific herring. The BSAI FMP was revised in January 2005 to incorporate previous amendments and to better organize the document. A review of BSAI FMP Amendments can be found in Section 2.15 of the BA.

The GOA Groundfish FMP was approved by the Secretary on February 24, 1978, and implemented by regulations published on November 14, 1978 (44 FR 52709; NPFMC 2005b). Since that time, it has been amended over sixty times, and its focus has changed from the regulation of mainly foreign fisheries to the management of fully domestic groundfish fisheries. The geographical extent of the FMP management unit is the U.S. EEZ 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 (Figure 2.2). The GOA groundfish FMP covers fisheries for all stocks of finfish except salmon, steelhead, Pacific halibut, Pacific herring, and tuna. In terms of both the fishery and the groundfish resource, the GOA groundfish fishery forms a distinct management unit. The GOA FMP was revised in January 2005 to incorporate previous amendments and to better organize the document. A review of GOA FMP Amendments can be found in Section 2.16 of the BA.

2.2.2.1 Objectives of the FMPs

The history of fishery development, target species and species composition of the commercial catch, bathymetry, and oceanography differ between the GOA and the adjacent BSAI management area. Although many species occur over a broader range than the BSAI or GOA management areas, with only a few exceptions (e.g., sablefish), stocks of common species in each management area are believed to be different from those in the other management area. Each FMP contains management policies and measures for the groundfish fisheries occurring in the management area. These policies and measures are explained in detail in the BA (see Section 2.2.2). Objectives of the FMPs are:

Primary Plan Objectives:

1. Promote conservation while providing for optimum yield.
2. Promote efficient use of fishery resources but not solely for economic purposes.
3. Promote fair resource allocation without allowing excessive privileges.
4. Use best scientific data available.

Secondary Plan Objectives:

1. Conservation and management measures must be flexible enough to account for unpredictable variations in resource and industry.
2. Manage stocks throughout their range.
3. Promote rebuilding if stocks are less than Maximum Sustainable Yield.
4. Promote efficiency while avoiding disruption of existing social and economic structures.

5. Management measures should contain a safety margin in setting Acceptable Biological Catches when the quality of information concerning the resource and the ecosystem is questionable.
6. Minimize impacts of fishing strategies on other fisheries and environment.

Management Objectives:

1. Rational and optimal biological and socioeconomic use of resource.
2. Minimize impact on prohibited species and rebuild halibut stocks.
3. Seek to maintain the productive capacity of the habitat required to support the groundfish fishery.

2.2.2.2 Stocks in the GOA

Stocks governed by the GOA FMP include all finfish, except salmon, steelhead, halibut, herring, and tuna, which are distributed or are exploited in the area described above. Harvest allocations and management are based on the calendar year.

Five categories of species or species groups are likely to be taken in the groundfish fishery. Species may be split or combined within the "target species" category according to procedures set forth in the FMP without amendments to this FMP, notwithstanding the designation listed in the FMP. The optimum yield concept is applied to all except the "prohibited species" category. These categories are described as follows (and in the Table below):

1. Prohibited Species – are those species and species groups the catch of which must be avoided while fishing for groundfish, and which must be immediately returned to sea with a minimum of injury except when their retention is authorized by other applicable law. Groundfish species and species groups under the FMP for which the quotas have been achieved shall be treated in the same manner as prohibited species.
2. Target species – are those species that support a single species or mixed species target fishery, are commercially important, and for which a sufficient data base exists that allows each to be managed on its own biological merits. Accordingly, a specific total allowable catch (TAC) is established annually for each target species. Catch of each species must be recorded and reported. This category includes walleye pollock, Pacific cod, sablefish, shallow and deep water flatfish, rex sole, flathead sole, arrowtooth flounder, Pacific ocean perch, shortraker/rougheye rockfish, northern rockfish, "other slope" rockfish, pelagic shelf rockfish, demersal shelf rockfish, thornyhead rockfish, Atka mackerel, and skates.
3. Other Species – are those species or species groups that currently are of slight economic value and not generally targeted upon. This category, however, contains species with economic potential or which are important ecosystem components, but insufficient data exist to allow separate management. Accordingly, a single TAC applies to this category as a whole. The TAC will be equal to 5 percent of the combined TACs for target species. Catch of this category as a whole must be recorded and reported. The category includes squid, sculpins, sharks, and octopus.
4. Forage fish species – are those species which are a critical food source for many marine mammal, seabird and fish species. The forage fish species category is established to allow for the management of these species in a manner that prevents the development of a commercial directed fishery for forage fish. Management measures for this species category will be specified in regulations and may include such measures as prohibitions on directed fishing, limitations on allowable bycatch retention amounts, or limitations on the sale, barter, trade or any other commercial exchange, as well as the processing of forage fish in a commercial processing facility.

5. Non-specified species – are those species and species groups of no current economic value taken by the groundfish fishery only as an incidental catch in the target fisheries. Virtually no data exist which would allow population assessments. No record of catch is necessary. The allowable catch for this category is the amount that is taken incidentally while fishing for target and other species, whether retained or discarded.

Groundfish stocks in the GOA (NPFMC 2005b)

Management Group	Species
Prohibited Species[1]	Pacific halibut Pacific herring Pacific salmon Steelhead trout King crab Tanner crab
Target Species[2]	Walleye pollock Pacific cod Sablefish Flatfish (shallow-water flatfish, deep-water flatfish, rex sole, flathead sole, arrowtooth flounder) Rockfish (Pacific ocean perch, northern rockfish, shortraker rockfish, rougheye rockfish, other slope rockfish, pelagic shelf rockfish, demersal shelf rockfish[3], thornyhead rockfish) Atka mackerel Skates (big and longnose skates, other skates)
Other Species[4]	Squid Sculpins Sharks Octopus
Forage Fish Species[5]	Osmeridae family (eulachon, capelin, and other smelts) Myctophidae family (lanternfishes) Bathylagidae family (deep-sea smelts) Ammodytidae family (Pacific sand lance) Trichodontidae family (Pacific sand fish) Pholidae family (gunnels) Stichaeidae family (pricklebacks, warbonnets, eelblennys, cockscombs, and shannys) Gonostomatidae family (bristlemouths, lightfishes, and anglemouths) Order Euphausiacea (krill)

[1] Must be immediately returned to the sea
[2] TAC for each listing
[3] Management delegated to the State of Alaska
[4] Aggregate TAC for group
[5] Management measures for forage fish are established in regulations implementing the FMP

2.2.2.3 Stocks in the BSAI

Stocks governed by the FMP include all stocks of finfish and marine invertebrates except salmonids, shrimps, scallops, snails, king crab, Tanner crab, Dungeness crab, corals, surf clams, horsehair crab, lyre crab, Pacific halibut, and Pacific herring.

Five categories of species or species groups are likely to be taken in the groundfish fishery. The optimum yield concept is applied to all except the "prohibited species" category. These categories are described as follows (and in the table below):

1. Prohibited Species – are those species and species groups the catch of which must be avoided while fishing for groundfish, and which must be returned to sea with a minimum of injury except when their retention is authorized by other applicable law. Groundfish species and species groups under the FMP for which the quotas have been achieved shall be treated in the same manner as prohibited species.
2. Target species – are those species that support either a single species or mixed species target fishery, are commercially important, and for which a sufficient data base exists that allows each to be managed on its own biological merits. Accordingly, a specific TAC is established annually for each target species. Catch of each species must be recorded and reported. This category includes pollock, Pacific cod, sablefish, yellowfin sole, Greenland turbot, arrowtooth flounder, rock sole, flathead sole, Alaska plaice, "other flatfish", Pacific ocean perch, northern rockfish, shortraker rockfish, rougheye rockfish, "other rockfish", Atka mackerel, and squid.
3. Other Species – are those species or species groups that currently are of slight economic value and not generally targeted upon. This category, however, contains species with economic potential or which are important ecosystem components, but insufficient data exist to allow separate management. Accordingly, a single TAC applies to this category as a whole. Catch of this category as a whole must be recorded and reported. The category includes sculpins, sharks, skates, and octopus.
4. Forage fish species – are those species which are a critical food source for many marine mammal, seabird and fish species. The forage fish species category is established to allow for the management of these species in a manner that prevents the development of a commercial directed fishery for forage fish. Management measures for this species category will be specified in regulations and may include such measures as prohibitions on directed fishing, limitations on allowable bycatch retention amounts, or limitations on the sale, barter, trade or any other commercial exchange, as well as the processing of forage fish in a commercial processing facility.
5. Nonspecified species – are those species and species groups of no current economic value taken by the groundfish fishery only as an incidental catch in the target fisheries. Virtually no data exist which would allow population assessments. No record of catch is necessary. The allowable catch for this category is the amount which is taken incidentally while fishing for target and other species, whether retained or discarded.

Groundfish stocks in the BSAI (NPFMC 2005a)

Management Group	Species	
	Finfish	Marine Invertebrates
Prohibited Species[1]	Pacific halibut Pacific herring Pacific salmon Steelhead	King crab Tanner crab
Target Species[2]	Walleye pollock Pacific cod Sablefish Yellowfin sole Greenland turbot Arrowtooth flounder Rock sole Flathead sole Alaska plaice Other flatfish Pacific ocean perch Northern rockfish Shortraker rockfish Rougheye rockfish Other rockfish Atka mackerel	Squid
Other Species[3]	Sculpins Sharks Skates	Octopus
Forage Fish Species[4]	Osmeridae family (eulachon, capelin, and other smelts) Myctophidae family (lanternfishes) Bathylagidae family (deep-sea smelts) Ammodytidae family (Pacific sand lance) Trichodontidae family (Pacific sand fish) Pholidae family (gunnels) Stichaeidae family (pricklebacks, warbonnets, eelblennys, cockscombs, and shannys) Gonostomatidae family (bristlemouths, lightfishes, and anglemouths)	Order Euphausiacea (krill)

[1] Must be returned to the sea
[2] TAC for each listing
[3] Aggregate TAC for group
[4] Management measures for forage fish are established in regulations implementing the FMP

2.2.2.4 Fishery Management Measures

Overviews of management measures contained in the FMPs are provided in Tables 2.1a and 2.1b. In some cases, management measures are specific (e.g. the Pribilof Islands Conservation Area) while some measures are much less specific (e.g. marine mammal measures) and are thus implemented in more detail in regulation. The specific management measures, implemented in regulations, which pertain to the conservation of Steller sea lions are described in Section 2.5.2.

General regulations governing U.S. fisheries appear at 50 CFR Part 600, and regulations specifically governing the groundfish fisheries in the EEZ off Alaska appear at 50 CFR Part 679. The regulations therein prescribe the existing regulatory framework for the federally managed groundfish fisheries off Alaska. Groundfish management areas are provided in Figure 2.2.

2.2.3 The Decision Making Process – Implementing Policy

There are two major decision making areas initiated by the Council: the implementation of FMP and regulatory amendments; and the setting of the annual total allowable catch (TAC) specifications. The following description of the management process is intended to be generic, illustrating the process by which FMP amendments and regulatory amendments are developed. The setting of TACs will be described below in the section on the annual fisheries assessment and specifications. The overall management process is illustrated in Figure 2.1.

2.2.3.1 Involved Entities

The following entities are integral in the decision making process for the implementation of the FMPs and the harvest of groundfish fisheries in Alaska:

NMFS

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

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

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

U.S. Coast Guard

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

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

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

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

State of Alaska

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

North Pacific Fishery Management Council

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

1. prepares and submits FMPs for each fishery that requires conservation and management, as well as amendments to each plan;
2. prepares comments on certain applications for foreign fishing and on FMPs or amendments prepared by the Secretary [of Commerce];
3. conducts public hearings to allow public participation in the management process;

4. submits to the Secretary reports that it deems necessary or that were requested by the Secretary;
5. for each fishery, reviews on a continuing basis the assessments and specifications necessary to achieve optimum yield from, the capacity and extent to which United States fish processors will process United States harvested fish from, and the total allowable level of foreign fishing in, each fishery; and
6. conducts any other activities required by the MSA or necessary and appropriate to the foregoing functions.

In addition to the main Council body, the Council maintains four main committees and panels related to groundfish fishery management. The Advisory Panel consists primarily of representatives of the fishing industry and is intended to advise the Council on any matters pertaining to the FMPs and amendments. The Scientific and Statistical Committee consists of appointed scientists and is intended to assist in the development, collection, and evaluation of statistical, biological, economic, social, and other scientific information necessary for development and amendment of FMPs. The two remaining committees are Plan Teams for the BSAI and GOA groundfish fisheries. These teams review stock assessment methods and results, and make recommendations on harvest levels to the Council based on the status and trends of each stock and its tolerance for fishery removal. The Council appoints other committees as needed to advise the Council on other issues (e.g., the Steller Sea Lion Mitigation Committee has been utilized to inform the Council on sea lion related conservation issues).

2.2.3.2 Council and NMFS Fishery Management Policy

The Council has developed a management policy and objectives to guide its development of management recommendations to the Secretary of Commerce. The Council's policy is to apply judicious and responsible fisheries management practices, based on sound scientific research and analysis, proactively rather than reactively, to ensure the sustainability of fishery resources and associated ecosystems for the benefit of future, as well as current generations. The productivity of the North Pacific ecosystem is acknowledged to be among the highest in the world. For the past 30 years, the Council management approach has incorporated forward looking conservation measures that address differing levels of uncertainty. This management approach has in recent years been labeled the precautionary approach. Recognizing that potential changes in productivity may be caused by fluctuations in natural oceanographic conditions, fisheries, and other, non-fishing activities, the Council intends to continue to take appropriate measures to insure the continued sustainability of the managed species. It will carry out this objective by considering reasonable, adaptive management measures, as described in the MSA and in conformance with the National Standards, the ESA, the National Environmental Policy Act, and other applicable law. This management approach takes into account the National Academy of Science's recommendations on Sustainable Fisheries Policy.

As part of its policy, the Council intends to consider and adopt, as appropriate, measures that accelerate the Council's precautionary, adaptive management approach through community-based or rights-based management, ecosystem-based management principles that protect managed species from overfishing, and where appropriate and practicable, increase habitat protection and bycatch constraints. All management measures will be based on the best scientific information available. Given this intent, the fishery management goal is to provide sound conservation of the living marine resources; provide socially and economically viable fisheries for the well-being of fishing communities; minimize human-caused threats to protected species; maintain a healthy marine resource habitat; and incorporate ecosystem-based considerations into management decisions.

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

2.2.3.3 Implementing the FMPs

FMPs, amendments to FMPs, and regulatory amendments are developed by the Council, submitted to the Secretary of Commerce (Secretary) for review, and may be approved, disapproved, or partially approved. Amendments also may require implementing regulations. Once the regulations are effective, NMFS has responsibility for day-to-day management of the fisheries. Enforcement of the regulations is carried out jointly by NMFS and the U.S. Coast Guard. Disapproved and partially approved FMPs and FMP amendments are returned by NMFS to the Council with an explanation of the reasons for disapproval. The Council may then decide whether to revise and resubmit the FMP/amendment. If the Council fails to develop a necessary FMP/amendment, or fails to revise an FMP/amendment following Secretarial disapproval or partial approval within a reasonable period of time, the Secretary may develop a Secretarial FMP/amendment. Secretarial authority to approve, disapprove or partially approve is set out in Section 304(a)(3) of the MSA.

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

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

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

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

Once the Council has determined its final recommendation, the recommendation is transmitted to the Secretary of Commerce. The principal documents that are submitted include (a) the proposed FMP text or text changes in the case of an FMP amendment, (b) the draft analysis of potential environmental and socioeconomic impacts of the preferred alternative and other alternatives considered by the Council, and (c) any proposed regulations that would implement the action, if the amendment is approved. The proposed implementing regulations are published in the Federal Register as a notice of proposed rule making with a 15 to 60 day comment period.

After receipt of the official FMP/amendment review package, the Secretary must immediately commence review of the package to determine whether the proposed FMP or FMP amendment is consistent with MSA, including the national standards, and other applicable law and must immediately publish a notice of availability in the Federal Register to start the 60 day period of public review. Within 30 days after the end of the public comment period, the Secretary must approve, disapprove or partially approve the FMP amendment by written notice to the Council. If Secretarial action is not taken within the required time period, then the FMP amendment takes effect as if it were fully approved.

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

When the Council recommends regulations to implement an FMP or amendment, the Secretary reviews them to determine their consistency with the underlying FMP. If NMFS determines that the proposed regulatory amendment is consistent, then it is published in the Federal Register, but if the determination is negative, NMFS must notify the Council in writing specifying the inconsistencies and providing recommendations for revision that would make the proposed regulation consistent. An approved FMP, FMP amendment or regulatory amendment is implemented by publication of a notice of approval (for FMP amendments without regulations) or a final rule in the Federal Register. The rule normally is not effective for an additional 30 days after it is published, as required under the Administrative Procedure Act.

2.2.3.4 State of Alaska Parallel Fisheries

The Alaska Department of Fish and Game (ADF&G) manages fishing activity within the State of Alaska (State) territorial waters (from zero to three nm, hereby referred to as state waters). With the exception of State fisheries that have specified guideline harvest limits (GHLs) for species such as sablefish, Pacific cod, and the Prince William Sound pollock fishery, ADF&G coordinates their groundfish fishery openings and in-season adjustments with federal fisheries. For example, when groundfish fishing is open in federal waters, current state regulations allow fishing for pollock, Pacific cod, and Atka mackerel to occur in certain State waters in what is referred to as the "parallel" fishery (Title 05 Chapter 28.087 of the Alaska Administrative Code). The State defines the parallel fishery as the following: "For the purposes of this section, "parallel groundfish fisheries" means the Pacific cod, walleye pollock, and Atka mackerel fisheries in state waters opened by the commissioner, under emergency order authority, to correspond with the times, area, and unless otherwise specified, the gear of the federal season in adjacent federal waters". However, the State retains regulatory jurisdiction over fisheries within State waters. Fish harvested are counted against the federal TAC to ensure the parallel fishery is conducted within the constraints on the federal fishery.

Parallel fisheries occur inside State territorial waters from 0 to 3 nm, which happen to lie almost entirely within Steller sea lion critical habitat. Usually, the State mirrors federal closure areas for Steller sea lions. Two notable exceptions occurred regarding the 2001 protection measures. The State adopted all of the federal closures areas contained in the 2001 conservation measures (NMFS 2001), except for fishing for Pacific cod using pot around Cape Barnabas and Caton Island. Waters out to 3 nm around these two sites was not closed by the State, thus federal regulations were modified in 2003 to allow them to be open for pot fishing.

The GOA and BSAI FMPs reference the groundfish fisheries of the State of Alaska. Since some of the stocks of groundfish harvested in State waters may be the same stocks that are harvested in Federal waters, provisions are made for some groundfish stocks to allow both a fishery in State waters and a fishery in federal waters.

2.3 Exploitation Strategy

In 2002, the Council convened a panel to provide an independent scientific review of the current harvest strategy embodied in the FMPs (Goodman *et al.* 2002). The focus of the review was on describing the harvest policy, the role of $F_{40\%}$ as a reference point, and to determine whether changes should be made to account for particular species or ecosystem needs in accordance with the MSA. This opinion relies heavily on the Goodman *et al.* (2002) report; it provides an excellent review of the harvest strategy and the potential consequences to non-target species and the ecosystem as a whole. See the Goodman *et al.* (2002) report for further background on fisheries management and exploitation strategy. This section of the opinion focuses on describing the exploitation strategy as it relates to harvests of prey species important to ESA-listed species and incorporates much of the descriptive text from Goodman *et al.* (2002).

Harvests in the BSAI and GOA fisheries are governed by the BSAI and GOA FMPs. Identification of an explicit "harvest strategy" in these FMPs is somewhat problematic (Goodman *et al.* 2002). The FMPs allow for a wide range of possible harvests for any given stock in any given year, such that, the plans are consistent with a large number of harvest strategies. However, any harvest allowed by the FMPs is required to be consistent with the National Standards described in the MSA. Of particular relevance in this regard is National Standard 1, which states, "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry" (Title III, Section 301(a)(1)). Optimum yield, in turn, is defined as that which (Section 3(28)):

a. will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;
b. is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and
c. in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery.

Definitions that may be referenced when considering the exploitation strategy are:

Maximum sustainable yield (MSY) is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions.

Optimum yield (OY) is the amount of fish which:

a) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;
b) is prescribed as such on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor; and
c) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery.

Overfishing level (OFL) is a limit reference point set annually for a stock or stock complex during the assessment process. Overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis. Operationally, overfishing occurs when the harvest exceeds the OFL.

Acceptable biological catch (ABC) is an annual sustainable target harvest (or range of harvests) for a stock or stock complex, determined by the Plan Team and the Scientific and Statistical Committee during the assessment process. It is derived from the status and dynamics of the stock, environmental conditions, and other ecological factors, given the prevailing technological characteristics of the fishery. The target reference point is set below the limit reference point for overfishing.

Total allowable catch (TAC) is the annual harvest limit for a stock or stock complex, derived from the ABC by considering social and economic factors.

In addition to definitional differences, OY differs from ABC and TAC in two practical respects. First, ABC and TAC are specified for each stock or stock complex within the “target species” and “other species” categories, whereas OY is specified for the groundfish fishery (comprising target species and other species categories) as a whole. Second, ABCs and TACs are specified annually whereas the OY range is constant. The sum of the stock-specific ABCs may fall within or outside of the OY range. If the sum of annual TACs falls outside the OY range, TACs must be adjusted or the FMP amended and in the case of the BSAI, congressional action would be necessary for a statutory amendment (Consolidated Appropriations Act of 2004 sets the BSAI OY at 2 million mt).

2.3.1 Background: Principles of Sustainable Fisheries and Surplus Production

The average biomass (weight of the stock) at which a stock persists depends on the relationship between the spawning (breeding) stock biomass and the average production of new fish, reduced to take account of how well those recruits survive after they enter the fishery. The relationship between stock biomass and production is of major importance in fisheries management. If there was no stock then there could not be any production. At the other end of the spectrum, such as that in a pristine environment, there would also be zero or negative production because regardless of how many recruits were produced, there would not be enough food for them to all grow and survive through to an age at which they would be caught. Between the zero and high values of stock biomass where production is zero, there are intermediate values of stock biomass at which production increases to a maximum and then decreases again.

It is theoretically possible to have sustainable fishing at almost any level of stock biomass, so long as the catch that is taken balances the production. In principle, therefore, sustainable fishing could take place anywhere between very low or very high stock sizes. The ability to manage with confidence a stock to any given stock size would depend, however, on how well the stock size is known, how well the relationship between stock size and production is understood, how well catches can be controlled to match production, the dynamics of the stock's response to deviations from the intended level of catch, and a variety of other difficult and uncertain factors.

The level of stock size that produces the maximum possible production is the biomass at maximum sustainable yield (B_{MSY}). In practice, because of economic and social objectives, as well as uncertainty, there are good reasons for trying to manage fish stocks near to, but somewhat below the stock size that confers MSY. The MSY is the highest theoretical production (yield, or catch) that can be continuously taken from a stock under constant environmental conditions without affecting the production of new recruits. It is estimated from models based on surplus production, stock-recruitment relationships, and other methods. In practice, MSY, and the level of fishing effort needed to take it are difficult to assess. Nevertheless, MSY is a benchmark in fisheries theory, international agreements and national legislation; as such, it is the basis for important reference points used in fishery management.

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

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

For an unfished stock of a particular size, recruitment may occur at levels greater than necessary to replace a stock (i.e., maintain the stock at that size). Such "excess" is essential, for example, for population growth. In a deterministic "single-species context", this excess is considered a surplus that can be removed by fishing without harm to the stock. The concept of surplus recruitment is illustrated by the Ricker (1954) stock-recruitment relation in Figure 2.3. The Ricker curve indicates a density-dependent relation between stock and recruitment where recruitment varies as a function of some measure of stock size (e.g., number or biomass). The Ricker curve also suggests that recruitment reaches a peak at some stock level and then declines with increasing stock size. The excess or surplus recruitment in this case is represented by the vertical difference between the stock-recruitment line and the replacement line. In the simplest case, without random variability and where the fishable stock consists of a single age group, this excess represents sustainable yield. At some stock size, the excess reaches a maximum, which is the maximum sustainable yield.

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

The Beverton-Holt spawner-recruit relationship has the feature that recruitment increases as a function of spawning biomass to an asymptotic level. In contrast, the Ricker curve has a dome-shaped pattern in which recruitment peaks at an intermediate level. The biological mechanism(s) for this peak include cannibalism of adults on small fish and crowding effects due to overescapement. Consequently, it need not be true that equilibrium recruitment is highest at the pristine carrying capacity.

2.3.1 Overview of the Harvest Strategy

The following description is excerpted from Goodman *et al.* (2002):

> The current harvest strategy is essentially a maximum sustainable yield (MSY) single-species approach, modified by some formal safeguards incorporated to ward against overfishing as defined from the single-species standpoint, and with opportunities of a less-structured nature for reducing harvest rates further in response to perceived social, economic and ecological concerns. No quantitative standards or specific decision rules are stated for these latter considerations, except as they are imposed, from outside the MSA, by the ESA or the MMPA, and only for particular populations.
>
> The overfishing level (OFL) set for each stock is an estimate either of the fishing mortality rate associated with MSY (F_{MSY}) or an estimate of a surrogate for F_{MSY}. The OFL is treated in the management system as a limit that should not be exceeded except with a very low probability. The acceptable biological catch (ABC) set for each stock is an estimate of a target rate, which is intended to establish some margin between it and the OFL. The hope is that managing so as to achieve this target on average will accomplish the desired compliance with exceeding the limit (OFL) only rarely. The ad hoc downward adjustments of harvest in response to other social, economic, and ecological considerations takes place in the deliberations where the total allowable catch (TAC) is set subject to the constraint that it be less than or equal to the ABC.
>
> The formulaic component of the reduction of harvest rate from the theoretical MSY harvest rate (from OFL to ABC) is by an amount that is often modest, when expressed as a fraction of the harvest rate; but in terms of the total tonnage involved, or its dollar value, the amount is considerable. The margin is also small relative to real natural variation, and small relative to the practical uncertainty about stock status or population parameters for many of the target stocks and indeed for most of the ecosystem. By contrast, in actual practice, the reduction of the TAC from the ABC has for some stocks and some years been quite large, but there is no explicit and general formula for this reduction.
>
> The formal and standardized quantitative portions of the process of determining OFL and ABC begin with the assignment of each stock to one of six “Tiers” based on the availability of information about that stock. Tier 1 has the most information, and Tier 6 the least. The so-called $F_{40\%}$ construct, which is one focus of our review, plays a prominent role in some of the Tiers (2, 3, and 4) but not the others. Notably, in Tier 3 (which is where many of the major BSAI/GOA stocks are assigned) and Tier 4, the estimate of $F_{40\%}$ is used as a surrogate for a fishing mortality rate that is somewhat below FMSY.
>
> $F_{40\%}$ is the calculated fishing mortality rate at which the equilibrium spawning biomass per recruit is reduced to 40% of its value in the equivalent unfished stock. This is an esoteric, but useful, measure of the amount by which the associated fishing rate reduces the stock size, in the long run. The useful features of this particular measure are two-fold. First, its calculation is less sensitive to the details of the stock-recruitment relationship than is the calculation of F_{MSY}, so it is practical to estimate F40% for stocks that are not well enough studied for estimation of F_{MSY}. The second is that, for a range of dynamics encompassing many, but not all, of the BSAI and GOA target groundfish stocks, modeling studies have shown that harvesting at $F_{35\%}$ accomplishes about the

same thing as harvesting at F_{MSY}, so harvesting at the slightly lower rate, $F_{40\%}$, establishes a modest margin of safety.

2.3.2 MSY and Optimum Yield

Concepts such as productivity and MSY should be viewed in terms of the groundfish complex as a unit rather than for individual species or groups. Yet, due to the difficulty in doing this, estimates of the groundfish complex have been computed by summing MSY estimates for individual species and species groups. Under the MSA, optimum yield is prescribed on the basis of the maximum sustainable yield from each fishery, as reduced by any relevant economic, social, or ecological factor (16 U.S.C. 1802 § 3(28)(B)). In both the BSAI and GOA FMPs the concept of optimum yield has been applied to the sum total of the groundfish catch in these regions. Optimum yield for total BSAI groundfish catch is set as a range from 1.4 million mt to 2.0 million mt (NPFMC 2005a). The endpoints of the range were determined by subtracting 15% from the endpoints of the range of MSY estimates available at that time. The BSAI FMP justified the 15% reduction by stating that it 1) reduces the risk associated with relying upon incomplete data and questionable assumptions in assessment models used to determine the condition of stocks, and 2) is probably a conservatively safe level for the groundfish complex.

Early studies estimated MSY for the GOA groundfish complex ranging from 804,950 mt in 1983 to 1,018,750 mt for the 1987 fishing year. This range was obtained by summing the MSY ranges for each target species excluding the “other species” category. However, current multi-species models suggest that the sum of single-species MSYs provides a poor estimate of MSY for the groundfish complex as a whole (NPFMC 2005b). The range of optimum yield specified in the FMP is 116,000-800,000 mt of groundfish for the target species and the “other species” categories, to the extent this can be harvested consistently with the management measures specified in this FMP. This range was established in 1987 based on the examination of historical and recent catches, recent determinations of ABC, and recent and past estimates of MSY for each major groundfish species. This derivation from historical estimates of MSY and fishery performance reflects the combined influence of biological, ecological, and socioeconomic factors. The end points of the range were derived as described below.

For the minimum value, 116,000 mt was approximately equal to the lowest historical groundfish catch during the 21-year period 1965-1985 (116,053 mt in 1971, NPFMC 1986). In that year catches of pollock, Pacific cod and Atka mackerel were all at very low levels. Given the status of the groundfish resources and the present management regime, it was considered extremely unlikely that future total harvest would fall below this level. Thus, the TACs must be established so as to result in a sum of at least 116,000 mt. The upper end of the OY range, 800,000 mt, was derived from MSY information. The MSY for all species of groundfish (excluding the other species category) between 1983 and 1987 ranged from 804,950 mt in 1983 to 1,137,750 mt for the 1987 fishing year. The average MSY over the five-year period was 873,070 mt. Therefore, the upper end of the range is approximately equal to 92 percent of the mean MSY for the five-year period. The ABC summed for all species ranged from 457,082 mt in 1985 to 814,752 mt in 1987. Most of the variation in the ABC and catch over the five-year interval resulted from changes in the status of two species: pollock and flounder. Pollock ABC ranged from 112,000 mt in 1987 to 516,600 mt in 1984; while flounder ABC ranged from 33,500 mt in 1985 to 537,000 mt in 1987. Therefore, the 800,000 mt upper end of the OY range was selected in consideration of the volatility in pollock and flounder ABC, and the potential for harvesting at MSY.

F_{MSY} has a long history as a target level of fishing mortality at which stocks could be managed in order to maximize yields. However, the experience accumulated over past decades shows that FMSY is not necessarily a good target from a conservation perspective, or from an economic one or even from the perspective of sustainable yields (Ludwig 1995). Due to natural fluctuations, for example, the long-term average yield that can be obtained from an F_{MSY} policy will be lower than the MSY level that would be estimated assuming constancy. Similarly, if a constant catch level, equal to the calculated MSY assuming constancy, is taken annually from a fluctuating population, the stock will decline. An added problem is that FMSY is difficult to estimate and, therefore, it is difficult to implement F_{MSY} policies accurately without exceeding the intended target with an unsatisfactory frequency.

The practical realization that many stocks in fact were overfished, despite being hypothetically managed at F_{MSY}, was influential in the negotiation of several international instruments during the mid-1990s and in the reauthorization of the MSA in the U.S. An end result was a policy change to treat F_{MSY} as a limit rather than a target.

2.3.4 Harvest Control Rules

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

(1) Target reference points should be set safely below limit reference points.
(2) A stock that is below its MSY level should be harvested at a lower rate than if the stock were above its MSY level.
(3) Criteria used to set target catch levels should be explicitly risk averse, so that greater uncertainty regarding the status or productive capacity of a stock corresponds to greater caution in setting target catch levels.

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

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

The two sets of harvest control rules in the BSAI and GOA Groundfish FMPs are prescribed through a set of six tiers which are listed below in descending order of preference, corresponding to descending order of information availability. For tier (1), a "pdf" refers to a probability density function. For tiers (1-2), *MSY* refers to maximum sustainable yield, which is the largest catch which the stock can withstand, on average, over a long period of time (given current environmental conditions). For tiers (1-3), the coefficient “*a*” is set at a default value of 0.05, with the understanding that a different value for a specific stock or stock complex may be used if supported by the best available scientific information. For tiers (2-4), a designation of the form "*F*" refers to the fishing mortality (*F*) associated with an equilibrium level of spawning biomass per recruit (SPR) equal to *X%* of the equilibrium level of spawning biomass per recruit in the absence of any fishing. For tier (3), the term $B_{40\%}$ refers to the long-term average biomass that would be expected under average recruitment and $F=F_{40\%}$. Tiers for fished stocks are listed in Table 2.8.

Tier 1) Information available: Reliable point estimates of B and B_{MSY} and reliable pdf of F_{MSY}.
  1a) Stock status: $B/B_{MSY} > 1$
    $F_{OFL} = m_A$, the arithmetic mean of the pdf
    $F_{ABC} \leq m_H$, the harmonic mean of the pdf
  1b) Stock status: $a < B/B_{MSY} \leq 1$
    $F_{OFL} = m_A \times (B/B_{MSY} - a)/(1 - a)$
    $F_{ABC} \leq m_H \times (B/B_{MSY} - a)/(1 - a)$
  1c) Stock status: $B/B_{MSY} \leq a$
    $F_{OFL} = 0$
    $F_{ABC} = 0$
Tier 2) Information available: Reliable point estimates of B, B_{MSY} , F_{MSY} , $F_{35\%}$, and $F_{40\%}$.
  2a) Stock status: $B/B_{MSY} > 1$
    $F_{OFL} = F_{MSY}$
    $F_{ABC} \leq F_{MSY} \times (F_{40\%} /F_{35\%})$
  2b) Stock status: $a < B/B_{MSY} \leq 1$
    $F_{OFL} = F_{MSY} \times (B/B_{MSY} - a)/(1 - a)$
    $F_{ABC} \leq F_{MSY} \times (F_{40\%} /F_{35\%}) \times (B/B_{MSY} - a)/(1 - a)$
  2c) Stock status: $B/B_{MSY} \leq a$
    $F_{OFL} = 0$
    $F_{ABC} = 0$
Tier 3) Information available: Reliable point estimates of B, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$.
  3a) Stock status: $B/B_{40\%} > 1$
    $F_{OFL} = F_{35\%}$
    $F_{ABC} \leq F_{40\%}$
  3b) Stock status: $a < B/B_{40\%} \leq 1$
    $F_{OFL} = F_{35\%} \times (B/B_{40\%} - a)/(1 - a)$
    $F_{ABC} \leq F_{40\%} \times (B/B_{40\%} - a)/(1 - a)$
  3c) Stock status: $B/B_{40\%} \leq a$
    $F_{OFL} = 0$
    $F_{ABC} = 0$
Tier 4) Information available: Reliable point estimates of B, $F_{35\%}$, and $F_{40\%}$.
    $F_{OFL} = F_{35\%}$
    $F_{ABC} \leq F_{40\%}$
Tier 5) Information available: Reliable point estimates of B and natural mortality rate M.
    $F_{OFL} = M$
    $F_{ABC} \leq 0.75 \times M$
Tier 6) Information available: Reliable catch history from 1978 through 1995.
    OFL = the average catch from 1978 through 1995, unless an alternative value is established by the SSC on the basis of the best available scientific information
    ABC ≤ 0.75 × OFL

The following is a description of the tier system from Goodman *et al.* (2002):

> The dynamics of only one stock covered by the FMP, BSAI pollock, are well-enough quantified to qualify for Tier 1. In Tier 1 the limiting F_{OFL} is the equivalent of the point estimate of F_{MSY} (that is to say, roughly, the "best" estimate without adjusting for uncertainty), and the target F_{ABC}

is the harmonic mean of the distribution of the estimate for F_{MSY}. The harmonic mean has the mathematical property that it is less than the simple average (roughly, the point estimate) by an amount that increases with the spread of the distribution, so this establishes a margin that increases with the uncertainty in the estimate. However, this mechanism for adjusting the F_{ABC} downward from the F_{OFL} does not have the statistical property of ensuring a constant specified confidence that the F_{ABC} does not exceed the true F_{MSY}, as would be ensured by using a lower confidence limit of the estimate of F_{MSY} for the F_{ABC}.

Tier 2 differs from Tier 1 in that only point estimates of the key population parameters are available, so the distribution of the estimate for F_{MSY} is not known. In this Tier, the limiting F_{OFL} is the point estimate of F_{MSY}, much as in Tier 1, but a different formula (based on the adjustment used in Tier 3) is used for adjusting the F_{ABC} downward from F_{OFL}. The mathematics of the different formulas used for adjusting the F_{ABC} downward from F_{OFL} in Tier 1 and Tier 2 does not guarantee that the margin so established in Tier 2 will be wider than the margin in Tier 1.

Tier 3 differs from Tier 2 in that information is insufficient for any estimation of MSY. In this Tier, the limiting F_{OFL} is the point estimate of $F_{35\%}$ and the target F_{ABC} is the point estimate of $F_{40\%}$. The width of the margin between F_{ABC} and F_{OFL}, in this Tier, therefore, will be essentially the same as in Tier 2, and the relation to the width of the margin in Tier 1 is variable. Most of the major target stocks in the BSAI/GOA are in Tier 3.

Tier 4 differs from Tier 3 in that information is insufficient for estimation of target biomass levels. In this Tier, the limiting F_{OFL} is the point estimate of $F_{35\%}$, and the target F_{ABC} is the point estimate of $F_{40\%}$, both as in Tier 3. The width of the margin between F_{ABC} and F_{OFL}, in this Tier, therefore, will be identical to that in Tier 3, and essentially the same as in Tier 2, and the relation to the width of the margin in Tier 1 is variable.

Tier 5 differs from Tier 4 in that information is insufficient for estimating $F_{40\%}$ or $F_{35\%}$, so the limits and targets use different surrogates to attempt to approximate management for MSY. In this Tier, the limiting F_{OFL} is the point estimate of the natural mortality rate of the stock, and the target F_{ABC} is three fourths of that value. The limiting F_{OFL} in this Tier maybe either conservative or aggressive relative to the limiting F_{OFL} of $F_{35\%}$ in the three Tiers above. Theoretical work [Deriso 1982 among others and Thompson] has shown that M is often higher than F_{MSY}, so it would be a better as a limit than a target. The margin between F_{ABC} and F_{OFL} in this Tier, corresponding to a 25% reduction of fishing mortality rate, is wider than the margin in Tiers 2 through 4. Most of the minor target stocks in the BSAI/GOA are in Tier 5.

Tier 6 differs from Tier 5 in that information is insufficient for estimating any of the stock parameters, and all that is known is the catch history. In this Tier, the limiting F_{OFL} is the average historic catch, and the target F_{ABC} is three fourths of that value. In practice, without estimates of stock size, the control is exerted simply through a limit on amount of catch. The margin between F_{ABC} and F_{OFL}, in this Tier, considered as a fractional reduction, is the same as in Tier 5.

In Tiers 1 through 3 there are provisions for rapid rebuilding of stocks from an overfished condition, by reductions in the target fishing mortality rate triggered whenever the estimate of stock biomass is below the target biomass. There is no such provision in Tiers 4 through 6. In Tiers 1 through 5, the information on the stock is sufficient to give clear indications if the stock status is departing substantially from the management goals. In Tier 6, this is not the case.

We see that for the most part there is not a clear systematic progression in increasing conservatism in the targets or in the width of the margin between target and limit, in moving from the Tiers with more information to those with less. Similarly, there is not, for the most part, a clear systematic incentive, in terms of potential for greater harvest, to improve the information base in order to move a stock from Tiers with less information to Tiers with more. Finally, the control rule provisions to accelerate rebuilding of stocks from an overfished condition do not apply to the 3 Tiers with the least information, and which, therefore, are subject to the greatest uncertainties. Within Tier, almost all the inputs to the control rule are point estimates, and so these do not adjust in response to uncertainty either.

2.3.4 Stock Status: Overfished and Overfishing

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

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

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

For each BSAI and GOA groundfish stock managed under tiers 1-3, the following algorithm is used to determine stock status with respect to MSST (Figure 2.3.4-1).

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

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

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

- If the mean spawning biomass for the third year is below ½ B_{MSY}, the stock is approaching an overfished condition.
- If spawning biomass for the third year is above B_{MSY}, the stock is not approaching an overfished condition.
- If spawning biomass for the third year is between ½ B_{MSY} and B_{MSY}, the determination depends on the mean spawning biomass at the end of 12 years.
- If the average ending stock size in these simulations is below B_{MSY}, the stock is approaching an overfished condition.
- If the average ending stock size in these simulations is above B_{MSY}, the stock is not approaching an overfished condition.

2.3.5 Critical Assumptions

2.3.5.1 MSY Proxies and F_x

F_{MSY} proxies are necessary in situations where there is insufficient knowledge of a clear stock-recruitment relationship, either due to lack of data or to other sources of uncertainty, that make the estimates of F_{MSY} too unreliable to be applied in management. This concept is perfectly identified in the Tier system of the Status Determination Criteria for the GOA and BSAI FMPs in which F_{MSY} estimates are only used in the information-rich tier, and a series of proxies are used in the more data-poor tiers.

Restrepo *et al.* (1998) and Gabriel and Mace (1999) review a series of F_{MSY} proxies that have been advocated by various authors in the past, primarily based upon simulation studies. Some of the proxies used in the past include Fmax, $F_{0.1}$ and Fmed. But the class of reference points based on spawning potential ratios ($F_{\%SPR}$) has gained more prominence recently, first as reference points for recruitment overfishing and later as proxies for F_{MSY}. Values in the range $F_{20\%}$ to $F_{30\%}$ have been proposed as recruitment overfishing thresholds (Goodyear 1993; Rosenberg *et al.* 1994) while values in the range $F_{35\%}$ to $F_{40\%}$ have been proposed as F_{MSY} proxies (Clark 1991; Clark 1993; Mace 1994).

On the question of what value of $F_{\%SPR}$ should be used as an F_{MSY} proxy, Clark (1991) simulated a variety of life history types and concluded that $F_{35\%}$ was a reasonable proxy, unless recruitment presented strong serial correlation, in which case $F_{40\%}$ would be more appropriate (Clark 1993). However, a recent study by MacCall (2002) suggests that harvest policies that used $F_{35\%}$ to $F_{40\%}$ as targets may have been "too aggressive" for several groundfish stocks off the west coast of the U.S. Furthermore, Clark (2002) suggested that it may be necessary to have targets of $F_{50\%}$ to $F_{60\%}$ for stocks with low resilience in order to maintain a proper balance between average yields and average abundance. Here, "resilience" refers to a stock's capability to recover from overfishing. Long-lived stocks that are characterized by an old age at first maturity—such as many rockfish—have low resilience.

There is also the question of what F_{MSY} proxies should be used for other non-groundfish species in the groundfish FMPs such as squid or octopus. However, we are not aware of any studies that recommend alternatives for these species.

It is difficult to evaluate the appropriateness of a specific F_{MSY} proxy for a specific stock because such evaluation requires the analyst to make assumptions about key population parameters (e.g., the stock-recruitment relationship) that will determine the outcome of the evaluation. For the most part, the guidance that has been provided has been generic and based on simulating hypothetical life history types. Nevertheless, the current scientific reasoning can be summarized by the advice on default F_{MSY} proxies provided by Restrepo *et al.* (1998):

- $F_{30\%}$ for stocks with high resilience
- $F_{35\%}$ for stocks with "average" resilience

- $F_{40\%}$ for stocks with moderate to low resilience
- $F_{50\%}$ to $F_{60\%}$ for stocks with very low productivity (such as rockfish and most elasmobranches).

In cases where there is so little information about a stock's population parameters that it is not possible to estimate spawning potential ratios, the options for using proxies are very few. The natural mortality rate (M) or a fraction of M, have been advocated as proxies for F_{MSY}. Thompson (1993) suggested that F=0.8M could provide reasonable protection against overfishing, and Deriso (1987) showed that M was approximately equal to $F_{0.1}$, a reference point that is advocated as an F_{MSY} proxy when selectivity and maturity schedules coincide.

Collie and Gislason (2001) showed in a multispecies context that commonly used biological reference points, including F_{MSY}, $F_{0.1}$, $F_{40\%}$, B_{MSY}, and $B_{40\%}$, are much more sensitive to changes in natural mortality (i.e., predators) than to growth changes (i.e., prey). They recommend conservative biological reference point-based F's conditioned on the level of predation for species that are primarily prey items. For a species that is primarily a predator, the usual reference points are amenable to conservation needs.

Tiers 3 and 4 make use of $F_{35\%}$ and $F_{40\%}$ to determine upper limit and default target fishing mortality rates, respectively. A simplistic interpretation of this system is that $F_{35\%}$ is being used as the default proxy for F_{MSY}, while $F_{40\%}$ is used as an estimator of a target F that is safely below F_{MSY}.

For the most part, the $F_{35\%}$ level as a proxy for F_{MSY} is in line with the values suggested in the literature. However, it should be noted that direct comparisons with literature studies are difficult to make for Tier 3 because the OFL and ABC control rules are not constant-F strategies. In these control rules, fishing mortality decreases linearly with stock size if the biomass falls below a threshold equal to $B_{40\%}$ (the B_{MSY} proxy). In contrast, the simulation studies mentioned in the previous section evaluated harvest rates that were kept constant, even when the simulated populations reached a low size. While average long-term yields may be similar in simulations using both shapes of control rules, it is likely that the average biomasses will differ. All else being equal, the control rules in Tier 3 are more conservative than the strategies analyzed by Clark (1993) and others and labeled as $F_{35\%}$ or $F_{40\%}$. For a more complete evaluation of the performance of Tier 3, it is recommended that the simulation study of Clark (1993) be carried out applying the F_{OFL} and F_{ABC} harvest rates of Tier 3.

The tier system in the groundfish FMPs is a blanket system that covers all stocks in the two FMPs without making allowances for the diversity in life-history types present. As suggested by Clark (2002), $F_{35\%}$ harvest rates may not be sufficiently conservative for stocks with very low productivity, such as rarely-recruiting and long-lived rockfish species. Lower rates, on the order of $F_{50\%}$ to $F_{60\%}$, may be more appropriate to balance yield and conservation objectives for such species as well as those that are primary prey of other species in the ecosystem (Collie and Gislason 2001). Another potential problem has to do with stock complexes. Because productivity of each species in the complex is likely to be different, a single $F_{\%SPR}$ proxy will not perform equally well for all stocks in the complex.

The OFL values that are set according to Tiers 5 and 6 seem reasonable as conservative estimates of F_{MSY} levels in data-poor situations. While it may be possible to set up simple simulation studies to evaluate the performance of Tier 5 and 6 proxies, it is better to improve the general knowledge about these stocks in order to facilitate their classification into more data-rich tiers.

2.3.5.2 Stock Recruitment

Recruitment is the only source of replenishment for the numbers of individuals in the fished portion of a population. Biomass may be increased by somatic growth, but the biomass of a cohort is also a function of the number of individuals in that cohort. Thus, recruitment can be viewed as one process by which fished populations are maintained and their future status assured. The factors and processes that determine recruitment have been a source of extensive discussion and debate in fisheries biology. The debate has focused largely on two questions: (1) is the process of recruitment density-independent or density-dependent, and (2) if density-dependent, what is the nature of the relation between recruitment and stock size.

The regulations implementing the BSAI and GOA FMPs are based on the assumption that recruitment is essentially a density-independent phenomenon. That is, environmental factors (e.g., temperature, currents, primary and secondary production for developing larvae, cannibalism, predation) are assumed to be the principal determinants of the size of a recruited age class for the BSAI and GOA groundfish stocks. Thus, the size of a recruiting cohort is assumed to be independent of the size of the stock that produced it (at least when the stock size is >20% of its unfished biomass). In addition, recruitment is also assumed to be independent of time or year (i.e., recruitment does not exhibit any trends over time). Examples of such trends would include increasing or decreasing recruitment over time, increasing or decreasing variation in recruitment over time, or auto-correlation (connectivity between points in time series).

The harvest policy, under the FMP, asserts that as long as a stock is maintained at or above a minimal size (½ B_{MSY}), recruitment will be unaffected and the stock is healthy. These policies are based on a single-species approach to fisheries management designed to be precautionary. However, if recruitment is a declining function of stock size (i.e., recruitment is more likely to be small when stock size is small), or if recruitment is declining over time for other or unknown reasons, then the population may be more likely to become overfished.

When spawner-recruitment relationships are uncertain, the F_{ABC} and F_{OFL} are based on estimates of current stock status and considerations of spawning biomass per recruit. A designation of the form “$F_{X\%}$” refers to the F associated with an equilibrium level of spawning per recruit (SPR) equal to X% of the equilibrium level of spawning per recruit in the absence of any fishing. The use of SPR analyses to derive biological reference points for fisheries management has undergone broad scientific review and is used to form the basis of harvest control rules in several systems throughout the world (Clark 1991, Clark 1993, Thompson 1993). The use of $F_{35\%}$ as a proxy for F_{MSY} stems from the work of Clark (1991) who showed that a large fraction of the potential yield from a typical groundfish stock could be obtained at a rate of $F_{35\%}$ across a discrete set of plausible stock-recruitment relationships, including both Ricker and Beverton-Holt forms. Subsequent analyses showed that $F_{40\%}$ would reduce the probability of low biomass if recruitment was highly variable or auto-correlated (Clark 1993). Research continues to refine estimates of biological reference points. For example recent analyses have focused on considerations of reproductive rates at low stock sizes (Myers *et al.* 1996) and applications of Clark’s general approach to species that possess similar life history characteristics (Dorn in review).

The concern for listed species that prey on fish is that if spawning-recruitment relationships are uncertain, or if the recruitment is small when stock size is small, or if recruitment is declining over time for other or unknown reasons, then the population may be more likely to be unknowingly overfished, and prey availability reduced. However, the concepts discussed in the above paragraphs show that NMFS has adopted a long-term harvest strategy based on general principles of population growth that minimizes the risk of recruitment overfishing. The approach expressly considers the need to maintain spawning stocks above some threshold and recognizes the considerable interannual variability in recruitment resulting primarily from environmental factors. Assessment scientists consider the influence of parameter selection within their models to provide the best possible estimate of stock status. This is particularly true in the case of assessments for important Steller sea lion forage species such as walleye pollock, Pacific cod and Atka mackerel. The influences of key parameters such as natural mortality, on perceptions of stock status are analyzed within the SAFE reports, but generally in a single species context. Analyses include formally addressing uncertainty surrounding M using Bayesian meta-analysis (e.g., Thompson *et al.* 1999) or attempts to formally address time trends in natural mortality by key predators (e,g, Livingston and Methot 1998, Hollowed *et. al.* 2000). However, as is discussed in greater detail in Section 2.3.5.3 on natural mortality, the relationship between single-species overfishing thresholds and those defining ecosystem overfishing (Pikitch *et al.*, Jackson, Pew Ocean Commission 2003) is largely unknown. Ecosystem overfishing, by definition, could affect the recovery of ESA-listed species. Although, it would not control specifically for localized depletions that could lead to unsuccessful foraging.

2.3.5.3 Natural Mortality

Natural mortality (M) refers to the rate of decline of a fished stock as a consequence of natural processes. These include predation by other fishes, marine mammals, and seabirds, as well as some level of mortality due to disease, injury, starvation, etc. The relation between M and fishing mortality (F) is an important consideration in the fishery management strategy. Ironically, natural mortality is one of the most difficult parameters of a population to estimate.

Natural mortality (M) is a fixed parameter and not estimated in the pollock, Pacific cod and Atka mackerel stock assessments. For Eastern Bering Sea (EBS) pollock, the reference model assumed fixed natural mortality-at-age values of M=0.9, 0.45, and 0.3 for ages 1, 2, and 3+ respectively (Ianelli *et al.* 2005). The EBS mortality-at-age values were originally estimated in a cohort analysis by Wespestad and Terry (1984). For Gulf of Alaska (GOA) pollock the stock assessment assumed a fixed natural mortality rate of 0.3 for all ages (Dorn *et al.* 2005). The GOA value of 0.3 is based on an analysis by Hollowed and Megrey (1990) which estimated natural mortality using a variety of methods. For EBS and GOA Pacific cod, the stock assessment presented 3 models; Models 1 and 2 assumed a value of M fixed at the traditional value of 0.37 and Model 3 estimated M internally (Thompson and Dorn 2005). The 2006 Pacific cod ABC is based on Model 2 which assumed a fixed value of 0.37 for all ages. The value of 0.37 was originally estimated in the 1993 BSAI Pacific cod assessment (Thompson and Methot 1993), and all subsequent assessments of BSAI and GOA Pacific cod assessments have used this value, with one exception in the GOA. The BSAI Atka mackerel assessment assumed a fixed value of 0.3 for all ages based on the regression model of Hoenig (1983, Lowe *et al.* 2005), which is based on the longevity of the species. Lowe and Fritz (1997) explored several alternative methods to estimate natural mortality for Atka mackerel; the current assumed value of 0.3 is consistent with values derived from a variety of methods (Lowe *et al.* 2005).

In the single species stock assessments model there is no explicit accounting for other consumers. Hollowed *et al.* (2000) developed a model for GOA pollock that explicitly includes predation (e.g., consumption by arrowtooth flounder, Pacific halibut, Steller sea lions and Pacific cod). The total natural mortality (predation plus residual M) was higher than the assumed M used in the pollock assessment. The role of pollock as prey in the Gulf of Alaska ecosystem cannot be fully evaluated using a single species assessment model (Hollowed *et al.* 2000), and the current pollock assessment includes both a single species model, and an ecosystem considerations section that includes results from ecosystem models (Dorn *et al.* 2005).

Harvest policies in the North Pacific are based on fishing mortality rates that reduce the level of spawning biomass per recruit to some percentage of the unfished level ($F_{X\%}$). For most stocks, 40% of the unfished spawning biomass per recruit is used, i.e., the harvest policy is based on an $F_{40\%}$ fishing mortality rate. There is a positive and nearly linear relationship between M and $F_{40\%}$. The $F_{xx\%}$ harvest policies are designed to maintain sufficient spawning biomass to ensure recruitment to the stock. If M is higher, an average recruit would not live as long and thus it would produce less spawning biomass over its lifetime. Consequently, a higher fishing mortality rate is needed to reduce spawning biomass to 40% of the unfished level. Clark (1999) found that specifying a conservative (lower) natural mortality rate is typically more precautionary (from a single species perspective) when natural mortality rates are uncertain.

Stock assessment models are used to project these stocks based on the assumption of constant natural mortality rates. TACs are set each year at values consistent with the harvest control rules and other provisions of the FMPs (e.g., the OY caps). For some stocks in some years, this amounts to fishing at the maximum permissible ABC. In such instances, the recommended fishing mortality rate typically varies directly with M. For example, if the intent is to fish at a rate of $F_{40\%}$ and M happens to be over-estimated while all other parameters are estimated without error, the recommended fishing mortality rate will exceed the true value of $F_{40\%}$.. However, over-estimation of M leads not only to errors in the estimate of $F_{40\%}$ but to errors in the estimate of stock size as well. Errors in estimated stock size resulting from over-estimation of M can be either positive or negative (Thompson 1994). The combined effects of these two errors can result in a recommended short-term catch that is either higher or lower (Thompson 1994) than the short-term catch corresponding to the intended harvest strategy. In the long term, however, catch tends not to be sensitive to error in M except when gross under-estimates occur, in which case catches tend to be lower than those corresponding to the intended harvest strategy. Because the relationship between the estimate of M and the recommended catch is complicated, trends and variance in this parameter are evaluated and the resulting uncertainty incorporated into the TAC setting process. Toward this end, SAFE reports are required to address alternative estimates of M and its effects on model outputs.

The effect of reductions in prey biomass on other consumers in the environment has received little treatment in traditional fisheries management. Sea lions, or other ecosystem consumers, do not have the technological advantages of fishing fleets or the ability to change strategies, and have limited physiological reserves to cope with declining availability. Adding fishing mortality to natural mortality reduces the availability of prey to other consumers. When biomass reaches a threshold, predators are no longer able to successfully forage for that prey, even if considerable biomass remains in the system. This explains the fact that carrying capacity for these consumers will go to zero before prey biomass in the system goes to zero. Thus, natural mortality of target/prey stocks can not be partitioned as simply as the allocation portrayed in Figure 2.4 without consequences for the other consumers in the ecosystem. As far as effects on protected species, overall biomass goals alone may not be as adequate for other consumers as it is for fishermen. Availability implies things like spatial and temporal distribution in relation to the predator, this would be important as well. Goodman *et al.* (2002) describe the following:

> The conventional assessment world view does recognize that there is a natural mortality rate, M, operating on the target stock, and this natural mortality is assumed largely to be the result of consumption in the food web. Generally M is assumed to be constant in the conventional assessment models, but it must be understood that this does not assume (or assign) a constant total consumption by higher trophic levels. The constant natural mortality rate, M, is in units per capita of the target stock. Thus the total consumption by higher trophic levels, when M is assumed to be constant, will vary in proportion to the target stock size (or biomass). A harvest management strategy, such as $F_{40\%}$, that by design reduces the biomass of the target stock biomass by a large fraction, will, all other things being equal, reduce the total consumption by higher trophic levels by a similar large fraction, and we would expect the predator populations to be reduced accordingly. This may or may not be deemed a desirable, or acceptable, outcome from the standpoint of policy. And, in fact, all other things often are not equal, especially in ecosystems, and there are a variety of mechanisms whereby the reduction in target stock biomass by a harvest strategy such as $F_{40\%}$ could cause a more than proportional reduction in the populations of predators dependent on those same stocks for prey, as is recognized in the ecosystem-effects world view.

2.3.6 Ecosystem Considerations

The MSA and resulting regulations require that relevant social, economic, and ecological factors be considered in the setting of optimum yield for a fishery. The regulations (50 CFR § 600.310 (f)(3)(iii)) provide the following examples of ecological factors:

> "stock size and age composition, the vulnerability of incidental or unregulated stocks in a mixed-stock fishery, predator-prey or competitive interactions, and dependence of marine mammals and birds or endangered species on a stock of fish. Also important are ecological or environmental conditions that stress marine organisms such as natural or manmade changes in wetlands or nursery grounds, and effects of pollutants on habitat and stocks."

The FMP process considers the species managed under it as parts of functioning ecosystems. However, ecosystem management is extremely complex. In setting the harvest rate, managers also attempt to be sufficiently protective of the larger ecosystem in which the harvesting occurs. An Ecosystem Considerations chapter has been added to the SAFE documents since 1995 and is evolving to be more operational, and other multi-species studies have been undertaken. Ecosystem indicators are being evaluated, and multi-species models have been constructed. The multi-species models have allowed consideration of ecosystem impacts in a way that single-species models cannot address. They are not viewed as a replacement of the single-species approach, which remains the determinant of catch control, but rather they add insight into potential ecosystem effects. To date, the multi-species modeling studies reported in the SAFE and SEIS documents have suggested that fishery impacts on fish species in the BSAI and GOA systems seem to be about the same order of magnitude as what is shown in single-species models. Nevertheless, it is known from theoretical models of harvest dynamics in a predator-prey competition system that harvesting at single-species MSY levels will not achieve MSY for the aggregate because of species interactions. This knowledge is one of the reasons that the BSAI OY cap was set at 85% of the single-species MSYs.

2.4 Annual Fisheries Assessment

The annual fisheries management cycle consists of activities that can be grouped into three main functions: (1) resource assessment, (2) stock assessment (ABC), and (3) setting the total allowable catch (TAC) levels. The activities that comprise these three steps are illustrated in Figure 2.1. Target species were discussed in Section 2.2.2 and are provided in Table 2.2.

The purpose of stock assessment is to describe those stocks that are targeted by the fisheries and the nature and magnitude of fishery effects on those stocks (i.e., the stocks' tolerance for fishing). Consistent with the fundamental approach to fishery management, the primary objective of stock assessments is to estimate biomass and the size-age structure of target stocks. The following sections provide the basic description of the stock assessment process.

2.4.1 Resource Surveys and Biomass Assessment

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

2.4.1.1 Groundfish Surveys

The purpose of the groundfish surveys is to estimate the distribution and abundance and age structure of groundfish species. This information is essential to the annual assessment of stock conditions used in the determination of the annual ABC's and TACs. Current surveys are designed to provide information to manage groundfish harvests on a single species basis. Management of groundfish harvests on a multi-species level requires additional information and understanding that are not currently available.

Three types of surveys are currently conducted, including bottom trawl for shellfish and bottom fishes, hydroacoustic or echo integration-trawl (EIT) for pollock , and longline for bottom fishes (e.g., sablefish) of the deeper waters of the continental shelf and slope. Summer bottom trawl surveys of the eastern Bering Sea shelf have been conducted annually since 1972, with the current standardized time series beginning in 1979. These surveys follow a systematic grid of sampling stations. A triennial bottom trawl survey of the Bering Sea continental slope was conducted triennially from 1979 to 1991 and then resumed on a biennial schedule in 2000-2004 (the planned 2006 survey was canceled due to lack of funding). Triennial summer bottom trawl surveys for the Aleutian Islands and the Gulf of Alaska shelf and upper continental slope began in 1980 and 1984, respectively. In 1999 the GOA was changed from a triennial to a biennial bottom trawl survey and extended to cover the continental slope out to 1,000 m depth. The Aleutian Islands survey moved to a biennial schedule in 2000. The Gulf of Alaska, Aleutian Islands, and eastern Bering Sea continental slope surveys are based on area and depth-stratified random sampling among a set of predetermined stations.

EIT surveys in the Bering Sea and Gulf of Alaska have been conducted on a series of winter and summer annual and biennial surveys. Annual winter EIT surveys were initiated in 1981 to study abundance of spawning pollock in Shelikof Strait (except in 1982 and 1999), and in 1988 to study pollock abundance in the vicinity of Bogoslof Island (except in 1990 and 2004). Winter surveys have also been conducted in the Gulf of Alaska in the Shumagin Islands/Sanak Trough area in 1994-96 and 2001-2006 and on the shelf break east of Kodiak Island in 2002-2006. Summer EIT surveys of pollock on the Bering Sea shelf were surveyed triennially from 1979 to 1994 and in 1996, 1997, and 1999 and then changed to a biennial schedule in 2000. Limited summer EIT surveys of Gulf of Alaska pollock were conducted in 2003 and 2005 and are expected to be continued on a biennial basis.

Summer longline surveys were initiated by Japanese scientists in 1979 to assess sablefish abundance over the upper continental slope in the Gulf of Alaska. These surveys are now conducted by U.S. scientists, and have been extended to the Aleutian Islands and the eastern Bering Sea slope, where they are conducted in alternate years. Current surveys are as follows:

1. Annual summer bottom trawl surveys of the eastern Bering Sea shelf,
2. Biennial summer bottom trawl surveys in the Aleutian Islands and GOA (shelf and continental slope),
3. Annual summer longline surveys for estimation of sablefish abundance,
4. Annual winter EIT surveys in the Bogoslof, Shelikof, Shumagin Islands/Sanak Trough, and shelf break east of Kodiak areas,
5. Biennial summer EIT survey of eastern Bering Sea shelf pollock, and
6. Biennial summer EIT survey of Gulf of Alaska pollock.

As noted above, surveys are conducted to assess the distribution, abundance or stock biomass of groundfish stocks. In addition, they also provide important information on age and sex composition, recruitment of young fish to the fished stock, length and weight at age, reproductive status or condition, food habits, and other pertinent biological characteristics. Assessment of each of these parameters may be affected by sampling variability, measurement error, or systematic bias. Considerable effort is directed at minimizing measurement error and bias, but sampling variability may still occur and evaluated and reported to provide an indication of the confidence with which final parameter estimates may be used. Table 2.3 provides an indication of the sampling variability observed for each assessed stock. The error is expressed as the coefficient of variation (CV) which is equal to ((standard error/estimate)*100). For example, the CV for pollock in the eastern Bering Sea is 20%. This CV indicates that if the surveys were conducted repeatedly under the same conditions, 68% of the time (i.e., ± 1 standard error is defined as 68%) the new survey biomass estimates would fall within the interval from the current biomass estimate minus 20% to the current estimate plus 20%. If this estimation procedure is unbiased, then 68% of the time this interval also would be expected to enclose the true value for pollock in the area assessed. To use a specific example, if the pollock biomass estimate above was 100,000 mt, then 68% of the time the true value would occur between 80,000 and 120,000 mt.

A principal concern of the survey design with respect to listed species is whether the timing and frequency of the surveys, and the scale of the surveys, allow for biomass estimates that can be used to assess potential competition at scales relevant to foraging listed species, especially Steller sea lions. Survey information is also used to spatially allocate TACs to management areas. Surveys in the GOA and AI are used to allocate TACs in proportion to biomass. However, more frequent surveys would be necessary in order to confidently allocate TACs in proportion to biomass in areas smaller than entire regions (e.g. in areas smaller than GOA). For the AI in particular, surveys conducted just prior to the beginning of the fishery could be an effective tool in ensuring that local harvest rates are approximately equal to the stock-wide target harvest rate.

2.4.1.2 Stock Structure

Research on stock structure for groundfish species is continuing (e.g., Bailey *et al.* 1999). Currently, the best available information is based on limited tagging data for sablefish and Pacific cod, morphometrics or genetic studies for pollock, Pacific ocean perch, Atka mackerel, and a few other rockfish.

Pollock will be used in this section as an example to describe some of the patterns in stock structure that have been observed in the past. Pollock in the BSAI are managed as three units: eastern Bering Sea, Aleutian Islands, and the Aleutian Basin/Bogoslof Island (Basin). Recruitment to the Basin stock is thought to occur primarily as density-dependent migration of pollock from the eastern Bering sea shelf stock. Large cohorts of shelf pollock appear to be the source of most of the pollock in the Basin, which suggests that the Basin stock itself is not self-sustaining. Fishing on the Basin stock was terminated in 1992 by international agreement, but it has since failed to recover. Given the reduced recruitment in the 1990s compared to the large year classes in the late 1970s and 1980s, the Basin stock would have been expected to decline in size even in the absence of fishing. The extent to which spawning in the Bogoslof region contributes to recruitment of the shelf stock is unknown. For example, overfishing in the Basin may have exacerbated the decline of the Basin stock, and it may have adversely affected recruitment in the shelf stock.

Pollock stocks in the Aleutian Islands region have also declined since the mid-1980s, from a high of 496,000 mt in 1983 to 105,000 mt in 1997 and 130,000 mt in 2004 (Barbeaux *et al.* 2005). Since the decline of pollock in the Aleutian Islands parallels that of the Basin, the two stocks may be closely related. Several explanations for the lack of population recovery in the Aleutians might be explained primarily as a series of years with poor recruitment. Barbeaux *et al.* (2005) describe the pattern of pollock fishing in the Aleutians in the 1990s, where the fishery moved increasingly westward apparently because spawning aggregations in the eastern portion had disappeared (i.e. around Kanaga Island and in Amukta Pass). It is not known whether spawning from these basin aggregations contributed to the Aleutian stock. The degree to which Aleutian Islands pollock abundance depends on movement from the EBS is also unknown. It is possible that the EBS fishery causes some interception of potential Aleutian Islands recruitment.

2.4.1.3 Stock Complexes

Under the FMPs, many stocks have been placed in complexes (e.g., groupings). Uncertainty is an even greater concern for species managed in complexes because they often are placed into complexes if the available information is insufficient to manage a species as a single target stock. The risk of fishery effects on a single species may be greater when the species is fished as part of a complex. Fishing mortality rates for complexes may be tolerable for more common or prolific species, but may not be tolerable for the more rare, slow-growing, long-lived species with relatively limited capacity for reproduction, recruitment, or recovery. For example, if a complex consists of three species, one with natural mortality (M) = 0.10, the second with M = 0.15, and the third with M = 0.20, and Fishing Mortality (F) is set for the whole complex based on either M = 0.15 or 0.20, then overfishing is likely for the species with M = 0.10. The only way to ensure that none of the species in the complex are subject to overfishing would be to set F on the basis of the lowest M. But M is unknown for many of the species in these complexes.

More than 144 stocks are incorporated into management complexes: GOA deepwater flatfish (3 spp.), GOA shallow-water flatfish (8+ species), GOA other slope rockfish (12+ spp.), GOA shortraker/rougheye rockfish, GOA pelagic shelf rockfish (4+ spp.), GOA demersal shelf rockfish (7 spp.), AI northern / sharpschin rockfish (2 spp), BSAI other flatfish (16 spp.), other rockfish (33+spp.), other slope rockfish (17 spp.), BSAI squid (multiple species), and AI shortraker /rougheye rockfish (2 spp.)(Table 2.2).

Some of the large complexes listed above (e.g., BSAI and GOA other species) are composed of a very diverse assemblage of species, some of which are prey for listed species (e.g., squid, octopus, and sculpins). While the magnitude of fishing effects on any single species in the other species assemblage is not thought to be large given the group catch amounts, the limited or non-existent information on the status or catch of any single species makes this determination uncertain. One example of precautionary management that addresses this is the establishment of retention thresholds for forage fish (e.g., osmerids and myctophids) to prohibit the establishment of new commercial fisheries. In general, the ecological consequences of fishing on groundfish complexes can not be evaluated due to the lack of data on the stock structure of individual species.

2.4.1.4 Stock Distribution

As noted in the above description of stock surveys, information on the distribution of affected (fished and unfished) stocks is vital to assessment of fishery effects. The distribution of a species is an important determinant of the ecological role it plays in local marine communities, including availability to predators. This information is required to assess fishery effects on prey availability in Steller sea lion critical habitat. Better information on the spatial and temporal distribution of prey are needed to improve the assessment of whether the prey base under the current fishing regime is optimal in promoting the recovery of Steller sea lions.

2.4.1.5 Stock Biomass

Biomass is used to describe or estimate stock status and trend, tolerance for fishing, and reproductive capacity. Under the current harvest guidelines, a fishing mortality rate for a species is set on the basis of its effect on target stock biomass and its reproductive capacity. That is, the fishing mortality rate is intended to maintain the species at B_{MSY} or a proxy for it ($B_{40\%}$). Further, the stock-recruitment relation fundamental to the MSY concept is based on recruitment as a function of spawning biomass. Thus, stock biomass is clearly an important measure of the stock and a basis for evaluating potential fishery yields. Female spawning biomass from 1980 to 2005 is provided for pollock, Pacific cod, and Atka mackerel in Table 2.4; also shown is the current $B_{100\%}$ level, and the relationship to that benchmark in each year.

Accurate estimates of stock biomass depend both on information from surveys and from the fishery (total removals and catch age composition). Biomass estimates for the early years of the pollock fishery are uncertain. Estimates of stock biomass for the early years of the pollock fishery are uncertain because of limited and potentially biased information from both sources. In the Bering Sea, the trawl survey began in the late 1960s, but the survey was initially designed to survey crab populations and did not encompass the range of the pollock stock (Bakkala *et al.* 1985, Megrey and Wespestad 1990). In 1975, the survey was expanded to cover most of the eastern Bering Sea shelf, and has been conducted annually since 1979. Catch information from the foreign fishery during the 1970s was submitted by the fishing nations at bilateral meetings or under provisions of the International North Pacific Fisheries Commission. Since this was prior to the development of fisheries observer programs, there was no way to verify the accuracy of the catch information, and there were often questions about the credibility of some the reported fisheries data (Megrey and Wespestad 1990).

Based on a 1999 pollock assessment (Ianelli *et al.* 1999), pollock age 3+ biomass in the 1970s ranged from 5.2 mmt (million metric tons) in 1971 to 2.0 mmt in 1974 (Figure 2.5). By contrast, Megrey and Wespestad (1990) reported that pollock in the EBS ranged from about 8 mmt (million metric tons) to 12 mmt for the same time period. The precision of the Ianelli *et al.* (1999) estimates is depicted by the 95% confidence intervals in Figure 2.5, which suggest that biomass in 1970s may have been as high 7.1 mmt (in 1971) or as low as 1.1 mmt (in 1974). These estimates of uncertainty are only approximate and also rely on assumptions of known natural mortality, relatively precise and unbiased total catch estimates and correct model specification. Therefore, the actual variance is likely to be larger than that indicated in Figure 2.5 (NRC 1996). Furthermore, fishery selectivity estimates from Ianelli *et al.* (1999) were allowed to vary over time to reflect the fact that the fleet composition has changed over time from foreign vessels to joint venture operations to the current domestic fleet. This increases the overall variance of the model. Another effect of time-varying fishery selectivity can change the interpretation of “available” biomass and simple exploitation rates comparing total catch compared to age 3+ biomass. For example, in 1974 about 23% of the “available” biomass was aged 1 and 2. This was quite high and compares to an average of 3% for the entire period 1964-1999. This is due to the fact that the 1972 year class was quite strong and that the gear selectivity at that time was more concentrated on young pollock. Harvest rates during the mid-1970’s is depicted by Ianelli *et al.* (2005) to be about 40% with the 95% confidence interval near 50% (Figure 2.5).

At present, biomass estimates or indices are available for 3 of the 43 species or species groups listed in Table 2.3. For approximately 17 out of 43 of these stocks, biomass by age is not available. However, no groundfish stock in the BSAI or GOA is currently being subjected to overfishing (a fishing mortality rate higher than the maximum allowable rate) and regardless of the level of information on each species, given an absence of a history of overfishing, it is unlikely that any stock would be in an overfished condition defined using the single species criteria (biomass has fallen so low that a special rebuilding plan is needed). Again, to address the question of whether harvests based on imperfect biomass information for groundfish stocks affects listed species (for example biomass estimates are not available for 3 of the 43 species in Table 2.3), it is important to go back to the ecosystem concept and relate it back to foraging behavior of the listed species. The stocks for which the least information is available are the most lightly fished and least abundant species. Therefore, the present inability to determine the status of certain stocks may have little potential to affect listed species.

2.4.2 Stock Assessment

Each year, scientists from NMFS and ADF&G collect data, and compile and update databases on catch, age and size composition, and survey biomass. Stock assessment scientists from these agencies analyze the data and calculate estimates of key population parameters. In most cases, contemporary stock assessment models are constructed to integrate the scientific information, except when information is not sufficient for model construction. The techniques of stock assessment are summarized in the texts by Hilborn and Walters (1992), Quinn and Deriso (1999), and Haddon (2001). An overview of issues related to stock assessment points out the difficulties and challenges (NRC 1998). The processes of stock assessment and harvest strategy development are interrelated. Stock assessment parameters are used in development of the harvest strategy, and the current biomass-based harvest strategy utilizes the most recent biomass estimates in determining ABC, OFL, TAC, and whether overfishing is occurring. Nevertheless, the goal of harvest strategy development is to provide a stable, quantitative set of control rules for operating the fisheries, and the goal of stock assessment is to use the best available scientific information to determine the status of the population in reference to the quantities that are inputs to the rules.

2.4.2.1 Modeling

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

Models can take a large variety of forms, but in essence they all serve the same purpose–they allow thoughts, theories, and data (observations of the world) to be organized and simplified such that complicated issues can be cut through and clear logic applied. Theoretical models may be used to follow through to logical conclusions. Statistical models may be used to “fit” data and estimate parameter values (fixed numbers) to be used elsewhere. Simulation models may be used to combine theory, knowledge and data to consider what might be and to ask “what if?” questions. Models as used in ecology and fisheries are often highly complex, using state-of-the-art mathematics, statistics and computing approaches, but they always represent major simplifications of real systems.

In a deterministic model all processes are treated as completely predictable in principle. Therefore, if all parameters are known and fixed, a deterministic model run repeatedly from the same starting point will repeatedly result in the same sequence of outputs. In fact, this is only partially true–some deterministic models can behave chaotically (apparently randomly within bounds) for certain parameter inputs and can actually be used as “random number” generators. In a stochastic model, there is random variability in some of the parameters or processes. Running a stochastic model many times will, therefore, result in different outcomes. Stochastic models are in principle closer to reality, but only if the variability can be properly incorporated; this is very difficult and makes stochastic models difficult to set up and apply. A stochastic model may be fitted to data from the history of a population, but it will not predict a unique future for that population.

Stock assessment models used in fisheries are standard tools of fisheries science. Single species stock assessment models are used to consider the data collected from fisheries or research on fish stocks. Those data contain information on how fish age, grow and mature, how fish die and how fisheries select fish of different sizes or ages. The data, though, are never perfect and there are always many things that assessment scientists have to make assumptions about, often based on experience elsewhere. What the assessment models do, given data, assumptions and prior knowledge, is allow inferences to be made about the past and present state of stocks. This allows scientists to advise managers as to the status of stocks: whether or not stocks have been, or are currently, overfished, and whether or not overfishing is taking place. In addition to assessment models to determine stock status, it is common also to forecast the future state of stocks under different catch levels or rates. Forecasting involves updating the estimated current status using assumptions or models to determine how many new fish (recruits) there will be in the future.

Assessment models and forecasts may be deterministic or stochastic and they take many different forms. Production models represent the state of a stock by a single variable (stock biomass) and estimate production (yield, or catch) from its relationship with biomass. Age (or size) structured models represent the state of a stock by the number of fish in each age (or size) class. They differ from production models in that whilst a stock may have had the same biomass at different points in history, the yields produced would have been different because the stock would have been made up of differently aged (or sized) fish.

A deterministic model is in equilibrium when all of the variables stay the same from year to year. This kind of constancy doesn’t occur in the real world; it is an attribute of a model. Although equilibrium results are hypothetical, they are nevertheless widely used to obtain reference points for fishery management. A production model would be in equilibrium once the catch equals the yield, because this will maintain the biomass at a constant value. An age (or size) structured model, however, would only be in equilibrium when the numbers of fish in each age (or size) group in both the stock and the catch is the same each year. The equivalent to equilibrium for a stochastic model is a stationary distribution, where the relevant variables exhibit a kind of consistent range of variation over time, though they are not constant. Analysis of stochastic models is more involved than analysis of deterministic models, and even the definition of appropriate indicators of good performance requires much more thought with stochastic models. Nevertheless, variability is a feature of the world, so there is merit to examining reference points from the perspective of stochastic models.

Three types of models or modeling approaches are used for the stocks fished under the BSAI and GOA FMPs (Table 2.3): stock synthesis 2, AD model builder, and survey index. In general, these models include a range of elements from simple numerical or accounting procedures to complex mathematical functions. The nature and blend of these elements depends, in part, on the information that is available and the preferences of the scientist(s) modeling the stock. Nonetheless, all have the same general purpose of describing the wild stock and evaluating its tolerance to fishing.

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

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

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

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

Growth

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

Maturation

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

Maturation of all individuals in a cohort may occur over a single year or over a period of several years.

Reproduction

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

Natural mortality

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

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

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

Fishing mortality

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

Recruitment

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

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

Recruitment can be incorporated into fisheries models in a variety of ways, two of which will be described here. First, recruitment can be modeled as a function of the reproductive stock (based on either numbers or biomass) (Fig. 2.3). The shape of an assumed or demonstrated stock-recruitment function is a crucial consideration in modeling recruitment. Importantly, among all the stocks fished under the BSAI and GOA FMPs, a stock-recruitment function has been characterized only for the pollock stock of the eastern Bering Sea.

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

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

2.4.2.2 Target Harvest Rates

The TAC-setting framework establishes $B_{40\%}$ as a reference point in defining the maximum permissible value of ABC. Stocks above that level may be reduced through harvesting. Stocks below that level may still be harvested, but at reduced rates to allow the stock to recover over time to a level considered safe. Regulations currently allow for most stocks to be harvested until they reach 2% of their unfished level. On the surface, this approach would appear to not be sufficiently precautionary to assure that fish stocks are adequately protected from overfishing. This could unknowingly result in a reduced prey availability to other predators including listed species. However, the overall management approach does include checks to reduce the probability that a stock will reach such a low level. Particularly, catch would fall almost quadratically with spawning biomass, meaning that catch would be constrained to a very small level long before a stock fell to 2% of its estimated unfished level. For Steller sea lions, a modified control rule was implemented in 2001 which halts all fishing for pollock, Pacific cod, and Atka mackerel when spawning biomass reaches 20% of pristine levels (NMFS 2000). Figure 2.6 provides an example for GOA pollock which further includes additional conservation measures implemented by the assessment author (Barbeaux *et al.* 2005).

At present, no stocks in tiers 1 to 3 have come anywhere close to the 2% level in the history of the FMPs. However it is possible to reach that level for some species. For pollock, Pacific cod, and Atka mackerel fishing under the modified control rule (Figure 2.6) ceases when biomass reaches $B_{20\%}$. This ensures that as biomass decreases to relatively low levels that there will no longer be any fishing effect on these important prey species for Steller sea lions (NMFS 2000). This does not ensure that biomass will not drop further below $B_{20\%}$; poor recruitment or increased natural mortality could drive the stock even lower, but the modified control rule does remove the fishing related effect. In 2003, GOA pollock biomass reached a low of 26% of theoretical pristine levels (Dorn *et al.* 2005).

Stocks in tiers 1 to 3 can be evaluated with respect to the reference points in Figure 2.7 (B_{MSY}, or the proxy $B_{40\%}$, ½ B_{MSY}, and $0.05B_{MSY}$). None of these values can be estimated for stocks in tier 4. Thus, the status of stocks in tier four can not be determined relative to an unfished level, nor can they be determined relative to their MSST.

Stocks in tier 5 can not be assessed with respect to their unfished level or their MSST. These stocks can be harvested at an F_{ABC} of 0.75*M. To evaluate the potential effect of this strategy on a tier 5 stock, an example was developed using an M value of 0.3, age of recruitment of three, and a growth schedule consistent with pollock (Ianelli *et al.* 1999). Harvesting at F = M * 0.75 would reduce the spawning stock biomass to about 50% of its unfished level under this scenario. The intent of the guidelines for tier 5 was to approximate the $B_{40\%}$ strategy, based on the idea that harvesting at F=M would produce $F_{30\%}$. On that basis, the guidelines for tier 5 also do not appear to be precautionary as they aim at the same harvest level on the basis of less information.

Stocks in tier 6 also can not be assessed with respect to their unfished level or their MSST. Only one stock, squid, falls into tier 6. The tier 6 guidelines suggest that the OFL should be set at the mean catch from 1978 to 1995, unless an alternative (unspecified) level is set by the Council's SSC. The ABC level is then set at 0.75*OFL. While these guidelines would not necessarily insure the protection of a stock in tier 6, catches of squid in the BSAI and GOA (less than 2,000 mt in 2005) are relatively low compared to squid biomass estimates based on predation models in the eastern Bering Sea (Sobelevsky 1996). The guidelines are based on the assumption that a stock that has tolerated a certain mean level of catch can continue to tolerate that level (or that level times 0.75) indefinitely. While in general, these harvest guidelines may not be sufficiently precautionary to assure that stocks in tier 6 are adequately protected, the only stock currently in tier 6, squid, does not appear to be overfished.

2.4.2.3 Uncertainty

That we live in an uncertain world is well enough known, and uncertainty is inherent throughout the process by which TACs are set. How can fishery management deal with the large uncertainty and the resulting lack of predictability? One view is that uncertainty should result in conservative management decisions that attempt to implement "margins of safety" in the direction of reducing somewhat the amount of exploitation, especially when biological elements and systems are involved. A refinement of this view is that decisions need to be made in full recognition of risks (that is, the probability of something bad happening), but be well supported by careful analyses of the risks involved. This latter approach has been adopted, to some extent, by the majority of fishery management agencies where professional fishery managers attempt to take actions that are intended to control risks to an acceptable level (risk management), and where the estimates of the amount of risk involved are clarified (risk assessment) for them by scientists and others.

Fisheries systems are complex and the relationships between their various elements are not simple; this would make fisheries systems hard or impossible to predict even if we had complete understanding of them. Uncertainty prevents predictability on at least three counts: structure of systems, the way structures are modeled, and extrapolation. The structures of the complex fisheries systems to be managed are poorly understood. The way to model structures can only be achieved through careful analyses of data collected at appropriate scales. Historically it has been very difficult to obtain quantities of oceanographic and population data at the right scales for purposes of fisheries (or marine mammal) modeling. For the groundfish fisheries, the primary means by which fishery assessment uncertainty is conveyed is through the annual SAFE report

There are four main sources of uncertainty in mathematical models of biological and other systems:

- Process error is a consequence of the effects of underlying demographic (population) and environmental stochastic (random) variability on the dynamics of the system,
- Observation (measurement) error is a consequence of the way in which observations are made of the system. This may be due to the chosen sampling strategy, or errors in data collection,
- Estimation error is the inaccuracy and imprecision in the estimates of system parameters, which can result from all other sources of uncertainty and the statistical methods used to make inferences, and
- Model error all models are caricatures of reality, and thus fail to represent the system dynamics in full. This has two consequences. First, model mis-specification will contribute to estimation error when making inferences. Second, model misspecification will cause systematic errors in forecasting (sometimes referred to as forecast error).

Biomass and projected yield estimates are uncertain. For EBS pollock, the model specified for providing these estimates has been extensively evaluated for sensitivity to assumptions and was selected to reflect uncertainties due to alternative models (Ianelli *et al.* 2005). Other sources of uncertainty from this model include observation errors associated with survey and fishery data, and the synthesis of a wide variety of information.

Uncertainty in current and future biomass can be expressed as a cumulative probability plot (Figure 2.8). This figure shows that the 2005 level has about 7% probability of being below (the uncertain) $B_{40\%}$ level. The level of uncertainty increases into the future (under alternative constant-catch scenarios listed as an example) due to the impact of variable and uncertain future recruitment. In practice, these uncertainties decrease as information on the recruitment strengths is obtained.

Uncertainty in projected yield specifications is due to a number of sources. These include uncertainty in biomass (above), uncertainty in future selectivity-at-age patterns, and uncertainty in natural mortality estimates (if specified). Based on estimates of uncertainty from the EBS pollock assessment (Ianelli *et al.* 2005) the marginal distribution of the joint Bayesian posterior distribution of projected 2006 MSY yield shows a high level of uncertainty (Figure 2.9). This figure indicates that the median yield is about 2.9 million tons but that there is about 25% probability that the “true” 2006 MSY level is less than 1.5 million mt. Since the Council’s SSC has considered this stock to be managed under Tier 1 of Amendment 56, the uncertainty in this calculation is adjusted to be formally risk-averse and the harmonic mean yield (which is smaller as uncertainty increases) results in an ABC value of 1.87 million mt.

2.4.2.4 Draft Stock Assessment and Fishery Evaluation Report (SAFE)

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

(1) Information on which to base harvest specifications,

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

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

The BSAI and GOA FMPs require the following minimum contents of the SAFE reports:

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

(2) Estimates of MSY and ABC.

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

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

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

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

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

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

2.4.3 Setting the Catch Specifications

Descriptions of procedures for setting harvest quotas are provided in the GOA and BSAI FMPs and are incorporated herein by reference (NPFMC 2005a and 2005b). This includes a description of MSY and OY as they pertain to conservation of target stock biomass and sustainability of the groundfish complex in the BSAI and GOA. The FMPs also include a definition of Overfishing Level (OFL) which is the maximum allowable rate of fishing that is prescribed through a set of six tiers which are assigned to target species fisheries in order of information availability with which annual stock assessments are made.

The Council has developed a procedure to set annual harvest levels by specifying a total allowable catch for each groundfish fishery on an annual basis. The procedure is used to determine TACs for every groundfish species and species group managed by the FMP.

Scientists from the AFSC, ADF&G, and other agencies and universities prepare SAFE documents annually (see above). These documents are first reviewed by the Groundfish Plan Team, and then by the

Council's SSC and AP, and the Council. Reference point recommendations are made at each level of assessment. Usually, scientists recommend values for ABC and OFL, and the AP recommends values for TAC. The Council has final authority to approve all reference points, but focuses on setting TACs so that OY is achieved and OFLs are not exceeded.

The procedure for setting TAC consists of the following steps:

1. Determine the ABC for each managed species or species group. ABCs are recommended by the Council's SSC based on information presented by the Plan Team.
2. Determine a TAC based on biological and socioeconomic information. The TAC must be lower than or equal to the ABC. The TAC may be lower if bycatch considerations or socioeconomic considerations cause the Council to establish a lower harvest.
3. Sum TACs for "target species" and "other species" to assure that the sum is within the optimum yield range specified for the groundfish complex in the FMP. If the sum falls outside this range the TACs must be adjusted or the FMP amended.

2.4.3.1 Plan Team Review of Stock Assessments

In Section 2.3 we discussed the development of the draft SAFE report by the stock assessment author. After the draft SAFE has been prepared, the stock assessments and recommendations are then reviewed by the BSAI and GOA groundfish plan teams, which consist of members from the AFSC, ADF&G, the Washington Department of Fisheries, the U.S. Fish and Wildlife Service, the International Pacific Halibut Commission, and the University of Alaska at Fairbanks. The plan teams then prepare their recommendations to the Council's Advisory Panel and SSC, and the main body of the Council. The Council's SSC has final authority for determining whether a given item of information is "reliable" for the purpose of determining ABCs and OFLs, and may use either objective or subjective criteria in making such determinations.

2.4.3.2 Council Process and the Development of Multi-Year TACs

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

The TAC for a specific stock or stock complex may be sub-divided for biological and socio-economic reasons according to percentage formulas established in FMP amendments. For particular target fisheries, TAC specifications are further allocated within management areas (eastern, central, western Aleutian Islands; Bering Sea; eastern, central, western GOA; Figure 2.2), among management programs (open access or community development quota program), processing components (inshore or offshore), specific gear types (trawl, hook-and-line, pot, jig), and seasons according to regulations.

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

At its December meeting, the Council will review the final SAFE reports, recommendations from the Groundfish Plan Teams, SSC, AP, and comments received. The Council will then make final harvest specifications recommendations to the Secretary for review, approval, and publication. New final annual specifications will supersede current annual specifications on the effective date of the new annual specifications.

The Secretary, after receiving recommendations from the Council, will determine up to 2 years of TACs and apportionments thereof, and reserves for each stock or stock complex in the "target species" and "other species" categories, by January 1 of the new fishing year, or as soon as practicable thereafter, by means of regulations implementing the FMPs. Notwithstanding designated stocks or stock complexes listed by category, the Council may recommend splitting or combining stocks or stock complexes in the "target species" category for purposes of establishing a new TAC if such action is desirable based on commercial importance of a stock or stock complex and whether sufficient biological information is available to manage a stock or stock complex on its own merits.

2.4.3.3 Harvest Specifications

The amount of harvest during a year for each groundfish species is controlled by the harvest specifications. For 2006 and 2007, the Council made recommendations for TAC for the Alaska groundfish fisheries. These are shown in Tables 2.5 (GOA) and 2.6 (BSAI) and 2.7 (combined areas for pollock, Pacific cod, and Atka mackerel through 2008). Incidental harvest of groundfish species also is limited by the maximum retainable amounts (MRAs) specified in the regulations. These MRAs are in Tables 10 and 11 to 50 CFR part 679 and are included in the BA as Tables 2.6.6.3 (GOA) and 2.6.6.4 (BSAI). Note that for Table 2.6.6.3, the other species MRA for the arrowtooth flounder fishery was changed by Amendment 69 to 20 percent, effective April 12, 2006 (71 FR 12626, March 13, 2006).

2.5 Commercial Fisheries Prosecution

The prosecution of the fisheries can be grouped into two main functions: (1) implementation of the fisheries, and (2) monitoring the catch and fisheries effects. The activities that comprise these two steps are illustrated in Figure 2.1.

2.5.1 Implementation of the Fisheries

2.5.1.1 Fishery Status

The fishery for a target species may be categorized as open to directed fishing, closed to directed fishing, or prohibited. When a species fishery is open to directed fishing, vessels are allowed to target and retain it with no restrictions on the amount harvested. If the catch is expected to reach the TAC and some amount of TAC must be held in reserve for incidental catch in other fisheries, then a portion of the TAC may be established as a "directed fishing allowance," meaning that directed fishing is allowed only on that portion of the TAC. For example, for the BSAI pollock fishery, 3.35% of the TAC is established as an "incidental catch allowance" and the directed fishery is based on the remaining 95% of the TAC. For fisheries other than BSAI pollock and fixed gear Pacific cod, the amount for a "directed fishing allowance" is determined by NMFS as the season progresses, and is established by an in-season regulatory action. Once the directed fishing allowance for a species is taken, the fishery is closed to directed fishing. When a species is closed to directed fishing, vessels are allowed to retain up to the maximum retainable amounts at any time during the fishing trip (Tables 10 and 11 to 50 CFR part 679).

This provision does allow targeting for the species on a haul-by-haul basis, as long as the maximum retainable amount for the trip is not exceeded. If the catch reaches the TAC, then the status changes to "prohibited retention" and retention is prohibited for the rest of the year. If NMFS determines that harvest of a species will reach the OFL, then the Regional Administrator has the authority to close the fisheries in which the species is taken to prevent overfishing.

2.5.1.2 Access and Permits

Both the GOA and BSAI FMPs prescribe requirements that restrict the participation of individuals and vessels in the groundfish fisheries. These programs include requirements for Federal groundfish fishing licenses, species and/or gear endorsements requirements for these licenses, and harvesting sideboards. These fisheries also may be managed under certain gear or time and area restrictions (provisions of the American Fisheries Act and the 2004 Consolidated Appropriations Act are incorporated herein by reference). The permits can be used to identify those vessels that must comply with certain fisheries management requirement. For instance, all federally permited vessels that are endorsed for Atka mackerel, Pacific cod or pollock fishing on their Federal Groundfish Fishing Permit must use a vessel monitoring system. Additional information regarding permits are in the regulations at 50 CFR 679.4.

License Limitation Program

A Federal groundfish license is required for catcher vessels (including catcher/processors) participating in all BSAI groundfish fisheries, other than fixed gear sablefish. However, the following vessel categories are exempt from the license program requirements:

a. vessels fishing in State of Alaska waters (0-3 miles offshore);
b. vessels less than 32 ft LOA; or
c. jig gear vessels less than 60 ft LOA using a maximum of 5 jig machines, one line per machine, and a maximum of 15 hooks per line.

Any vessel that meets the LLP qualification requirements will be issued a license, regardless of whether they are exempt from the program or not. The specifics of the LLP program and the species and gear endorsements described in Section 3.3.1 of the BSAI and GOA FMPs are incorporated here by reference.

Exempted Permits

The Regional Administrator, after consulting with the Director of the AFSC and with the Council, may authorize for limited experimental purposes, fishing activities that would otherwise be prohibited. This could include the targeted or incidental harvest of groundfish and prohibited species and fishing in areas that are closed to directed fishing, for continued fishing with gear otherwise prohibited, or for continued fishing for species for which the quota has been reached. Exempted fishing permits will be issued by means of procedures contained in regulations (50 CFR 679.6).

As well as other information required by regulations, each application for an exempted fishing permit must provide the following information: 1) experimental design (e.g., staffing and sampling procedures, the data and samples to be collected, and analysis of the data and samples), 2) provision for public release of all obtained information, and 3) submission of interim and final reports.

The Regional Administrator may deny an exempted fishing permit for reasons contained in regulations, including a finding that:

a. according to the best scientific information available, the harvest to be conducted under the permit would detrimentally affect living marine resources, including marine mammals and birds, and their habitat in a significant way;
b. issuance of the exempted fishing permit would inequitably allocate fishing privileges among domestic fishermen or would have economic allocation as its sole purpose; FMP for Groundfish of the BSAI Management Area Chapter 3 Conservation and Management Measures January 2005 24
c. activities to be conducted under the exempted fishing permit would be inconsistent with the intent of the management objectives of the FMP;
d. the applicant has failed to demonstrate a valid justification for the permit;
e. the activity proposed under the exempted fishing permit could create a significant enforcement problem; or
f. the applicant failed to make available to the public information that had been obtained under a previously issued exempted fishing permit.

2.5.1.3 Sector and Gear Allocations

Gear types authorized by the FMPs are trawls, hook-and-line, pots, jigs, and other gear as defined in regulations at 50 CFR part 679 (authorized gear types and fisheries are displayed in Table 2.8). Gear types and sector allocations for specific BSAI fisheries are described in detail in the annual harvest specifications (see Appendix 1). The complexity of the allocation scheme has grown since 2000 and is only described in general terms here.

In the eastern Bering Sea, pollock is allocated among four sectors, with 10% of the TAC allocated to the CDQ Program, 3.35% held in reserve for incidental catch (ICA), and the remainder split among the inshore, catcher/processor, and mothership sectors in the ratio of 50:40:10, respectively. The Aleutian Islands pollock fishery is allocated 10 percent to CDQ, a portion determined by NMFS inseason management to cover the ICA (9% in 2006), and the remainder to the Aleut Corporation. For all other BSAI fisheries (except sablefish - see below, and squid), 7.5% of the TAC is held as reserve for CDQ. After removal of CDQ reserve for Pacific cod, the remainder is allocated to jig (2%), hook-and-line (51%) and trawl (47%), with the trawl portion split evenly between catcher vessels and catcher/processors. The hook-and-line and pot gear allocation is further allocated as follows: 80% hook-and-line catcher/processors, 0.3% hook-and-line catcher vessels, 3.3% pot catcher/processors, 15% pot catcher vessels, and 1.4% to catcher vessels under 60 ft length overall using hook-and-line or pot gear. For sablefish in the Bering Sea, hook-and-line and pot together are allocated 50% and trawl is allocated 50%. For sablefish in the Aleutian Islands, hook-and-line and pot receive 75% and trawl 25% (20% of hook-and-line/pot allocation is held as CDQ reserve, as is 7.5% of the trawl allocation). For Atka mackerel, 1% of the allocation goes to jig gear. 15% of each target species or species group, except for pollock and the hook-and-line and pot gear allocation of sablefish, is placed in a non-specified reserve category.

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

2.5.1.4 Spatial and Temporal Restrictions

In addition to temporal and spatial allocation of TACs, certain areas are closed seasonally, year-round, or under special circumstances as established in regulations. Prohibitions specific to the protection of Steller sea lions or their habitat are described separately in Section 2.5.1.5. General time/area closures are as follows (see FMPs Section 3.5 for detailed descriptions and maps).

GOA Area Restrictions

Sitka Pinnacles Marine Reserve – All vessels

The Sitka Pinnacles Marine Reserve encompasses an area totaling 2.5 square nautical miles off Cape Edgecumbe. Vessels holding a Federal fisheries permit are prohibited at all times from fishing for groundfish or anchoring in the Sitka Pinnacles Marine Reserves. The area is illustrated in Figure 3-2 (NPFMC 2005b).

King Crab Closure Areas around Kodiak Island – Trawl gear only

A time/area closure has been developed to protect and rebuild the King Crab stock around Kodiak. Three area types have been designated as follows. In Type I areas, bottom trawling is closed year round. In Type II areas, bottom trawling is prohibited during the soft-shell season (February 15 to June 15). Type III areas are those that may be converted to Type I or Type II if a recruitment event occurs. A Type III area is open to bottom trawling until the number of females assessed for the area meets or exceeds the number required to hold a crab fishery. If a crab fishery is initiated, then no closure is in effect. If no crab fishery is initiated, then the Regional Administrator may designate the Type III area as a Type I or II area based on the information available. Type I, II, and III areas are illustrated in Section 3.5 of the GOA FMP (NPFMC 2005b).

Cook Inlet non-Pelagic Trawl Closure Area

The use of non-pelagic trawl gear is prohibited in Cook Inlet north of a line extending between Cape Douglas and Point Adam. This prohibition is intended to reduce crab bycatch and assist in the rebuilding of crab stocks. The area is illustrated in Figure 3-4 (NPFMC 2005b).

Southeast Outside Trawl Closure

Use of any gear other than non-trawl gear is prohibited at all times in the Southeast Outside district. The area is illustrated in Figure 3-5 (NPFMC 2005b)..

Essential Fish Habitat closures (pub. 6/28/06, effective July 28, 2006)

Closure areas provided in tables 22, 26 and 27 to 50 CFR part 679.

Alaska Seamount Habitat Protection Areas

No bottom tending gear or anchoring allowed.

Gulf of Alaska Slope Habitat conservation Areas

No bottom trawling allowed.

GOA Coral Habitat Protection Areas

No bottom tending gear or anchoring allowed.

BSAI Area Restrictions

The following time and area restrictions apply to some or all trawl vessels. Other time and area restrictions that may apply to trawl vessels are triggered by the attainment of a bycatch limit.

Crab and Halibut Protection Zone

The crab and halibut protection zone is closed to all trawling from January 1 to December 31. For the period March 15 to June 15, the western border of the zone extends westward. See Figure 3-2 (NPFMC 2005a).

Pribilof Islands Habitat Conservation Area

The Pribilof Islands Habitat Conservation Area is closed to all trawling from January 1 to December 31. See Figure 3-3 (NPFMC 2005a).

Chum Salmon Savings Area

The Chum Salmon Savings Area is closed to trawling from August 1 through August 31. See Figure 3-4 (NPFMC 2005a). Trawling is also prohibited in this area upon the attainment of an ‘other salmon’ bycatch limit.

Chinook Salmon Savings Areas

Closed to pollock trawling when 29.000 Chinook salmon limit is attained till April 15 or from September 1 through December 31 or both time periods (679.21(e)(7)(viii), depending on when limit is reached.

Red King Crab Savings Area

The Red King Crab Savings Area is closed to non-pelagic trawling year round, except that when the Regional Administrator of NMFS, in consultation with the Council, determines that a guideline harvest level for Bristol Bay red king crab has been established, he or she may open a subarea of the Red King Crab Savings Area to non-pelagic trawling. See Figure 3-5 (NPFMC 2005a).

Nearshore Bristol Bay Trawl Closure

The Nearshore Bristol Bay area is closed to all trawling on a year round basis, except a subarea that remains open to trawling during the period April 1 to June 15 each year. See Figure 3-6 (NPFMC 2005a).

Catcher Vessel Operational Area

Catcher/processors identified in the American Fisheries Act are prohibited from engaging in directed fishing for pollock in the catcher vessel operational area (CVOA) during the non-roe (“B”) season, unless they are participating in a community development quota fishery. See Figure 3-7 (NPFMC 2005a).

EFH Closures

Alaska Seamount Habitat Protection Areas (Table 22 to 50 CFR part 679)

No bottom contact gear or anchoring allowed.

Aleutian Islands Coral Habitat Protection Areas (Table 23 to 50 CFR part 679)

No bottom contact gear or anchoring allowed.

Aleutian Islands Habitat Conservation Area (Table 24 to 50 CFR part 679)

No bottom trawling allowed.

Bowers Ridge Habitat Conservation Zone (Table 25 to 50 CFR part 679)

No mobile bottom contact gear allowed.

2.5.1.2 Harvest of TAC

From 1964 to 2005, catch of pollock, Pacific cod, Atka mackerel, and total groundfish is provided in Table 2.9 including the percentage of total groundfish for each of the three species.

2.5.1.3 Incidental Catch

While fishery participants may target a certain species, they are not 100% effective in limiting their catch to that specific target. Other fishes and marine life are also caught to varying degrees depending on target species, gear type and fishing method, area fished and habitat type, season, depth, and other physical and biological factors. These other fishes and marine life are referred to as "incidental catch" or "bycatch."[1] Whether a species or stock is caught as a target by a fishing vessel, or incidentally by a vessel after another target, the catch is supposed to be included against the overall total allowed for a species or stock. That is, TACs are intended to represent the sum of all catch including targeted catch and incidental catch.

2.5.1.4 Bycatch of Prohibited Species

When a target fishery, as specified in regulations implementing the FMP, attains a prohibited species catch (PSC) limit apportionment or seasonal allocation as described in the FMPs and specified in regulations implementing the FMPs, the bycatch zone(s) or management area(s) to which the PSC limit apportionment or seasonal allocation applies will be closed to that target fishery (or components thereof) for the remainder of the year or season, whichever is applicable. The procedure for apportioning PSC limits is detailed in Section 3.6.2.3 of the FMPs (NPFMC 2005a,b).

Prohibited species include Alaska king crab, Tanner and snow crab, Pacific halibut, Pacific salmon species and steelhead trout, and Pacific herring. With some exceptions, retention is prohibited in the BSAI and GOA groundfish fisheries to eliminate any incentive to target these species. A description of the individual PSC limits can be found in Section 3.6.2.1 of the FMPs.

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

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

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

2.5.1.5 Retention and utilization requirements

Roe-stripping of pollock is prohibited, and the Regional Administrator is authorized to issue regulations to limit this practice to the maximum extent practicable. It is the Council's policy that the pollock harvest shall be utilized to the maximum extent possible for human consumption.

All vessels participating in the groundfish fisheries are required to retain all catch of Improved Retention/ Improved Utilization Program (IR/IU) species, pollock and Pacific cod, when directed fishing for those species is open, regardless of gear type employed and target fishery. When directed fishing for an IR/IU species is prohibited, retention of that species is required only up to any maximum retainable amount in effect for that species, and these retention requirements are superseded if retention of an IR/IU species is prohibited by other regulations.

No discarding of whole fish of these species is allowed, either prior to or subsequent to that species being brought on board the vessel except as permitted in the regulations. At-sea discarding of any processed product from any IR/IU species is also prohibited, unless required by other regulations.

All IR/IU species caught in the BSAI must be either 1) processed at sea subject to minimum product recovery rates and/or other requirements established by regulations implementing the FMP, or 2) delivered in their entirety to onshore processing plants for which similar processing requirements are implemented by State regulations.

2.5.2 Steller Sea Lion Conservation Measures

Immediately following the 2000 FMP Biological Opinion, the Council recommended an alternative suite of management measures intending to be substituted for the measures contained within the RPA of the 2000 Opinion which had found jeopardy and adverse modification. These alternative conservation measures were determined to avoid jeopardy and adverse modification to critical habitat for both the western and eastern distinct population segments of Steller sea lion (NMFS 2001). Therefore, the new measures recommended by the Council and adopted by NMFS, although not specifically required by an RPA, are in effect necessary as they replaced the specific measures in the RPA from the 2000 BiOp.

Greenpeace, American Oceans Campaign, and the Sierra Club challenged the 2001 BiOp On December 18, 2002, U.S. District Court for the Western District of Washington Judge Zilly granted motion for summary judgment on Greenpeace, American Oceans Campaign, and Sierra Club v. NMFS et al., No. C98-492Z). The opinion was remanded to NMFS for further consideration of issues as required by the Court. On June 19, 2003 NMFS prepared a supplement to the 2001 BiOp which further evaluated the fisheries and their interactions with Steller sea lions and affirmed the determination that the pollock, Pacific cod, and Atka mackerel fisheries did not jeopardize the species or adversely modify their critical habitat. The supplement evaluated fishery catch data from both before and after implementation of the conservation measures, which provided a unique perspective for a consultation. The Supplement showed that some conservation components to the action worked quite well while others did not perform up to expectations (see Supplement, Table IV-1). Because fisheries are dynamic, biomass amounts change, fish move, and the fleet is constantly adapting to changes in both the physical and economic environment, some of this is expected. Overall, the action was conservative enough to avoid jeopardy, while some elements certainly could be improved upon as described in the Supplement. However, changes were not required to avoid jeopardy or adverse modification in 2003.

Under the Steller sea lion conservation measures implemented in 2002, a complex suite of open and closed areas was used based upon the individual fishery. For that reason, it is impossible to easily sum these various closures and determine how much of the area is closed to fishing. The conservation measures which represents more of a mosaic is best described (for closure areas) by looking at each individual fishery and area to determine what is open or closed inside Steller sea lion critical habitat. A summary table of the measures required in the 2000 RPA and the action currently implemented is provided in Table 2.30.

Note that in the past several years, additional regulations were implemented in the BSAI and GOA groundfish fisheries to facilitate research on the interaction between groundfish fishing activities and Steller sea lions. These measures included temporary and season-specific closures of some areas to allow research to continue – e.g. near Unimak Island for Pacific cod research and Chiniak Gully for pollock studies. The Chiniak Gully closure is effective August 1 up to September 20 for the years 2006-2010 (71 FR 31105, June 1, 2006). Additional information can be found in regulations at 50 CFR 679.22.

2.5.2.1 No transit zones

No owner or operator of a vessel may allow the vessel to approach within 3 nm of Steller sea lion rookeries listed in 50 CFR part 223.202(a)(3) (Table 2.31).

2.5.2.2 Global control rule

The setting of TAC for the pollock, Pacific cod and Atka mackerel fisheries is 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 (pristine) 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 (see example at Figure 2.6).

2.5.2.3 Closure areas around rookeries and haulouts: Atka Mackerel, Pollock, and Pacific Cod Fisheries

Fishery closures are located in 50 CFR part 679.22 in Tables 4 through 6 and Table 12 (provided here as Tables 2.31 through 2.34). Individual haulouts and rookeries and their associated closures are identified for each fishery in the tables. Detailed maps of the closures are provided in Figures 2.10 through 2.12.

After the 2001 Biological Opinion, regulations were changed in 2003 to allow pot fishing within 0-3 n mi at Cape Barnabas and Caton Island, and further changed in 2005 implementing several additional measures in the GOA. Those measures are incorporated into the tables below. Thus, the following tables and text reflect the current status of groundfish fishery regulations that relate to Steller sea lion protection measures in the GOA and BSAI.

Gulf of Alaska Fisheries

Steller sea lion protection measures for the GOA include area closures to pollock and Pacific cod fishing as shown in Tables 4 and 5 to 50 CFR part 679. Table 12 of 50 CFR part 679 contains groundfish fishing closures within 3 nm of rookeries. 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. Directed pollock fishing and directed fishing for Pacific cod using trawl gear in general are prohibited within 20 nm of most rookeries and within 10 nm of most haulouts. Pacific cod fishing with hook-and-line gear and pot gear is less restrictive in the GOA with many haulout areas open to the shore and only the haulouts near Chignik closed to 20 nm. Directed fishing for Atka mackerel is prohibited (§ 679.22(b)(2)).

Bering Sea and Aleutian Islands Fisheries

Steller sea lion protection measures for the BSAI include area closures to Atka mackerel, pollock, and Pacific cod fishing as shown in Tables 4-6 to 50 CFR part 679. Table 12 of 50 CFR part 679 contains groundfish fishing closures within 3 nm of rookeries. Vessels using jig gear are exempt from all BSAI 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. Directed pollock fishing is prohibited within 20 nm of all haulouts and rookeries in the Aleutian Islands and all rookeries in the Bering Sea. Pollock fishing is also prohibited within either 10 nm or 20 nm of haulouts in the Bering Sea. Directed fishing for Pacific cod using trawl gear in general are prohibited within 20 nm of most rookeries and within 10 nm of most haulouts. Pacific cod fishing with hook-and-line gear and pot gear is less restrictive in the GOA with many haulout areas open to the shore and only the haulouts near Chignik closed to 20 nm.

2.5.2.4 Fishery restrictions in the GOA

Pollock (GOA)

In the GOA, pollock is apportioned by season and area, and is further allocated for processing by inshore and offshore components. Pursuant to § 679.20(a)(5)(iii)(B), the annual pollock TAC specified for the Western and Central Regulatory Areas of the GOA is apportioned into four equal seasonal allowances of 25 percent. As established by § 679.23(d)(2)(i) through (iv), the A, B, C, and D season allowances are available from January 20 through March 10, from March 10 through May 31, from August 25 through October 1, and from October 1 through November 1, respectively.

Pollock TACs in the Western and Central Regulatory Areas of the GOA in the A and B seasons are apportioned among Statistical Areas 610, 620, and 630 in proportion to the distribution of pollock biomass based on a composite of NMFS winter surveys and in the C and D seasons in proportion to the distribution of pollock biomass based on the four most recent NMFS summer surveys. Currently, the Council has recommended averaging the winter and summer distribution of pollock in the Central Regulatory Area for the A season to better reflect the distribution of pollock and the performance of the fishery in the area during the A season for the 2006 and 2007 fishing years. Within any fishing year, the underage or overage of a seasonal allowance may be added to, or subtracted from, subsequent seasonal allowances in a manner to be determined by the Regional Administrator. The rollover amount of unharvested pollock is limited to 20 percent of the seasonal apportionment for the statistical area. Any unharvested pollock above the 20 percent limit could be further distributed to the other statistical areas, in proportion to the estimated biomass in the subsequent season in those statistical areas (§ 679.20(a)(5)(iii)(B)). The WYK and SEO District pollock TACs are not allocated by season.

Section 679.20(a)(6)(i) requires the allocation of 100 percent of the pollock TAC in all regulatory areas and all seasonal allowances to vessels catching pollock for processing by the inshore component after subtraction of amounts that are projected by the Regional Administrator to be caught by, or delivered to, the offshore component incidental to directed fishing for other groundfish species. The amount of pollock available for harvest by vessels harvesting pollock for processing by the offshore component is that amount actually taken as incidental catch during directed fishing for groundfish species other than pollock, up to the maximum retainable amounts allowed by § 679.20(e) and (f). These incidental catch amounts are determined during the fishing year.

Pacific Cod (GOA)

Pacific cod fishing is divided into two seasons in the Western and Central Regulatory Areas of the GOA. For hook-and-line, pot, and jig gear, the A season begins on January 1 and ends on June 10, and the B season begins on September 1 and ends on December 31. For trawl gear, the A season begins on January 20 and ends on June 10, and the B season begins on September 1 and ends on November 1 (§ 679.23(d)(3)). After subtraction of incidental catch needs by the inshore and offshore components in other directed fisheries through the A season ending June 10, 60 percent of the annual TAC will be available as a directed fishing allowance during the A season for the inshore and offshore components. The remaining 40 percent of the annual TAC will be available for harvest during the B season and will be apportioned between the inshore and offshore components (§ 679.20(a)(6)(ii)). Any amount of the A season apportionment of Pacific cod TAC under or over harvested will be added to or subtracted from the B season apportionment of Pacific cod TAC (§ 679.20(a)(11)(ii)). The dates for the A season and the B season for the Pacific cod fishery differ from those of the A, B, C, and D seasons for the pollock fisheries.

Section 679.20(a)(6)(ii) requires the allocation of the Pacific cod TAC apportionment in all regulatory areas between vessels catching Pacific cod for processing by the inshore and offshore components. Ninety percent of the Pacific cod TAC in each regulatory area is allocated to vessels catching Pacific cod for processing by the inshore component. The remaining 10 percent of the TAC is allocated to vessels catching Pacific cod for processing by the offshore component. These seasonal apportionments and allocations of the Pacific cod TACs are shown below:

Pacific cod allocations by season and area in the GOA.

Area	Gear	Season	TAC Apportionment	Inshore	Offshore
W and C Regulatory Areas	H&L Pot Jig	Jan 1 – June 10	60	90	10
		Sept 1 – Dec 31	40	90	10
W and C Regulatory Areas	Trawl	Jan 20 – June 10	60	90	10
		Sept 1 – Nov 1	40	90	10
E Regulatory	All	Jan 1 – Dec 31	100	90	10

Area					

2.5.2.5 Fishery restrictions in the BSAI

Protection measures in the BSAI are more complicated than in the GOA because of additional types of areas that require protection beyond those listed in Tables 4 through 6 and 12 to 50 CFR part 679. All closures in the BSAI are in 50 CFR 679.22. The table below gives a general overview of closures:

General SSL protection area closures in BSAI.

Area	Restriction	Season	Exceptions
Rookeries	No groundfish fishing and no vessel transit 0-3 n mi	All year	See below in table
Haulouts	No directed fishing for pollock or P. cod 0-3 nm	All year	Jig vessels; also see below in table
Rookeries & haulouts	No directed trawl fishing for P. cod or pollock 0-10 nm	All year	Pribilof Is. Haulouts (see below)
Pribilof Is. haulouts	No directed trawl fishing for P. cod or pollock 0-3 nm	All year	
East of 178˚ W, trawl gear	Rookeries closed 0-10 n mi; haulouts closed 0-3 nm	All year	Agligadak closed 0-20 nm
West of 178˚ W, trawl gear	Rookeries & haulouts closed 0-20 nm until Atka mackerel fishery inside SSL CH is closed (applies to A & B seasons), then P cod trawling closed 0-3 nm of haulouts and 0-10 n mi of rookeries	All year	
Pot, H&L gear in Aleutian Islands	Closed in SSL CH east of 173˚ W to 170˚ W; Buldir rookery closed 0-10 nm; Agligadak rookery closed 0-20 nm	All year	
Seguam foraging area	Closed to pollock, P. cod and Atka mackerel	All year	
Bogoslof foraging area	Closed to Atka mackerel, P. cod, and pollock directed fishing	All year	H&L and jig vessels < 60' targeting P. cod allowed S of line extending from a point 3 nm N of

			Bishop Point to Cape Tanak
St. Lawrence & Hall Is., Cape Newenham, Round Is. haulouts	Closed 0-20 nm to pollock, P. cod and Atka mackerel	All year	
Bishop Point & Lava Reef haulouts	No directed H&L C/P fishing for P. cod 0-10 nm	All year	Vessels <60’
Amak rookery	No directed H&L or pot fishing for P. cod 0-7 nm	All year	
Steller Sea Lion Conservation Area (SCA)	No directed fishing for pollock	A season	
Catcher Vessel Operating Area (CVOA)	No directed trawl C/P fishing for pollock	B season	

Pacific cod

Pursuant to § 679.20(a)(7)(i)(A), 2 percent of the Pacific cod ITAC is allocated to vessels using jig gear, 51 percent to vessels using hook-and-line or pot gear, and 47 percent to vessels using trawl gear. Section 679.20(a)(7)(i)(B) further allocates the portion of the Pacific cod ITAC allocated to trawl gear as 50 percent to catcher vessels and 50 percent to catcher/processors. Section 679.20(a)(7)(i)(C)(*1*) sets aside a portion of the Pacific cod ITAC allocated to hook-and-line or pot gear as an ICA of Pacific cod in directed fisheries for groundfish using these gear types. Based on anticipated incidental catch in these fisheries, the Regional Administrator currently specifies an ICA of 500 mt. The remainder of Pacific cod ITAC is further allocated to vessels using hook-and-line or pot gear as the following DFAs: 80 percent to hook-and-line catcher/ processors, 0.3 percent to hook-and-line catcher vessels, 3.3 percent to pot catcher/processors, 15 percent to pot catcher vessels, and 1.4 percent to catcher vessels under 60 feet (18.3 m) length overall (LOA) using hook-and-line or pot gear.

Due to concerns about the potential impact of the Pacific cod fishery on Steller sea lions and their critical habitat, the apportionment of the ITAC disperses the Pacific cod fisheries into two seasonal allowances (see §§ 679.20(a)(7)(iii)(A) and 679.23(e)(5)). For pot and most hook-and-line gear, the first seasonal allowance of 60 percent of the ITAC is made available for directed fishing from January 1 to June 10, and the second seasonal allowance of 40 percent of the ITAC is made available from June 10 (September 1 for pot gear) to December 31. No seasonal harvest constraints are imposed for the Pacific cod fishery by catcher vessels less than 60 feet (18.3 m) LOA using hook-and-line or pot gear. For trawl gear, the first season is January 20 to April 1 and is allocated 60 percent of the ITAC. The second season, April 1 to June 10, and the third season, June 10 to November 1, are each allocated 20 percent of the ITAC. The trawl catcher vessel allocation is further allocated as 70 percent in the first season, 10 percent in the second season and 20 percent in the third season. The trawl catcher/ processor allocation is allocated 50 percent in the first season, 30 percent in the second season, and 20 percent in the third season. For jig gear, the first season and third seasons are each allocated 40 percent of the ITAC and the second season is allocated 20 percent of the ITAC. The table below lists the allocations and seasonal apportionments of the Pacific cod ITAC. In accordance with § 679.20(a)(7)(ii)(D) and (iii)(B), any unused portion of a seasonal Pacific cod allowance will become available at the beginning of the next seasonal allowance.

Pacific cod allocations by season and area in the BSAI.

Gear	TAC	Vessel Size	Season	TAC Split	Sector Apportionment	
H & L Pot	51 %	≥ 60’	Jan 1 – June 10	60		
			June 10 (Sept 1 for pot) – Dec 31	40		
		< 60’	No Restrictions			
Trawl	47 %		Jan 20 – Apr 1	60	C/V	70
					C/P	50
			Apr 1 – June 10	20	C/V	10
					C/P	30
			June 10 – Nov 1	20	C/V	20
					C/P	20
Jig	2 %		Jan 1 – Apr 30	40		
			Apr 30 – Aug 31	20		
			Aug 31 – Dec 31	20		

Pollock

Section 679.20(a)(5)(i)(A) requires that the pollock TAC apportioned to the Bering Sea subarea, after subtraction of the 10 percent for the Community Development Quota (CDQ) program and the 3.35 percent for the ICA, will be allocated as a directed fishing allowance (DFA) as follows: 50 percent to the inshore component, 40 percent to the catcher/processor component, and 10 percent to the mothership component. In the Bering Sea subarea, the A season (January 20–June 10) is allocated 40 percent of the DFA and the B season (June 10–November 1) is allocated 60 percent of the DFA. The AI directed pollock fishery allocation to the Aleut Corporation is the amount of pollock remaining in the AI subarea after subtracting 1,900 mt for the CDQ DFA (10 percent) and 1,800 mt for the ICA. When the AI pollock ABC is less than 19,000 mt, the annual TAC will be no greater than the ABC. When the AI pollock ABC equals or exceeds 19,000 mt, the annual TAC will be equal to 19,000 mt. In the AI subarea, 40 percent of the ABC is allocated to the A season and the remainder of the directed pollock fishery is allocated to the B season.

Section 679.20(a)(5)(i)(A)(4) also includes several specific requirements regarding pollock and pollock allocations. First, 8.5 percent of the pollock allocated to the catcher/ processor sector will be available for harvest by AFA catcher vessels with catcher/processor sector endorsements, unless the Regional Administrator receives a cooperative contract that provides for the distribution of harvest among AFA catcher/processors and AFA catcher vessels in a manner agreed to by all members. Second, AFA catcher/processors not listed in the AFA are limited to harvesting not more than 0.5 percent of the pollock allocated to the catcher/processor sector.

The table below lists seasonal apportionments of pollock and harvest limits within the Steller Sea Lion Conservation Area (SCA). The harvest within the SCA, as defined at § 679.22(a)(7)(vii), is limited to 28 percent of the annual directed fishing allowance (DFA) until April 1. The remaining 12 percent of the 40 percent of the annual DFA allocated to the A season may be taken outside the SCA before April 1 or inside the SCA after April 1. If the 28 percent of the annual DFA is not taken inside the SCA before April 1, the remainder is available to be taken inside the SCA after April 1. The A season pollock SCA harvest limit will be apportioned to each sector in proportion to each sector's allocated percentage of the DFA.

Pollock allocations by season and area in the BSAI.

Area	DFA	Season	DFA Allocation	Restriction
Bering Sea	Inshore 50 % C/P 40 % Mothership 10 %	Jan 20 – June 10	40 %	No more than 28 % from the SCA before Apr 1
		June 10 – Nov 1	60 %	
Aleutian Islands	Aleut Corp 100 %	Jan 20 – June 10	40 %	
		June 10 – Nov 1	60 %	
Bogoslof		Closed		

Atka Mackerel

Pursuant to § 679.20(a)(8)(i), up to 2 percent of the Eastern Aleutian District and the Bering Sea subarea Atka mackerel ITAC may be allocated to jig gear. The amount of this allocation is determined annually by the Council based on several criteria, including the anticipated harvest capacity of the jig gear fleet. Currently there is a 1 percent allocation of the Atka mackerel ITAC in the Eastern Aleutian District and the Bering Sea subarea to the jig gear.

Section § 679.20(a)(8)(ii)(A) apportions the Atka mackerel ITAC into two equal seasonal allowances. After subtraction of the jig gear allocation, the first seasonal allowance is made available for directed fishing from January 1 (January 20 for trawl gear) to April 15 (A season), and the second seasonal allowance is made available from September 1 to November 1 (B season) (see table below).

Pursuant to § 679.20(a)(8)(ii)(C)(*1*), the Regional Administrator will establish a harvest limit area (HLA) limit of no more than 60 percent of the seasonal TAC for the Western and Central Aleutian Districts. A lottery system is used for the HLA Atka mackerel directed fisheries to reduce the amount of daily catch in the HLA by about half and to disperse the fishery over two districts (see § 679.20(a)(8)(iii)).

Atka mackerel allocations by season and area in the BSAI.

Gear	ITAC Split	Area	Seasonal ITAC Split	Season	Seasonal Allocation	Restrictions
Jig	~2 %			Jan 1 – Dec 31		
Other gear	~98 %	W & C Regulatory Areas	~60 %	Jan 1 (20-trawl) – Apr 15	50 %	Each season's harvest occurs in W & C HLAs (see regulations)
				Sept 1 – Nov 1	50 %	
		E Reg Area & Bering Sea	~40 %	Jan 1 (20-trawl) – Apr 15	50 %	
				Sept 1 – Nov 1	50 %	

2.5.2.6 Area Closed

Table 2.35 displays the amount of area closed and area composed of each critical habitat zone and for each fishery and area. Table 2.36 presents this information as a percentage of each zone which is closed within critical habitat, and Figure 2.13 is a graphical representation of Table 2.36 sorted by amount of the 0-10 nm zone closed, plotted with the associated closures in 10-20 nm for each particular fishery. The amount of area that would have been closed under the 2000 FMP Biological Opinion is displayed in Table 2.37. Gear types are not listed separately because the closure areas are identical for all gear types. Overall, 63% of critical habitat was closed, but only 65% of the 0-10 nm area was closed. One important difference in the closure areas was that under the 2000 FMP Biological Opinion any area that was closed was closed to all three species which would insure no competition for any of the three, whereas under the 2001 conservation measures this is not the case. An area closed to pollock fishing may be open to Pacific cod fishing, or Atka mackerel. Thus, closure areas are not exactly equal.

2.5.3 Monitoring and Evaluation of Fisheries Catch

Catch data used to manage the groundfish fisheries under the BSAI and GOA FMPs are collected from vessels, processors, and fishery observers trained by NMFS. This section discusses recordkeeping and reporting requirements, data used for catch estimation, and the in-season fishery management programs. Monitoring of the fisheries is necessary to ensure that they are prosecuted in compliance with management regulations and do not threaten the health and status of the target stocks or the ecosystem, including listed species and critical habitat. The catch is monitored by a catch accounting system (CAS) to ensure that it does not exceed the TAC by excessive amounts.

2.5.3.1 Recordkeeping and reporting requirements

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

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

2.5.3.2 Collection of catch data

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

Estimating catch weight

Observers provide estimates of total catch and species composition, and species-specific biological data used in stock assessments. Observers are required aboard vessels 125 feet or greater in length overall (LOA) for 100% of their fishing days, and aboard vessels 60-124 feet LOA for 30% of their fishing days (Table 2.38). Observers are required at shoreside and floating processing plants according to processing rate, with 100% observer coverage of plants processing 1,000 metric tons or more per month, and 30% observer coverage of plants processing 500 to 1,000 metric tons per month. Observers have multiple duties, but highest priority is given to estimation of catch weight, species composition, and timely inseason reporting. Haul-specific total catch weights are estimated by observers using volumetric, direct weight, or tally methods. Volumetric and direct weight methods of catch weight estimation are applied primarily in trawl fisheries, while tally methods are used in hook-and-line and pot fisheries. Observers are instructed to make independent estimates of catch weight for as many hauls/sets as possible. Unverified vessel estimates of catch weight are reported by observers as Official Total Catch (OTC) for hauls and sets where observers are unable to make an independent estimate. In 1997, observers independently estimated 72% of hauls/sets aboard observed vessels, accounting for 68% of the total reported observed OTC of 1.5 million metric tons. Vessel estimates were used for 7% of hauls/sets (10% of OTC by weight), and alternate estimates (proportioned delivery weight, expansion from sampled to unsampled hook-and-line sets, etc.) were used for the remaining 20% of hauls/sets (22% of OTC by weight). The catch estimation methods used by observers vary among the vessel types, due to differences in available equipment and in fishery operations.

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

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

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

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

Estimating species composition

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

Estimating discards

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

2.5.3.3 Reporting of catch data

Vessel data

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

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

Processor data

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

Vessel monitoring system data

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

2.5.3.4 Estimation of groundfish catch

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

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

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

2.5.3.5 In-season Management of TAC Apportionments

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

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

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

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

2.5.3.6 Retention and utilization

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

2.6 Pending Actions

2.6.1 Salmon Bycatch Reduction, Amendments 84a and 84b

The analysis for Amendment 84a is available from the NMFS Alaska Region website at http://www.fakr.noaa.gov. This amendment is in the process of Regional review based on the Council's recommendation in October 2005. In the mid-1990s, the Council and NMFS implemented regulations to control the bycatch of chum salmon and Chinook salmon taken in the BSAI trawl fisheries. These regulations established closure areas in areas and at times when salmon bycatch had been highest based on historical observer data. Information from the fishing fleet indicates that bycatch may have been exacerbated by the current regulatory closure regulations, as much higher salmon bycatch rates were reportedly encountered inside the closure areas. Some of these bycaught salmon include Chinook and chum stocks of concern in western Alaska. Further, the closure areas impose increased costs on the pollock fleet and processors. To address this immediate problem, the Council will examine and consider other means to control salmon bycatch that have the potential to be more flexible and adaptive, but still meet Council intent to minimize impacts to the salmon in the eastern Bering Sea.

Under the preferred alternative, certain trawl vessels would be exempt from the Chum Salmon Savings Area and Chinook Salmon Savings Areas closures. The exemption would be in effect so long as the pollock cooperatives and CDQ groups have in place an effective salmon bycatch voluntary rolling “hot spot” (VRHS) closure system to avoid salmon bycatch. Although fishing patterns may change under the alternative, as the pollock fishery is no longer mandatorily forbidden to fish in the established savings areas, the changes due to the alternative are unlikely to result in a significant change in the interaction between the fisheries and threatened or endangered species. To the extent that CPUE for pollock can be increased under this alternative, by increasing the flexibility of the cooperatives to avoid salmon bycatch, interactions with seabirds and marine mammals should also decrease as vessels spend less time catching their allocations. This action is part of the action included in the salmon consultation with NMFS NW Region.

Amendment 84b is being developed. This amendment would refine the current salmon savings areas if necessary in the event pollock vessels either surrender or lose their exemption and return to fishing under the regulatory salmon bycatch program. Further, alternatives to the VRHS system and/or the regulatory salmon bycatch program should be developed to assess whether they would be more effective in reducing salmon bycatch.

2.6.2 BSAI Pacific Cod Allocations, Amendment 85

The Council took final action on an amendment to the BSAI FMP that changes the amount of the BSAI Pacific cod TAC allocated to various sectors. The preferred alternative is based on historic retained catch by each fishing sector, with some exceptions for the <60' fixed gear and jig gear sectors, yet remains within the overall intent of SSL protection measures as they pertain to seasonal and sector allocation requirements. In general, the Council's preferred alternative revises the initial annual allocations to each sector to reflect historic catch and mirrors the current temporal distribution of catch by overall gear sector, to account for TAC that is annually reallocated among gear sectors late in the year. Thus, while each sector's initial allocation is modified, the amount of the TAC allocated to each overall gear sector (trawl, fixed, and jig gear) in the first half of the year does not differ from status quo. The public review draft analysis for this amendment is available on the Council’s website and the final Council motion is provided at: http://www.fakr.noaa.gov/npfmc/analyses/AM85motion406.pdf. The intent is that this amendment will be implemented in January 2008.

2.7 Interrelated and Interdependent Actions

By regulation, the *effects of an action* include the direct and indirect effects of an action on listed species or designated critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. *Interrelated actions* are those that are part of a larger action and depend on the larger action for their justification. *Interdependent actions* are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

Although not directly contained within the FMPs themselves, regulations at 50 CFR part 600 implement the MSA provisions. Specifically, the issuance of scientific research permits may be provided by the Regional Administrator by § 600.745 (Scientific research activity, exempted fishing, and exempted educational activity). Except for the exempted fishing permits, these are authorized under the MSA only and provide the support for the resource assessment program and represent an interrelated action. This research may be conducted by either fishery research vessels or fishing vessels chartered by NMFS.

2.8 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)). The action area is determined by the effects of the BSAI and GOA groundfish fisheries which remove fish biomass from the North Pacific Ocean and Bering Sea. 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 (Figure 1.1 in NPFMC 2005a). 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 by the State parallel fisheries.

The action area, as described, includes the range of both the western (endangered) and eastern (threatened) DPSs of the Steller sea lion in Alaska, the western and central North Pacific stock of humpback whales and the North Pacific sperm whale stock. 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 previously found to adversely affect Steller sea lions are the Atka mackerel, pollock, and the Pacific cod fisheries. In addition, the Alaska groundfish fisheries were determined to be likely to adversely affect sperm and humpback whales.

2.9 Critical habitat within the action area

Critical habitat designated for Steller sea lions occurs within the action area. Steller sea lion critical habitat is described in Section 3, and listed in 50 CFR part 226.202 (provided here as Tables 2.39 and 2.40 and Figures 2.14 and 2.15). Only those areas designated areas within Alaska are within the action area. Thus, critical habitat in Oregon and California are outside of the action area and are unlikely to be affected by the proposed action.

3 STATUS OF SPECIES

3.1 Steller Sea Lion: Western and Eastern Distinct Population Segments (DPS)

3.1.1 Species description

The Steller sea lion (*Eumetopias jubatus*) belongs to the Order Carnivora, Suborder Pinnipedia, Family Otariidae, and Subfamily Otariinae. The family contains the extant genera *Arctocephalus*, *Callorhinus*, *Eumetopias*, *Neophoca*, *Otaria*, *Phocarctos*, and *Zalophus*. The genus *Eumetopias* contains one species, the Steller (also called northern) sea lion, *E. jubatus*. The Steller sea lion range extends across the Pacific Rim from southern California, Canada, Alaska, and into Russia and northern Japan (Figure 3.1).

Steller sea lions are the largest otariid and show marked sexual dimorphism with males larger than females. The average standard length is 282 cm for adult males and 228 cm for adult females (maximum of about 325 cm and 290 cm, respectively); weight of males averages 566 kg and females 263 kg (maximum of about 1,120 kg and 350 kg) (Fiscus 1961, Calkins and Pitcher 1982, Loughlin and Nelson 1986, Winship *et al.* 2001). The pelage is light buff to reddish brown and slightly darker on the chest and abdomen. Naked parts of the skin are black (King 1954). Adult males have long, coarse hair on the chest, shoulders, and back; the chest and neck are massive and muscular. Newborn pups are about 1 m long, weigh 16-23 kg, and have a thick, dark-brown coat that molts to lighter brown after 6 months (Daniel 2003). A more detailed physical description is given in Loughlin *et al.* (1987) and Hoover (1988).

Female Steller sea lions attain sexual maturity and first breed between 3 and 8 years of age (Pitcher and Calkins 1981). The average age of reproducing females (i.e., generation time) is about 10 years based on the life tables from Calkins and Pitcher (1982) and York (1994). They normally ovulate and breed annually after maturity although because of a high rate of reproductive failures, estimated birth rates have ranged from 55% to 63% (Calkins and Goodwin 1988, Pitcher and Calkins 1981, Pitcher *et al.* 1998). They give birth to a single pup from late May through early July and then breed about 11 days after giving birth. They undergo delayed implantation and the blastocyst implants about 3.5 months after breeding. Some offspring are weaned near their first birthday while others continue suckling for an additional year or more. While males may attain physiological maturity before 7 years of age, they are seldom able to establish and defend a territory until 8 years or older (Thorsteinson and Lensink 1962, Pitcher and Calkins 1981).

3.1.2 Listing status

In the 1950s, the worldwide abundance of Steller sea lions was estimated at 240,000 to 300,000 animals, with a range which stretched across the Pacific Rim from southern California, Canada, Alaska, and into Russia and northern Japan (Figure 3.1). By 1990, the U.S. portion of the population had declined by about 80%, which prompted NMFS to list the Steller sea lion as a threatened species under the ESA on April 5, 1990 (55 FR 12645). The listing was based primarily on substantial declines that occurred in the 1980s (as high as 15% per year) in the population currently designated as the western distinct population segment (DPS) as well as on a reduced population size in the population now designated as the eastern DPS. After listing in 1990, the rate of decline decreased to about 5% per year. Critical habitat was designated on August 27, 1993 (58 FR 45269) based on the location of terrestrial rookery and haulout sites, spatial extent of foraging trips, and availability of prey items (Tables 2.39 and 2.40; Figures 2.14 and 2.15).

In 1997, after continued declines in Alaska, the Steller sea lion population was split into a western DPS and an eastern DPS based on demographic and genetic dissimilarities (62 FR 30772)(Figure 3.1). Population Viability Analysis (PVA) models indicated a continued decline at the 1985-1994 rate would result in extinction of the western DPS in 100 years or a 65% chance of extinction if the 1989-1994 trend continued for 100 years (62 FR 24354), therefore the western DPS, extending from Japan around the Pacific rim to Cape Suckling in Alaska (144°W), was up-listed to endangered. The eastern DPS, extending from Cape Suckling east to British Columbia and south to California, remained on the list as threatened because of the larger decline overall in the U.S. population, concern over western DPS animals ranging into the east, human interactions, and the lack of recovery in California (62 FR 24354).

The decline continued in the western DPS until about 2000. Since then, the population has increased at about 3% per year and has been relatively consistent across the U.S. portion of the range with the exception of the central Gulf of Alaska and the western Aleutian Islands areas. The Asian component of the western DPS has been relatively stable overall, but with regional differences. The eastern DPS has been increasing for over 20 years with the greatest increases in southeast Alaska and British Columbia, but generally poor performance in California at the southernmost extent of its range.

3.1.3 Population distribution and structure

The range of Steller sea lions extends around the North Pacific Ocean rim from northern Japan, the Kuril Islands and Okhotsk Sea, through the Aleutian Islands and Bering Sea, along Alaska's southern coast, and south to California (Figure 3.1)(Kenyon and Rice 1961, Loughlin *et al.* 1984, 1992). Seal Rocks, at the entrance to Prince William Sound, Alaska, is the northernmost rookery (60°09'N). Año Nuevo Island off central California is the southernmost rookery (37°06'N), although some pups were born at San Miguel Island (34°05'N) up until 1981. Prior to the decline in the west, most large rookeries were in the Gulf of Alaska and Aleutian Islands (Kenyon and Rice 1961, Calkins and Pitcher 1982, Loughlin *et al.* 1984, 1992, Merrick *et al.* 1987). As the decline continued, rookeries in the west became progressively smaller; consequently, the largest rookeries are now in Southeast Alaska and British Columbia. In 2005, the Forrester Island complex produced 3,429 pups and Hazy Islands 1,286 pups (both in Southeast Alaska). About 2,500 pups were counted at the Scott Islands rookery in British Columbia in 2002. In 2005, Ugamak Island (687 pups) and Pinnacle Rock (643 pups) were the largest rookeries in the Gulf of Alaska and Aleutian Islands.

Most adult Steller sea lions occupy rookeries[1] during the pupping and breeding season, which extends from late May to early July (Pitcher and Calkins 1981, Gisiner 1985). During the breeding season some juveniles and non-breeding adults occur at or near the rookeries, but most are on haulouts. Adult males, in particular, may disperse widely after the breeding season. Males that breed in California move north after the breeding season and are rarely seen in California or Oregon except from May through August (Mate 1973). During fall and winter many sea lions disperse from rookeries and increase use of haulouts, particularly terrestrial sites but also sea ice in the Bering Sea.

Steller sea lions are not known to make regular migrations, but they do move considerable distances (Baba *et al.* 2000). Animals marked as pups on rookeries in the Gulf of Alaska have been sighted in Southeast Alaska and British Columbia; some marked in British Columbia have been seen at Cape Saint Elias, Alaska; some marked in the eastern Aleutians have been seen in eastern Bristol Bay, Alaska; and some marked in Oregon have been seen in northern California, Washington, British Columbia, Southeast Alaska, and the northern Gulf of Alaska (Calkins and Pitcher 1982, Calkins 1986, Loughlin 1997). Raum-Suryan *et al.* (2002) analyzed resightings of 8,596 pups that were branded from 1975-1995 on rookeries in Alaska and reported that almost all resightings of young-of-the-year were within 500 km of the rookery where the pup was born, although subsequent observations documented movements of 11 month-old pups with their mothers of over 800 km. Juvenile animals were seen at much greater distances from their rookery of birth (up to 1,785

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[1] Throughout this document a rookery refers to a site where pups are born (usually a count of 50 or more pups), breeding occurs and sea lions may haulout during the non-breeding period; a site designated as a rookery will be called a rookery the entire year, even though breeding occurs there only from late May to early July.

km). Sightings of adults were generally less than 500 km away from the natal rookery although adult males have since been seen over 1000 km from the rookery where they held a territory (also their natal rookery).

Steller sea lion pups tagged in the Kuril Islands commonly moved northward to the east and west coasts of Kamchatka (Burkanov *et al.* 1997) and have also been seen as far south as Yokahama, Japan (Baba *et al.* 2000, NMFS unpublished data). Pups tagged on the Commander Islands have moved to the east coast of Kamchatka (Burkanov *et al.* 1997). Juveniles marked in the central Aleutian Islands have been observed in the Commander Islands.

NMFS designated two DPSs of Steller sea lion based on genetic studies and phylogeographical analyses from across the sea lion's range (62 FR 24345). The eastern DPS includes sea lions born on rookeries from California north through Southeast Alaska; the western DPS includes those animals born on rookeries from Prince William Sound westward (Bickham et al. 1996, Loughlin 1997). The regulatory division between DPSs is Cape Suckling (144º west longitude) in the northeast Gulf of Alaska. However, movement across this boundary by animals (particularly juveniles) from both populations does occur (Raum-Suryan *et al.* 2002).

Steller sea lions may sometimes disperse from their rookeries of birth and breed at other rookeries within their parent populations; this has the potential to affect local population dynamics and thus conforms to the concept of a "metapopulation" (Hanski and Simberloff 1997). In the case of Steller sea lions, a metapopulation may be considered a rookery or cluster of rookeries (York *et al*. 1996). Occasional dispersal of animals from their natal rookeries may have important consequences for expansion of the eastern population and possible recovery of the western DPS, as it provides a mechanism for occupying new territory or re-occupying vacant areas (Raum-Suryan *et al*. 2002). In Southeast Alaska, new rookeries were established as population size increased, at least partially the result of dispersal from the large Forrester Island rookery (Calkins *et al*. 1999, Raum-Suryan *et al*. 2002, ADF&G unpublished data).

Mitochondrial DNA (mtDNA) has been the primary marker used to examine Steller sea lion genetics. This marker is maternally inherited, so individuals inherit the same sequence as their mother (barring mutation) and pass that marker on to their offspring and so on. Bickham *et al*. (1996) reported on analyses of characteristics of mtDNA from 224 Steller sea lions sampled between the Commander Islands and Oregon. The researchers found a high level of genetic diversity with a large number of haplotypes occurring at a relatively low frequency (46 of 52 haplotypes with a frequency less than 0.03). Additional analyses from over 1,200 sea lions identified over 130 haplotypes range-wide (Bickham *et al*. 1998a, Ream 2002). A distinct break in the distribution of haplotypes was found between locations sampled in the western part of the range (Russia to the eastern Gulf of Alaska) and eastern locations (Southeast Alaska and Oregon), indicating restricted gene flow between two populations. These researchers speculated that the two populations did not evolve from a single maternal ancestor but rather descended from the genetic makeup of two populations that inhabited separate glacial refugia during the last ice age.

Loughlin (1997) reviewed information on genetics, together with what is known about distribution, population response, and phenotypic characteristics, to identify Steller sea lion populations. He found that the strongest support for multiple populations came from the genetics results described above, but information on distribution and movement patterns and population responses provided additional support. Loughlin concluded that Steller sea lions should be managed as two populations, an eastern population that includes all animals born on rookeries east of Cape Suckling, Alaska, and a western DPS that includes all animals born at rookeries west of Cape Suckling. NMFS accepted this recommendation and in 1997 reclassified Steller sea lions as two distinct population segments under the ESA (62 FR 24345).

Bickham *et al*. (1998a) analyzed mtDNA from an additional 191 Steller sea lions, mostly from regions not sampled in their previous study, e.g., Kuril Islands, British Columbia, and California. The results from those samples combined with previous results confirmed the high degree of genetic differentiation between eastern and western DPSs. Bickham *et al.* (1998b) also analyzed mtDNA from 36 Steller sea lions sampled in the Gulf of Alaska in 1976-1978 and compared the results with samples collected in the 1990s following the steepest population decline (Bickham *et al.* 1996). They found that the high level of haplotypic diversity previously noted for the present population had been maintained between the two sampling periods. Thus, genetic diversity of Gulf of Alaska sea lions had been retained in spite of the recent major decline in abundance. Phylogenetic analysis by Harlin-Cognato *et al.* (2006) indicates that the current genetic structure of sea lions is the result of Pleistocene glacial geology which influenced the availability of suitable rookery habitat.

Substantial additional genetic research was conducted with larger samples from throughout the of Steller sea lion range, including most rookeries in Asia. The results of these studies generally confirm the strong east/west population delineation, but differ in their description of further structure within the western DPS when looking either at mtDNA or nuclear DNA (Trujillo *et al.* 2004, Baker *et al.* 2005, Hoffman *et al.* 2006, NMFS unpublished data). A further complexity is the possibility that the geographic boundary between the western and eastern populations may be changing or possibly disappearing (Pitcher *et al.* in press 2006, NMFS unpublished).

Trujillo *et al.* (2004) examined mtDNA and nuclear DNA from the same samples to show that the population separation apparent from the mtDNA work was not clearly defined when males were taken into account. There was not a clear separation of populations based on genetics when markers from both parents were included. They suggested that the difference was either due to a faster population divergence at the mtDNA locus or that, like many other mammals, Steller sea lions show a greater level of male-mediated gene flow via immigration than in females, e.g. males tend to disperse more than females and do not show the same philopatry for their natal areas as females.

Support for this result comes from observational work in the eastern DPS with the monitoring of branded animals. Resights of animals branded as pups in one DPS have occasionally been reported at haulouts and rookeries within the other DPS. In addition, recent mtDNA work with large samples of pups from newly established rookeries in the eastern DPS has shown that some females born in the western DPS are pupping in the eastern DPS (NMFS unpublished data). Because these samples were collected from rookeries that were not yet established at the time of the ESA designation, they were not included in the original genetic studies.

Baker *et al.* (2005) using mtDNA hypothesized that a third population (Asian) may exist just west of the Commander Islands in Russia. However, they found that the line was not nearly as strong as the previous split between the eastern and western DPSs. Hoffman *et al.* (2006) followed up on the research by Baker *et al.* (2005) utilizing nuclear microsatellite markers (which is contributed by both parents) rather than mtDNA. They found that although there was strong female philopatry (as described by mtDNA methods), there was little evidence to support the separation of an Asian DPS due to potentially extensive male gene flow. Other unpublished research funded by NOAA Fisheries focusing on population structure within the western and eastern DPSs in the U.S. has shown that there may be metapopulation structure, specifically with a split at Samalga pass in the western DPS (O'Correy-Crow *et al.* submitted 2006). Conversely, of the two most recently established rookeries in the eastern DPS; about 70% of the pups born on Graves Rock were from western DPS females, and about 45% of the pups born at White Sisters were from western DPS females (NMFS unpublished, Pitcher *et al.* in press). This has potential long term implications to the viability of these populations and their management. It is possible that we are witnessing in real-time a very infrequent event in which female sea lions from one population cross over to breed in another. At this point, it appears that sea lions are only crossing (in detectable numbers) from west to east. The genetics data has been confirmed by the sighting of western DPS branded females with pups at Graves Rock and White Sisters (NMFS unpublished).

3.1.4 Population status and trends

Count data used to estimate population trend and evaluate status are of two types: counts of pups about 1 month of age and counts of animals over 1 year of age (i.e., non-pups). Counts of pups were usually made by observers on rookeries, herding the non-pups into the water, and walking through the rookery and counting the pups (Calkins and Pitcher 1982, Sease *et al.* 2001). Beginning in 2002, 126mm format aerial photography has also been used to count pups (Westlake *et al.* 1997, Snyder *et al.* 2001). In British Columbia, pup counts were made from 35mm slides taken during aerial surveys flown specifically to facilitate pup counts (vertical orientation).

Counts of pups on rookeries conducted near the end of the birthing season are nearly complete counts of pup production. These counts can be expanded to estimate approximate total population size based on an estimated ratio of pups to non-pups in the population (Calkins and Pitcher 1982, Trites and Larkin 1996). Based on estimates of birth rate and sex and age structure of a stable sea lion population from the Gulf of Alaska, Calkins and Pitcher (1982) estimated total population size was 4.5 times the number of pups born. Some pups die and disappear before the counts are made and a few are born after the counts are conducted (Trites and Larkin 1996); because of this the researchers selected 5.1 as a correction factor. It should be emphasized that this is a very general estimate of population size as several factors can affect the accuracy of this correction factor. Sex and age structure and mortality and birth rates may vary over time and among populations and require different correction factors.

Non-pups were counted in most instances from 35 mm color slides taken from aircraft during the breeding season (Calkins and Pitcher 1982, Merrick *et al.* 1987, Sease *et al.* 2001), although in recent years some counts were made from 126mm format aerial photographs. Counts from 35 mm slides and medium format photographs were highly correlated but, on average, slightly higher counts were obtained from medium-format photographs (Fritz and Stinchcomb 2005).

Counts of both pups and non-pups were used to estimate trend for the various geographic areas and sub-regions depending on availability of data (Figure 3.2). Trend analysis was conducted by linear regression of the natural logarithms of the counts by year. For the western DPS, estimates of population trend, an index to changes in absolute population abundance, were based on comparisons of counts among years at a group of sites consistently monitored since the 1970s (trend sites). Trend sites include the majority of animals observed in each survey (e.g., 72% in 1998, 75% in 2000; Sease *et al.* 2001). “Trend rookeries” are a subset of all trend sites and include all major rookeries except those on Outer and Attu Islands.

From the late 1960s through 2000, the western DPS declined over 80% in abundance, with steepest declines of approximately 15% per year occurring in the late 1980s and slower declines of about 5% per year in the 1990s (based on non-pup counts; Loughlin *et al.* 1992, Trites and Larkin 1996, Loughlin 1997, Sease and Loughlin 1999). Between 2000 and 2004, counts of non-pups on western DPS trend sites increased or were stable through much of the Alaskan range, suggesting that the decline may have stopped (Sease and Gudmundson 2002, Fritz and Stinchcomb 2005). The western DPS is now composed of about 44,800 sea lions in Alaska and approximately 16,000 in Asia.

The specific causes of the decline are not known, and the relative importance of various factors may have changed over time. While there is no consensus on the causes of the sharp decline in the 1980s or consensus on why the population declined at a slower rate through the 1990s, several factors have been proposed and have some degree of support. Direct mortality through incidental take in fisheries, commercial harvests, and illegal shooting (Perez and Loughlin 1991, Alverson 1992, Trites and Larkin 1992) has been proposed as one mechanism in the decline. A reduction in survival and possibly fecundity due to a reduced or modified prey base has frequently been proposed as a factor in the decline. This could have resulted from commercial fisheries (Fritz *et al*. 1995, Loughlin 1998) or by a major regime shift in the mid-1970s (Trenberth 1990, Springer 1998, Benson and Trites 2002, Le Boeuf and Crocker 2005, Trites *et al.* 2006a). Predation by killer whales, alone or in conjunction with other factors, may also have contributed to the declines of sea lions and other species of marine mammals in Alaska (Barrett-Lennard *et al.* 1995, Springer *et al*. 2003). It should be noted that Steller sea lions are not the only population of marine mammals to undergo a substantial decline in portions of western Alaska. Harbor seals (Pitcher 1990, Frost *et al*. 1999, Small *et al.* 2003, Ver Hoef 2003), northern fur seals (Trites 1992, Towell *et al.* 2006), and sea otters (Estes *et al.* 1998, Doroff *et al*. 2003) have all declined substantially over at least portions of the range of the western DPS of Steller sea lion.

During approximately the same period, the eastern DPS has more than doubled in size and is at its highest level in recent history, numbering 45,000 to 51,000 animals in 2002 (Pitcher *et al.* submitted). This population increased at about 3% per year from the late 1970s through 2002. Recent data from Southeast Alaska (2005) and California (2004) suggest continued population growth. Legal protection, both in the United States and Canada, probably played an important role in population growth.

3.1.4.1 Western DPS Status and Trend

The western DPS of Steller sea lion breeds on rookeries in Alaska (the U.S. portion of the western DPS) from Prince William Sound (144°W) west through the Aleutian Islands and in Russia on the Kamchatka peninsula, Kuril Islands and the Sea of Okhotsk (Bickham *et al.* 1996, Loughlin 1997). Loughlin *et al.* (1984) estimated the worldwide population of Steller sea lions was between 245,000 and 290,000 animals (including pups) in the late 1970s (1974-80). Though the genetic differences between the eastern and western DPSs were not known at the time, Loughlin *et al.* (1984) noted that 90% of the worldwide population of Steller sea lions was in the western DPS in the early 1980s (75% in the U.S. and 15% in Russia) and 10% in the eastern DPS. Loughlin *et al.* (1984) concluded that the total worldwide population size (both DPSs) was not significantly different from that estimated by Kenyon and Rice (1961) for the years 1959 and 1960, though the distribution of animals had changed. After conducting a range-wide survey in 1989, Loughlin *et al.* (1992) noted that the worldwide Steller sea lion population had declined by over 50% in the 1980s, to approximately 116,000 animals, with the entire decline occurring in the range of the western DPS.

Alaska (U.S. portion of the range)

Steller sea lions use 38 rookeries and hundreds of haul-out sites within the range of the western DPS in Alaska (Figures 3.2, 3.3, and 3.4). The first reported counts of Steller sea lions in Alaska were made in 1956-1960 (Kenyon and Rice 1961, Mathisen and Lopp 1963), and these totaled approximately 140,000 for the Gulf of Alaska (GOA) and Aleutian Islands (AI) regions (Merrick *et al.* 1987)[2][3]. Subsequent surveys showed a major decline in numbers first detected in the eastern AI in the mid-1970s (Braham *et al.* 1980). The decline spread eastward to the central GOA during the

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[2] For the western DPS of Steller sea lion in Alaska, count data have generally been combined and analyzed in six subareas (Figure 3.2), which are geographically convenient but do not necessarily reflect biologically important units. Because earlier efforts to count sea lions were concentrated in the center of their Alaskan range, evaluations of long-term trends have often been calculated for the "Kenai to Kiska" index area, which includes the central and western Gulf of Alaska and the eastern and central Aleutian Islands.

[3] Nelson (1887) reported on natural history collections taken in Alaska from 1877-1881. They estimated large numbers of Steller sea lions in the Pribilof Islands (over 25,000) and relatively low numbers throughout the Aleutian Island chain. This information seems to be based on conversations with Aleuts and their hunting experience as well as with westerners on the Pribilof Islands. Their methods are unclear and impossible to evaluate. In general, they indicate that there may have been some dense aggregations of sea lions but otherwise somewhat scarce (relative to the Pribilofs) throughout the Aleutians.

late 1970s and early 1980s and westward to the central and western AI during the early and mid 1980s (Merrick *et al.* 1987, Byrd 1989). Approximately 110,000 adult and juvenile sea lions were counted in the Kenai-Kiska region in 1976-1979, and by 1985 and 1989, counts had dropped to about 68,000 (Merrick *et al.* 1987) and 25,000 (Loughlin *et al.* 1990), respectively. Since 1990 when Steller sea lions were listed under the ESA, complete surveys have been conducted throughout their range in Alaska every one or two years (Merrick *et al.* 1991, 1992, Sease *et al.* 1993, 1999, 2001, Strick *et al.* 1997, Sease and Loughlin 1999, Sease and Gudmundson 2002, Sease and York 2003, Fritz and Stinchcomb 2005).

Steller sea lion populations in parts of the Alaskan range of the western DPS may have begun to drop between the late 1950s and the mid 1970s (Table 3.1[4]). From the mid-1970s to 1990 the overall western DPS in Alaska declined by over 70%, with the largest declines in the AI (76% to 84%) and smaller declines in the GOA (23% to 71%; Table 3.1). Between 1990 and 2000, trend site counts continued to decline, though more slowly than in the 1980s, resulting in a total reduction of almost 90% since the 1950s and 83% since the 1970 (Figure 3.5). Sub-area declines from 1990 to 2000 had a different pattern than in the 1970s-1990 period, with smaller changes in the center of the Alaskan range (western GOA and eastern and central Aleutians: -32% to +1%) and larger declines at the edges (eastern and central GOA and western Aleutians: -54% to –64%). The average rate of decline between 1990 and 2000 for all trend sites in the western DPS was 5.1% per year (Sease *et al.* 2001).

Between 2000 and 2004, Kenai-Kiska and western Alaska population trend site counts of non-pup Steller sea lions increased by 12% (Table 3.1; Fritz and Stinchcomb 2005). Increases were not spread evenly across the range in Alaska, however. Non-pup counts increased by over 20% in the eastern Aleutian Islands and in the eastern and western GOA, and by 10% in the central Aleutian Islands, but were lower by as much as 16% in the central GOA and western Aleutians (Table 3.1; Figures 3.3 and 3.4). While overall non-pup counts from 2000 to 2004 increased, counts in the western GOA and eastern AI had essentially no trend between 1990 and 2004, suggesting that western Steller sea lions in the core of their Alaskan range may currently be oscillating around a new lower mean level.

Using the methods described in Loughlin *et al.* (1992), Loughlin (1997) estimated that the non-pup U.S. portion of the western DPS totaled approximately 177,000 animals in the 1960s; 149,000 in the 1970s; 102,000 in 1985; 51,500 in 1989; and only 33,600 in 1994. Using similar methods, Loughlin and York (2000) estimated the number of non-pups in the U.S. portion of the western DPS in 2000 at about 33,000 animals. Using a different method[5], Ferrero *et al.* (2000) and Angliss and Outlaw (2005) estimated the minimum abundance of the U.S. portion of the western DPS in 1998 at 39,031 and in 2001-2004 at 38,206, respectively, a decline of over 80% since the late 1970s.

Pups have been counted less frequently than non-pups, but the overall trends since the late 1970s have been similar to counts of non-pups (Table 3.2). The number of pups counted in the Kenai-Kiska region declined by 70% from the mid-1980s to 1994, with large declines (63% to 81%) in each of the four sub-areas (Figure 3.6). From 1994 to 2001-02, Kenai-Kiska pup counts decreased

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[4] In some cases the counts shown in this table are lower than total survey counts given above (and used in some other reports) because not all sites counted in a survey are trend sites.

[5] Estimated population numbers were based on a pup multiplier (e.g., 5.1 and 4.5 were used), while the minimum population estimates were based on adding the total number of non-pups counted in an aerial survey with the “best” estimate of pups counted.

another 19%, with the largest change (-39%) observed in the central GOA. The overall decline in the number of pups in the Kenai-Kiska region from the mid-1980s through 2002 was 76%. Pup counts in the eastern GOA (not included in the Kenai-Kiska region) declined by 35% from 1994 to 2002, while in the western Aleutian Islands, pup counts declined by 50% between 1997 and 2002 (Table 3.2). Between 2001-02 and 2005, increases in pup counts were noted in the eastern and western GOA and eastern AI, while pup counts declined in the central GOA and central and western AI. In June-July 2005, a medium format aerial survey for pups was conducted from Prince William Sound to Attu Island, which provided the first complete pup count for all western DPS rookeries in Alaska (n = 9,951 pups; NMFS unpublished data). Using the “pup” estimator (4.5) yields an estimate of approximately 44,800 Steller sea lions in the range of the western DPS in Alaska.

The population of Steller sea lions on the Pribilof Islands has seen similar declines, although the trends were initiated much earlier. Elliott (1880) reported that approximately 10,000 to 12,000 animals were distributed at rookeries on both St. Paul and St. George Islands in the 1870s. Osgood *et al.* (1916) described the importance of Steller sea lions to the local community for both food and material for clothing and boats. The pups especially were favored for their meat. Between 1870 and 1890, at least 4,000 sea lions were killed on St. Paul Island and by the early 1900s the local agent noted that the hunt should cease do to a reduced population (Osgood *et al.* 1916). In 1940, Scheffer counted 800-900 adults and 300-400 pups on St. Paul and noted that the population was growing and that the sea lions interfered with the management of the fur seal herd by competing for both food and space and “creating a nuisance to the men who drive and kill the seals” (Scheffer 1946). This competition initiated a request to cull part of the population. The recommendation was to kill 50 pups a month during June, July, and August to assess the seasonal quality of the pelts.

The combination of hunting and culling appears to have kept the Pribilof sea lion population at reduced numbers, and Loughlin *et al.* (1984) reported that the breeding rookeries on St. George Island were extirpated by 1916. No pups have been reported on St. George since. In the summer of 1960, 4,000 to 5,000 non-pups and 2,866 pups were counted on Walrus Island, just offshore of St. Paul (Kenyon 1962). Between the 1960s and 2005, however, numbers of non-pups and pups on Walrus Island declined over 90%, to 322 non-pups in 2001 and only 29 pups in 2005 (Figure 3.4 and Table 3.2; Loughlin *et al.* 1984, NMFS unpublished data). The cause of the declines during the last 50 years remains unexplained. Subsistence takes of non-pups have continued on the main islands of St. Paul and St. George averaging 141 during 1992-1998, but declined to less than 100 sea lions in the latter half of the 1990s (Wolfe and L.B. Hutchinson-Scarbrough 1999). Walrus Island is the only Steller sea lion rookery still active in the Pribilofs, but pup production has declined steadily from 2,866 in 1960 to approximately 334 in 1982, 50 in 1991, 39 in 2001, and only 29 in 2005 (NMFS 1992, NMFS unpublished data, Fritz and Stinchcomb 2005).

Russia and Asia

Steller sea lions use 10 rookeries and approximately 77 haul-out sites within the range of the western DPS in Russia (Figure 3.7). Of these 77 haul-outs, three had been rookeries, but presently no breeding occurs there, 49 are active haul-out sites, 20 have been abandoned (no sea lions seen there for the past 5-10 years), and five have inadequate information to assess their status. Analysis of available data collected in the former Soviet Union indicates that in the 1960s, the Steller sea lion population totaled about 27,000 (including pups), most of which were in the Kuril Islands. Between 1969 and 1989, numbers of adult and juvenile sea lions at major rookeries and haul-outs in the Kuril Islands alone declined 74% (Merrick *et al.* 1990). By the late 1980s and early 1990s, the total Russian population had declined by approximately 50% to about 13,000 (including pups) (Burkanov and Loughlin *in press*). Since the early 1990s, the population has increased in most areas and, in 2005, is estimated to number approximately 16,000 (including pups)(Burkanov and Loughlin *in press*).

Trends in counts of non-pup and pup Steller sea lions on selected rookeries and haulout sites have varied by subarea within Russian waters (Tables 3.3 and 3.4; Figure 3.8). In the Kuril and Commander Islands and in eastern Kamchatka, Steller sea lion numbers declined through the 1970s and 1980s, but increased slightly or were stable from the early 1990s through 2005 (Figures 3.8 and 3.9). In the western Bering Sea, there are no rookeries; numbers of non-pups have plunged over 90% and since 2000, have totaled less than 100 (Table 3.3). By contrast, Steller sea lion numbers on Tuleny Island and at two rookeries in the Sea of Okhotsk (on Iony and Yamsky Islands) have increased considerably in the last 15 years. Overall, counts of non-pups on all Russian trend sites were essentially stable between 1989 and 2004 (an annual rate of change of -0.02%, which is not significantly different from 0; p=0.96) (Figure 3.9).

The Steller sea lion is listed as an endangered species under Russian legislation. While the Russian government currently has no organized program of monitoring and research, both NMFS and the Alaska SeaLife Center have programs to monitor population trends (non-pup and pup counts), estimate vital rates (branding and re-sighting), collect food habits data, and conduct other research on Steller sea lions in Russia. It is anticipated that research on Russian-Asian sea lions will continue to be supported by both institutions in the near future.

Western DPS overall

The western DPS of Steller sea lions decreased from an estimated 220,000-265,000 animals in the late 1970s to less than 50,000 in 2000. The decline began in the 1970s in the eastern Aleutian Islands (Braham *et al.* 1980), western Bering Sea/Kamchatka and the Kuril Islands. In Alaska, the decline spread and intensified east and west of the eastern Aleutians in the 1980s and persisted at a slower rate through 2000 (Sease *et al.* 2001). The 12% increase in numbers of non-pups counted in the Alaskan range of the western DPS between 2000 and 2004 was the first region-wide increase observed during more than two decades of systematic surveys. The observed increase, however, has not been spread evenly among all regions of Alaska. Increases were noted in the eastern and western Gulf of Alaska and in the eastern and central Aleutian Islands, while the decline persisted through 2004 in the central Gulf of Alaska and the western Aleutian Islands. Non-pup counts at all western DPS trend sites in Alaska in 2004 were similar to the 1998 total, but were still 33% lower than the number counted in 1990. In Russia, both pup and non-pup data indicate that sea lion numbers are increasing at Sakhalin Island and in the Sea of Okhotsk and likely at the Commander Islands. However, non-pup numbers in Kamchatka and the Kuril Islands, the former core of the Russian range, declined substantially through the late 1980s, but have increased slightly through 2005. The number of western Steller sea lions throughout its range in Alaska and Russia in 2005 is estimated at approximately 60,000 (44,800 in Alaska and 16,000 in Russia).

3.1.4.2 Eastern DPS Status and Trend

The available historical records of Steller sea lion abundance were reviewed for the eastern DPS to relate current population size with levels prior to the initiation of standardized surveys (Figure 3.10). These records provide interesting insights into relative population levels but must be interpreted with caution because the older counts were obtained by a variety of methods and during varying times of the year. Count data obtained prior to 1970 were not subjected to quantitative analyses because of intermittent availability and concerns about comparability with more recent count data. Counts of both pups and non-pups were used to estimate trends for the various geographic areas depending on availability of data

(Figures 3.11 and 3.12). Trend analysis was conducted by linear regression of the natural logarithms of the counts by year.

Population trend was analyzed by geographic regions (Southeast Alaska, British Columbia, Washington, Oregon, and California) as the data were collected by various state and federal agencies in each area. Steller sea lions, particularly juveniles, range widely (Raum-Suryan *et al*. 2002), and therefore population estimates for a particular geographic area represent the number of animals supported by the rookeries in that area and not the exact number of animals present in the area at any time. This is particularly true when large rookeries are located near jurisdictional borders such as the boundaries between Southeast Alaska and British Columbia and between Oregon and California.

Southeast Alaska

Numbers of pups counted on rookeries increased from 2,219 in 1979 to 5,510 in 2005, an annual rate of increase of 3.1% (Table 3.5). In 1979, the Forrester Island rookery complex was the only rookery in Southeast Alaska. During the early 1980s, a rookery developed at Hazy Islands, and in the early 1990s at White Sisters. Recently, two additional sites, Graves Rocks and Biali Rocks, appear to have developed into rookeries with 175 and 100 pups counted respectively at the two sites in 2005. Since 1990, nearly all the increase in pup numbers has been at the newer rookeries, as pup numbers at the Forrester Island rookery were stable ($P = 0.302$). In addition to the five rookeries, sea lions used 30 major haulouts, plus several other sites for brief periods each year, probably in conjunction with seasonal prey concentrations.

At four of five rookeries in Southeast Alaska, counts of non-pups increased substantially from 1979 to 2005 (Table 3.6). Based on 2002 pup counts, estimated Steller sea lion abundance (all age classes) in Southeast Alaska was 21,947 animals (with the 4.5 pup multiplier) or 24,873 (with the 5.1 pup multiplier); by comparison, a total of 20,160 sea lions (pups plus non-pups) were counted during the 2002 survey.

Historical data for this region are scant, yet numbers of Steller sea lions were likely relatively low during the early 1900s when there may not have been any rookeries in Southeast Alaska (Rowley 1929, Imler and Sarber 1947). Numbers have progressively increased since that time (Calkins *et al.* 1999) and are now believed to be at a historical high.

British Columbia

Counts of Steller sea lion pups increased from 941 in 1971 to 3,281 in 2002 (Table 3.7; Olesiuk and Trites 2003), an annual rate of increase of 3.2% closely paralleling the trend in Southeast Alaska. Rookeries occur at North Danger Rocks, Cape St. James, and the Scott Islands (Maggot, Triangle, Sartine, and Beresford Islands). Sea lions also use 24 major haulout sites in British Columbia (Olesiuk 2001) plus a number of other seasonal haulouts (Bigg 1988).

Extensive sea lion reduction programs were conducted at many locations in British Columbia from 1912 through 1966, and sea lions were commercially exploited during the 1960s, resulting in the population being reduced to about 30% of peak levels of the early 1900s (Bigg 1988). A major rookery, the Sea Otter Group, was eradicated by about 1940 as a result of intensive control efforts and while sea lions still used it as a haulout it no longer serves as a rookery.

The most recent survey occurred in summer, 2002 and counted 15,402 sea lions including 3,281 pups and 12,121 non-pups (Table 3.7; Olesiuk and Trites 2003). Steller sea lion abundance (all age classes) in British Columbia, based on 2002 pup counts at rookeries, was 14,765 animals (with the 4.5 pup multiplier) or 16,733 (with the 5.1 pup multiplier). Olesiuk and Trites (2003) used the raw counts and a multiplier to estimate the total number of animals present in British Columbia waters during the breeding season of 2002 at 18,400 – 19,700 individuals of all ages, including non-breeding animals associated with rookeries in Southeast Alaska and Oregon. It appears that the British Columbia Steller sea lion population has largely recovered from the low levels of the 1970s, particularly when considered in conjunction with the adjoining Southeast Alaska population (Olesiuk 2001).

Washington

No rookeries exist in the state of Washington, but Steller sea lions are present along the coast throughout the year. Four major haulouts are used, and counts of non-pups have been made during the breeding season during most years since 1991, when numbers of sea lions increased at an average of 9.2% annually (Table 3.8). These animals are assumed to be immature animals and non-breeding adults associated with rookeries from other areas. Branded juvenile sea lions from the Forrester Island rookery in Southeast Alaska (Raum-Suryan *et al.* 2002) and from the Rogue Reef rookery in Oregon (Brown unpublished data) have been observed in Washington. Older records suggest that current numbers are reduced from historical levels. Between 2,000 and 3,000 Steller sea lions were reported during August and September of 1914, 1915, and 1916 in the Carroll Island area (Kenyon and Scheffer 1959, Scheffer 1950) while the maximum observed during 60 complete surveys of Washington haulouts between 1980 and 2001 was 1,458 in October, 2000 (non-breeding season count).

Oregon

Steller sea lions occupy two rookeries, located at Rogue Reef and Orford Reef, and eight haulout sites in Oregon. The total number of non-pup sea lions counted during the breeding season surveys at all of these sites has increased from 1,461 in 1977 to 4,169 in 2002 (Table 3.8; Brown *et al.* 2002), an annual rate of increase of about 3.7%. Although not nearly as well documented, pup numbers also appear to have increased. In 1996, 685 and 335 pups were counted at Rouge Reef and Orford Reef respectively, whereas in 2002, 746 and 382 pups were counted at the two sites. These counts were made from 126mm format, aerial photographs. Steller sea lion abundance (all age classes) in Oregon, based on 2002 pup counts at rookeries, was 5,076 animals (with the 4.5 pup multiplier) or 5,753 (with the 5.1 pup multiplier). A total of 5,297 animals were actually counted during the 2002 surveys.

Historical data on Steller sea lion abundance in Oregon are sketchy. Pearson and Verts (1970) estimated the population at 1,078 animals in 1968, somewhat lower than the 1977 count of 1,461. Population size was believed to be substantially smaller than in 1925 due to extensive human-caused mortality, in part stimulated by a bounty (Pearson and Verts 1970). After 3 decades of growth, this population has recovered substantially, but the relationship of present numbers to levels during the 1800s and early 1900s is not known.

California

Steller sea lions historically occupied five major rookeries and haulouts in California (San Miquel Island, Año Nuevo Island, the Farallon Islands, Sugarloaf Island/Cape Mendocino, and Saint George Reef) that have been surveyed periodically over the last 75 years (Table 3.9). While there is a long, intermittent time series of counts for California (Bonnot 1928, Bonnot and Ripley 1948, Bartholomew and Boolootian 1960, Orr and Poulter 1967, LeBoeuf *et al.* 1991, Westlake *et al.* 1997), standardized counting techniques for state-wide surveys were not implemented until 1996.

For this reason some caution is warranted when attempting to evaluate population trend from the older data. Population trends have differed markedly at the major sites; therefore, each site is discussed separately.

Previously, Steller sea lions ranged to the Channel Islands in Southern California, primarily using San Miguel Island but also Santa Rosa Island, which were considered the southernmost rookeries and haulouts (Bonnot 1928, Rowley 1929). It appears that sea lions used these sites seasonally and bred in small numbers (Stewart *et al*. 1993). In the early and middle 20th century, perhaps 2,000 Steller sea lions occupied the Channel Islands (Bonnot and Ripley 1948). Numbers appear to have begun declining about 1938 (Bartholomew 1967), and no adults have been seen there since 1983 and no births recorded since 1982 (Stewart *et al*. 1993). Additionally, several rookery and haulout sites along the California coast, primarily south of Año Nuevo, have been abandoned, as well as a documented rookery at Seal Rocks near San Francisco (Bartholomew and Boolootian 1967, Bonnot 1928, Bonnot and Ripley 1948, Rowley 1929).

Numbers of non-pup Steller sea lions at the two central California sites, Año Nuevo and the Farallon Islands, are currently only about 20% of the levels reported between 1927 and 1964 (Table 3.9). There appears to have been a particularly steep decline in the 1960s and 1970s. Counts appear to have recently stabilized or at least the rate of decline has lessened (Hastings and Sydeman 2002). Numbers of pups born on Año Nuevo declined from about 600 to 800 during the 1960s Le Boeuf *et al*. 1991, Orr and Poulter 1967) to 152 in 1999. However, between 1996 and 2004 the number of pups counted stabilized (P = 0.656). In 2004, 221 pups were counted at Año Nuevo. Recent pup production on the Farallons has been low (Hastings and Sydeman 2002) with a maximum of 22 pups counted in 2004. During the 1920s, the Farallon Islands and Año Nuevo were identified as the most important rookeries in California (Rowley 1929), with estimates of pup production at 400 and 625, respectively (Bonnot 1928).

Steller sea lions have been counted sporadically at the Sugarloaf/Cape Mendocino rookery and haulout during breeding seasons since 1927. Non-pup numbers appear to have been relatively stable, although highly variable, since 1996. The two highest counts were 900 in 1930 and 740 in 2001 suggesting that the current population is comparable to historical levels. Pups have been counted in recent years and numbers have increased (62 in 1996 to 131 in 2004; +12.9% per year, R^2 = 0.725, P = 0.007)(Table 3.10).

The Saint George Reef rookery, located near the California/Oregon border, appears to be at a fairly high level relative to historical measures and counts of non-pups have been stable, although variable, since 1990 (Table 3.10). During 2004, 444 pups and 738 non-pups were counted at this site. Bonnot (1928) reported 1,500 Steller sea lions at Saint George Reef in 1927 and Bonnot and Ripley (1948) counted 700 animals in 1930. Pups have been counted since 1996 (except for 1997) and have increased (243 in 1996 to 444 in 2004; +9.8% per year, R^2 = 0.703, P = 0.009).

Statewide in California, total non-pup counts at these five major rookery and haulouts during the first half of the last century ranged from 4,500 to 5,600. The 2004 count at these same five sites was 1,578 non-pups and 818 pups suggesting that only about a third as many animals are currently present in the state. Nearly all of the reduction has occurred at the three southern sites. From 1996 through 2004, statewide non-pups numbers were stable, while pup numbers increased at 7.5% per year, R^2 = 0.679, P = 0.112).

An additional 1,418 Steller sea lions were counted during the 2002 survey at 41 haulout sites (with counts raging from 1 to 692 animals on these haulouts and with 15 sites with more than 25 animals) along the California coast between Saint George Reef and Año Nuevo Island. Steller sea lion abundance (all age classes) in California, based on 2002 pup counts at rookeries, was 3,209 animals (with the 4.5 pup multiplier) or 3,636 (with the 5.1 pup multiplier). However, 3,815 animals were actually counted during the 2002 survey.

Eastern DPS Overall

Overall, the eastern DPS has increased at over 3% per year since the 1970s, more than doubling in Southeast Alaska, British Columbia, and Oregon (Table 3.11). The robustness of the observed positive trend for the eastern population over the past 25-30 years was confirmed by Bayesian trend analyses conducted by Goodman (see Appendix 3 in NMFS 2006). He estimated annual growth at 3.64% for nonpups in Oregon with a 95% confidence interval of 2.42 to 4.44% and concluded that there was an extremely low probability (0.01) that the actual growth rate was lower than 2% per year. For pups in Southeast Alaska he estimated annual growth at 3.13% (95% confidence interval of 2.29 to 3.95%). The probability of a growth rate below 1.5% per year was estimated at 0.1% for the Southeast counts.

Saint George Reef rookery and Sugarloaf rookery in northern California are near levels recorded early in the 20th century, and pup production has increased since 1996. This increase is probably at least partially the result of protective legislation, enacted in both the United States and Canada during the early 1970s, that reduced mortality at a time when the population was below carrying capacity. However, numbers of animals at the Año Nuevo rookery and the Farallon Islands in central California are substantially reduced (-90%) from those reported early in the 20th century (Bonnot 1928), despite legal protection from directed human take. The former haulout/rookery at San Miguel Island is now extinct, as are several other sites previously used in California (Rowley 1929). The reason for the large declines, since the mid-1900s, in southern and central California are not known. However, sympatric populations of other pinnipeds have grown greatly over the past 75 years (Stewart *et al.* 1993). In particular, a closely related species, the California sea lion (*Zalophus californianus*), has increased greatly from at most a few thousand in the 1920s (Bonnot 1928) to between 237,000 and 244,000 in 2004 (Carretta *et al*. 2005); some aspect of a competitive relationship may have been involved in the Steller sea lion decline. Changes in the ocean environment, particularly warmer water temperatures, have also been proposed as possible factors that favored California sea lions and other pinnipeds over Steller sea lions through changes in the distribution of favored prey (Bartholomew and Boolootian 1960).

The eastern population was subjected to substantial mortality by humans, primarily due to commercial exploitation and both sanctioned and unsanctioned predator control, (Bonnot 1928, Scheffer 1946, Rowley 1929, Bonnot and Ripley 1948, Pearson and Verts 1970, Bigg 1988, Scheffer 1950). Commercial exploitation occurred primarily in the 1800s and early 1900s while unsanctioned predator control probably persisted into the 1970s in some locations. Although not well documented, there is little doubt that numbers of Steller sea lions were greatly reduced in many locations.

Within the eastern DPS, 13 rookeries and about 85 major haulout sites currently exist from Cape Fairweather (58.8°N, 137.9°W) to Año Nuevo Island (37.1°N, 122.3°W). Populations associated with 12 of these rookeries have either increased or stabilized at relatively high levels in recent years. Total population size of the eastern DPS in 2002 was estimated to range between 45,000 and 51,000 animals of all ages (Table 3.11). Additional surveys in California during 2003 and 2004 and in Southeast Alaska during 2005 suggest the population has continued to increase since the 2002 survey and likely exceeds 50,000 animals.

Conditions for Steller sea lions in the eastern DPS appear to be most favorable in the northern portion of their range. Southeast Alaska and British Columbia together account for nearly 82% of total pup production. All four rookeries founded in the past 25 years are located in northern Southeast Alaska at the northern extent of the population range. The southernmost portion of the range has contracted and the southernmost active rookery, at Año Nuevo Island, appears to have stabilized at a low population size. A somewhat similar change in Steller sea lion distribution and the establishment of new breeding sites have been noted along the Asian coast, where the southern range limit moved northward by 500-900 km over the past 50 years and several new rookeries were established (Burkanov and Loughlin *in press*).

Currently, no Steller sea lion rookeries exist within a geographical gap (993 km) between the Scott Islands Rookery off northwest Vancouver Island and Orford and Rogue Reef Rookeries in southern Oregon. It is possible that additional rookeries were once located along this coastline, and it would not be surprising to see new rookeries founded or re-established, as has occurred in Southeast Alaska, if the population continues to increase. Steller sea lion rookeries are normally located on remote, offshore islands or reefs and require adequate areas above high water levels where young pups can survive most weather conditions and adequate prey is available on a consistent basis within the foraging range of lactating females. Perhaps the limited availability of such sites has prevented the establishment of additional new rookeries.

During the 1970s the eastern DPS contained only about 10% of the total number of Steller sea lions in the U.S. The large decline in the western DPS in conjunction with the increase in the east has changed the proportional distribution dramatically with over half of U.S. Steller sea lions now belonging to the eastern DPS.

3.1.5 Vital rates

Changes in the size of a population are ultimately due to changes in one or more of its vital demographic rates. Inputs to the population are provided by reproduction of adults (e.g., birth rates, natality, fecundity; probability that a female of a given age will give birth to a pup each year) and immigration. Outputs from the population include those that leave the population through emigration or death, which can also be inversely described by rates of adult and juvenile survivorship. Estimates of vital rates are best determined in longitudinal studies of marked animals, but can also be estimated through population models fit to time series of counts of sea lions at different ages or stages (e.g., pups, non-pups).

3.1.5.1 Survival

Causes of pup mortality include drowning, starvation caused by separation from the mother, disease, parasitism, predation, crushing by larger animals, biting by other sea lions, and complications during parturition (Orr and Poulter 1967, Edie 1977, Maniscalco *et al.* 2002, 2006 ADF&G and NMFS unpublished data). Older animals may die from starvation, injuries, disease, predation, subsistence harvests, intentional shooting by humans, entanglement in marine debris, and fishery interactions (Merrick *et al.* 1987).

Calkins and Pitcher (1982) estimated mortality rates using life tables constructed from samples collected in the Gulf of Alaska in 1975-1978. The estimated overall mortality from birth to age 3 was 0.53 for females and 0.74 for males; i.e., 47% of females and 26% of males survived the first 3 years of life. Annual mortality rate decreased from 0.132 for females 3-4 years of age, to 0.121 for females 4-5 years old, to 0.112 for females 5-6 years old, and to 0.11 by the seventh year; it remained at about that level in older age classes. Male mortality rates decreased from 0.14 in the third year to 0.12 in the fifth year. Females may live to 30 years and males to about 20 (Calkins and Pitcher 1982).

York (1994) produced a revised life table for female Steller sea lions using the same data as Calkins and Pitcher (1982) but a different model. The estimated annual mortality from York's life table was 0.22 for ages

0-2, dropping to 0.07 at age 3, then increasing gradually to 0.15 by age 10 and 0.20 by age 20. Population modeling suggested that decreased juvenile survival likely played a major role in the decline of sea lions in the central Gulf of Alaska during 1975-1985 (Pascual and Adkison 1994, York 1994, Holmes and York 2003). This is supported by field observations on two major rookeries in the western DPS. The proportion of juvenile sea lions counted at Ugamak Island was much lower in 1985 and 1986 than during the 1970s, suggesting that the mortality of pups/juveniles increased between the two periods (Merrick *et al.* 1988). A decline in the proportion of juvenile animals also occurred at Marmot Island during the period 1979-1994. A very low resighting rate for pups marked at Marmot Island in 1987 and 1988 suggested that the change in proportions of age classes was due to a high rate of juvenile mortality (Chumbley *et al.* 1997).

Holmes and York (2003) and Holmes *et al.* (in review) modeled Steller sea lion pup and non-pup population trends in the CGOA and concluded that both juvenile and adult survivorship had increased since the 1980s (Figure 3.13, top panel). This approach is consistent with preliminary analyses from the current branding program which also indicates increases in survival rates at numerous sites compared to survival rates observed in the late 1980s at Marmot Island (Figure 3.13, bottom panel; NMFS 2006b); at age 3 recent survival rates converge at levels higher than Marmot Island in the 1980s. Fay and Punt (2006) also concluded that survival had increased from the 1980s but that reproductive rates had likely declined.

3.1.5.2 Reproduction and growth

Steller sea lions have a polygynous reproductive system in which a single male may mate with multiple females. Males establish territories in May in anticipation of female arrival (Pitcher and Calkins 1981). Mating occurs on land (or in the surf or intertidal zones), thus males are able to defend territories and thereby exert at least partial control over access to adult females and mating privileges. The pupping and mating season is relatively short and synchronous, probably due to the strong seasonality of the environment and the need to balance aggregation for reproductive purposes with dispersion to take advantage of distant food resources (Bartholomew 1970). In late May and early June, adult females arrive at the rookeries, where pregnant females give birth to a single pup (twinning is rare). Viable births begin in late May and continue through early July. The sex ratio of pups at birth is approximately 1:1, though biased toward slightly greater production of males (e.g., Pike and Maxwell 1958, Lowry *et al.* 1982, NMFS 1992b). Pupping occurs throughout the sea lion range between the Aleutian Islands and California, with a median pupping date of 12-13 June (Bigg 1985, Merrick 1987). Pupping tends to be synchronous within individual rookeries with 90% of pups born within a 25-day period (Pitcher *et al.* 2001). Pitcher *et al.* (2001) found the earliest mean pupping dates at Forrester Island (southeast Alaska) and the latest mean pupping dates at Ano Nuevo Island (California). Mean date of birth became progressively later both north and south of Forrester Island. They hypothesized that timing of births at rookeries is determined through selection of periods when weather conditions are generally favorable for pup survival and when adequate prey are predictably available near rookeries for lactating females. The most likely explanation for temporal variability at individual rookeries is variable nutritional status of reproductive females (Pitcher *et al.* 2001).

Detailed information on Steller sea lion reproduction has historically been obtained from examinations of reproductive tracts of dead animals. These studies have shown that female Steller sea lions reach sexual maturity at 3-6 years of age and may produce young into their early 20s (Mathisen *et al.* 1962, Pitcher and Calkins 1981). Adult females normally ovulate once each year, and most breed annually (Pitcher and Calkins 1981). Males reach sexual maturity between 3 and 7 years of age and physical maturity by age 10 (Perlov 1971, Pitcher and Calkins 1981). Males are territorial during the breeding season, and one male may breed with several females. Thorsteinson and Lensink (1962) found that 90% of males holding territories on rookeries in the western Gulf of Alaska were between 9 and 13 years of age, while Raum-Suryan *et al.* (2002) found that males marked on Marmot Island as pups first became territorial at 10 and 11 years of age.

One of the key parameters governing population growth is reproductive output (birth rate). Reproductive output may be affected by nutrition, diseases, contaminants, and other factors (Merrick *et al.* 1987, Pitcher *et al.* 1998).

In samples collected in the Gulf of Alaska in the mid-1980s, Calkins and Goodwin (1988) found that 97% of females aged 6 years and older had ovulated. Ninety-two percent of females 7-20 years old were pregnant when they were collected in October during early implantation. The pregnancy rate of sexually mature females collected during April-May (late gestation) was only 60%, indicating that a considerable amount of intrauterine mortality and/or premature births occurred after implantation. Estimates of near-term pregnancy rates of all adult females were 67% from a collection of females taken from 1975-1978 and 55% from a similar collection during the mid-1980s (Pitcher *et al.* 1998), the difference was not statistically significant between periods (P = 0.34), yet the statistical power to detect the difference was less than 0.50. However, the difference in pregnancy rates of the lactating females between the 1970s (63%) and 1980s (30%) was significant (P = 0.059). Examination of reproductive tracts from female Steller sea lions killed near Hokkaido, Japan in 1995-96 showed that the pregnancy rate for females that had ovulated was 88% (23/26) (Ishinazaka and Endo 1999). These samples were collected in January and February, so this estimated pregnancy rate was much higher compared to the late-term rates of 55-67% estimated for sea lions from Alaska.

Better body condition was correlated with a higher likelihood that a female would maintain pregnancy. Comparatively low birth rates for females from the western DPS during the 1970s and 1980s (Pitcher and Calkins 1981) coupled with elevated embryonic and fetal mortality appear to have contributed to decreased reproductive performance during the period of early decline (Pitcher and Calkins 1981, Calkins and Goodwin 1988, Pitcher *et al.* 1998, NMFS 1998a, 1998b, 2000). Age-structured models fit to observed time series of pup and non-pup counts suggest that declines in reproductive performance of females in the western DPS continued into the 1990s in some or major parts of the Alaskan range (Holmes and York 2003, Fay 2004, Holmes *et al.* in review), but may have increased in the late 1990s and 2000s in most areas (Winship and Trites 2006). Holmes *et al.* (in review) make a strong case that at least in the central GOA, natality rates have continued to decline in the 1990s and 2000s from pre-decline levels (Figure 3.13).

It is important to obtain current estimates of birth rate since the most recent estimates are from 1985-86. Historically, birth rates were estimated from the examination of reproductive tracts from collected animals, which is not currently feasible. Estimates will need to be derived from alternative techniques such as mark-resight estimation, analysis of reproductive hormone levels in feces or tissue samples, or population modeling.

Steller sea lions collected in the Gulf of Alaska during the early 1980s showed evidence of reproductive failure and reduced rates of body growth that were consistent with nutritional stress (Calkins and Goodwin 1988, Pitcher *et al.* 1998, Calkins *et al.* 1998). Lactating females were less likely to become pregnant than non-lactating females during the early decline, indicating that the energetic stress of nursing while being pregnant with another pup may have prevented some females from giving birth each year (Pitcher *et al.* 1998). During the 1970s and 1980s, 97% of sexually mature females in the western DPS were pregnant in early gestation. However, the percentage of those females that carried their pregnancy to late gestation fell to 67% during the 1970s and to 55% in the 1980s (Pitcher *et al.* 1998). Better body condition was found to increase the probability that a female would maintain pregnancy. Comparatively low birth rates for females from the western DPS during the 1970s and 1980s (Pitcher and Calkins 1981) coupled with elevated embryonic and fetal mortality appear to have contributed to decreased reproductive performance during the period of early decline (Pitcher and Calkins 1981, Calkins and Goodwin 1988, Pitcher *et al.* 1998, NMFS 1998a, 1998b, 2000). Age-structured models fit to observed time series of pup and non-pup counts suggest that declines in reproductive performance of females in the western DPS continued into the 1990s in some or major parts of the Alaskan range (Holmes and York 2003, Fay 2004, Holmes *et al.* in review), but may have increased in the late 1990s and 2000s in most areas (Winship and Trites 2006).

Merrick *et al.* (1995) compared pup sizes at different sites where Steller sea lion populations were either decreasing or increasing, to determine if decreased pup size or growth was correlated with decreasing population trend. Their results were not consistent with this hypothesis; rather, they found that pups about two to four weeks of age weighed more at western, declining rookeries in the Aleutian Islands and GOA than at eastern, stable or increasing rookeries in southeast Alaska or Oregon. While western DPS 2-4 week-old pups weighed more than those in the eastern DPS, they were not disproportionately heavy for their length (Fadely and Loughlin 2001). These size differences may arise through different growth rates, as no significant differences have been found among neonatal mass among rookeries (Brandon and Davis 1999, Adams 2000). Brandon and Davis (1999) and Adams (2000) found that pups at rookeries in areas of decline grew faster than pups from southeast Alaska. As there were no differences in milk or energy intake among pups at these rookeries, differences in growth rates may be attributable to differences in pup activity (Adams, 2000), time spent fasting between suckling bouts, or other physiological costs (Brandon *et al.* 2005). These observed differences indicate that at least this phase of reproduction may not be affected; that is, if females are able to complete their pregnancy and give birth, then the size of those pups does not appear to be compromised. Possible alternative explanations for the observed size differences are that pups were measured at different ages (i.e., pups in the GOA and Aleutian Islands may have been born earlier and therefore were older when weighed), or that over time, harsher environmental conditions in the Aleutian Islands of the GOA have selected for larger pup size. Pup condition, measured as the ratio of observed body mass to that expected based on length, seems to be a reasonable index of condition related to survival (Trites and Jonker 2000). For the pups aged between 2 and 4 weeks, there was no general relationship between pup condition and pup numbers or magnitude of decline at rookeries, though the poorest average pup conditions during the late 1990s were associated with areas of greatest decline (Fadely and Loughlin 2001). There also was evidence that pup condition was poorest during weak depressions of the Aleutian Low, and better when the Aleutian Low was stronger.

Mothers nurse pups during the day, staying with a pup for the first week, then go to sea on foraging trips. Maternal attendance patterns seem to vary over the range, with the average length of foraging trips during lactation being about 24 hours to two days at the southernmost rookery at Año Nuevo Island, California (Higgins *et al.* 1988, Hood and Ono 1997), about 25 hours at Lowrie Island, 19 hours at Fish Island, 11 hours for Chirikof Island, and 7 hours in the Aleutian Islands (Brandon and Davis, 1999). Pups generally are weaned before the next breeding season, but it is not unusual for a female to nurse her offspring for a year or more. The ramifications of nursing a pup beyond a year on pupping frequency, or survival of a second pup, are unknown.

The length of the nursing period may be an important indicator of the female's condition and ability to support her pup, and the pup's condition at weaning (and hence, the likelihood that the pup will survive the post weaning period). Steller sea lion weaning takes place away from the rookeries, over a period of time, and thus has not been directly observed in Alaska. Thorsteinson and Lensink (1962) suggested that nursing of yearlings was common at Marmot Island in 1959. Pitcher and Calkins (1981) suggested that it is more common for pups to be weaned before the end of their first year, but they also observed nursing juveniles (aged 1 - 3). Porter (1997) distinguished metabolic weaning (i.e., the end of nutritional dependence of the pup or juvenile on the mother) from behavioral weaning (i.e., the point at which the pup or juvenile no longer maintains a behavioral attachment to the mother). He also suggested that metabolic weaning is more likely a gradual process occurring over time and more likely to occur in March-April, preceding the next reproductive season. In many otariids, the length of the lactation period varies among individuals and 'weaning' occurs over a period of time, rather than at a single point of time as with phocids (Lee *et al.* 1991). Using an allometric relationship between weaning mass and maternal mass for otariids (Kovacs and Lavigne 1992), and assuming a maternal mass of 530 lbs. (240 kg) (midpoint of range of maternal masses, 386.8 - 663 lbs

(175 - 300 kg) (Calkins and Pitcher 1982), Steller sea lions could be expected to wean when achieving a body mass of 159 - 183 lbs (72 - 83 kg). According to growth data of Calkins and Pitcher (1982), this is achieved at an age of 11 months, and assuming a median pupping date of June 12, is an age reached in mid-May. A weaning age of 11 months was also used in analyses of comparative mammalian weaning by Lee *et al.* (1991). The transition to nutritional independence may, therefore, occur over a period of months as the pup begins to develop essential foraging skills, and depends less and less on the adult female. The length of the nursing period may also vary as a function of the condition of the adult female. The nature and timing of weaning is important because it determines the resources available to the pup during the more demanding winter season and, conversely, the demands placed on the mother during the same period. A bioenergetic model suggested that a 10 year old female nursing a pup in the spring had to consume twice as much energy as a same age female without a pup (Winship 2000). The maintenance of the mother-offspring bond may also limit their distribution or the area used for foraging.

Relatively little is known about the life history of sea lions during the juvenile years between weaning and maturity. Female growth is asymptotic, and reaches 87% of the asymptote during their third year (Winship *et al.* 2001), a size typically associated with puberty in female pinnipeds (Laws, 1956). Pitcher and Calkins (1981) found that females reach sexual maturity between 2-8 years of age, with an average age of first pregnancy at 4.9 ±1.2 years, and may breed into their early twenties. The available literature indicates an overall reproductive (birth) rate on the order of 55% - 70% or greater (Pike and Maxwell 1958, Gentry 1970, Pitcher and Calkins 1981, Pitcher *et al.* in press). York (1994) derived age-specific fecundity rates based on data from Calkins and Pitcher (1982). Those rates illustrate a number of important points and assumptions. First, the probability of pupping is rare (about 10%) for animals 4 years of age or younger. Second, maturation of 100% of a cohort of females occurs over a prolonged period which may be as long as 4 years (starting at age 3 or 4). Third, the reported constancy of fecundity extending from age 6 to 30 indicates that either senescence has no effect on fecundity, or our information on fecundity rates is not sufficiently detailed to allow confident estimation of age-specific rates for animals older than age 6. Given the small size of the sample taken, the latter is a more likely explanation for such an assumption. Holmes *et al.* (in review) reanalyzed the Calkins and Pitcher (1982) pregnancy data and included reproductive senescence in their life table of the 1970s central Gulf of Alaska Steller sea lion population.

For mature females, the reproductive cycle includes mating, gestation, parturition, and nursing or post- natal care. Mating occurs about one to 2 weeks after giving birth (Gentry 1970). Copulation may occur in the water, but mostly occurs on land (Pitcher and Calkins 1998, Gentry 1970, Gisiner 1985). The gestation period is probably about 50 to 51 weeks, but implantation of the blastocyst is delayed until late September or early October (Pitcher and Calkins 1981). Due to delayed implantation, the metabolic demands of a developing fetus are not imposed on the female until well into fall and winter (Winship and Trites 2003). After parturition (birth), females nurse their pups over a period of months to several years. The reproductive success of an adult female is determined by a number of factors within a cycle and over time through multiple cycles. The adult female's ability to complete this cycle successfully is largely dependent on the resources available to her. While much of the effort to explain the Steller sea lion decline has focused on juvenile survival rates, considerable evidence suggests that decreased reproductive success may also have contributed to the decline.

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

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

- The observed differences in late pregnancy rates (67% in the 1970s and 55% in the 1980s) were not statistically significant. However, the direction of the difference is consistent with the hypothesis that reproductive effort in the 1980s was compromised.
- Pitcher *et al.* (1998) did observe a statistical difference in the late season pregnancy rates of lactating females in the 1970s (63%) versus lactating females in the 1980s (30%). This difference indicates that in contrast to lactating females in the 1970s, lactating females in the 1980s were less able to support a fetus and successfully complete consecutive pregnancies.

Male growth is also asymptotic, but constant until about year 6 and thus males grow at a greater rate for a longer period than do females (Winship *et al.* 2001). Males also reach sexual maturity at about 3 - 8 years old, but do not have the physical size or skill to obtain and keep a breeding territory until they are nine years of age or older (Pitcher and Calkins 1981). A sample of 185 territorial males from Marmot, Atkins, Ugamak, Jude, and Chowiet Islands in 1959 included animals 6 - 17 years of age, with 90% from 9 - 13 years old (Thorsteinson and Lensink 1962). Males may return to the same territory for up to 7 years, but most return for no more than 3 years (Gisiner 1985). During the breeding season, males may not eat for 1 to 2 months. The rigors of fighting to obtain and hold a territory and the physiological stress of the mating season reduces their life expectancy. Males rarely live beyond their mid-teens, while females may live as long as 30 years.

3.1.5.3 Demographic modeling

Demographic analysis of age distribution information has been used to estimate demographic rates in an attempt to identify the combination of changes in birth and survival rates that might account for the observed past changes in pup and non-pup numbers across the range of the western DPS in Alaska. These analyses are hampered by sparseness and spottiness of data. There are essentially only two collections of western Steller sea lions that were large enough and well-sampled (e.g., age, past and present reproductive status, food habits, condition, blood chemistry) to be useful in modeling studies: one collected in the mid 1970s (Calkins and Pitcher 1982) and another in the mid 1980s (Calkins and Goodwin 1988). Both samples, however, were collected largely within the Kodiak archipelago, but the 1980s collection was biased toward adult females. York (1994) created a life table estimate from the 1970s collection by assuming (1) that this collection was representative of age distributions and reproductive frequencies in the entire population, (2) that the population was in stable age distribution, and (3) that there was no population growth.

At a much less detailed level, some censusing techniques distinguish between pups and non-pups in the counts at many rookeries. There are over 30 rookeries that have been censused over the years in a regular, but much less frequent than annual, rotation. If assumptions are made about the tendency of non-breeding animals of breeding age, as well as animals of below breeding age, to be present on rookeries and be included in the counts (this is not actually known yet, and is a matter of ongoing investigation in the analysis of sighting records of branded animals), the time series of counts of pups and non-pups allow some inference about crude per capita birth rates to adults, crude per capita survival rates of the adults, and rates of survival from birth until recruitment to the breeding segment of the population.

York (1994) concluded from her life table analysis that the population decline observed in the 1980s at Marmot likely was primarily owing to a large drop in juvenile survivorship compared to the 1970s, a conclusion also reached by Pascual and Adkison (1994). Holmes and York (2003) extended these analyses of central Gulf of Alaska sea lions through the late 1990s and added an index of juvenile recruitment to the model. Their results, along with those of Fay (2004), indicated a drop in juvenile survivorship from the 1970s to the 1980s, and that the slower decline rate in the 1990s was associated with increases in juvenile and adult survivorship compared to the 1980s. However, their analyses also showed an erosion in fecundity (birth rates plus pup mortality through 1 month) that began in the late 1970s and early 1980s (Holmes and York 2003, Holmes *et al.* in review).

Fay (2004) and Winship and Trites (2006) broadened the geographic scope by estimating time series of vital rates for metapopulations, or at each rookery in the Gulf of Alaska and Aleutian Islands, from 1978-2002. Results of these studies suggest that the changes in vital rates responsible for the declines likely varied among subpopulations and with time. Juvenile and adult survival rates appear to have been lowest during the 1980s for many, but not all subpopulations, while juvenile survival in the western Aleutians appears to have been lower during the 1990s than during the 1980s. With regard to changes in fecundity, Fay (2004) found evidence of DPS-wide declines in birth rates beginning in the early 1980s with little or no rebound through 2000. Winship and Trites (2006) found declines in fecundity in the central Gulf of Alaska (similar to Holmes and York 2003, Fay 2004), but not elsewhere in the range of the western DPS.

The studies attempting to estimate past demographic rates were motivated in part by a hope that these could shed light on the various possible causes for the changes in vital rates responsible for the population decline. In this, the retrospective studies have been largely inconclusive. One exception is the study by Hennen (2006) which found an association between rate of by-rookery decline and the fishing activity around the respective rookies, for the period of the 1980s but not continuing into the 1990s. Hennen (2006) did not investigate how this effect might have been partitioned among birth rates and survival rates of various age classes.

Population viability and extinction risk

Population viability analysis (PVA) attempts to predict the probability of a population going extinct, or crossing a specified threshold, over a specified period. Four simulation models of varying complexity have been constructed to assess the likelihood that Steller sea lions will go extinct in western Alaska (York *et al.* 1996, Gerber and VanBlaricom 2001, Winship and Trites 2006, NMFS 2006[6]). Some of the models treated each rookery as independent populations, while others considered metapopulations (i.e., groups of rookeries), or combined counts from all rookeries between the eastern Gulf of Alaska and the western tip of the Aleutian Islands into a single population estimate.

The rookery-based and metapopulation modeling requires assumptions about rates of migration and recolonization. Those rates are not presently known, though they are the subject of ongoing monitoring of branded animals. Each of the models used information about rates of population change that occurred in the past to infer what might happen to sea lion populations in the future.

York *et al.* (1996) developed three models corresponding to three spatial scales (a rookery model, a cluster of rookeries model, and an aggregate model for the Kenai – Kiska area). They used a model of exponential growth randomly changing annually from a distribution that remains constant over time to model counts of adult female sea lions made at the peak of the breeding season. Using counts from 1976-1994 in their retrospective analysis, the rookery model predicted that the median number of adult females on each rookery between Kenai-Kiska would decline to

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[6] The PVA in NMFS (2006; in Appendix 3) was developed by Dr. Dan Goodman in coordination with the Steller Sea Lion Recovery Team and was funded by NMFS in order to facilitate the development of recovery criteria for the recovery plan. Further citations to NMFS (2006) in the discussion of PVA recognize the work of Dr. Goodman and the recovery team.

fewer than 50 animals with 80% of the rookeries disappearing within 100 years, and fewer than 5,000 females remaining by 2015. However, some sites (Akutan, Clubbing Rocks, Ugamak Island, Sea Lion Rocks, and Akun Island) were predicted to persist beyond 100 years despite extinctions at other rookeries. The cluster model grouped Steller sea lion rookeries into 5 clusters and found a relatively high probability of persistence of the western DPS due to positive growth rates in the western Gulf of Alaska cluster. However, pooling all rookery counts within the Kenai – Kiska area to form a single breeding population, and using the rates of decline that occurred from 1976-1994 to project the future, resulted in a predictable continued decline of the western DPS. York *et al.* (1996) concluded that there was no indication that the entire population would likely go extinct within 30 years, but that populations on some rookeries would probably be reduced to low levels (fewer than 200 adult females). The rookery-based model predicted the longest mean persistence time for the Kenai-Kiska population, while the geographic model (pooling all rookery counts) predicted the shortest.

Gerber and VanBlaricom (2001) used count data from 1965-1997 to develop two viability models that evaluated the sensitivity of extinction risk to various levels of stochasticity, spatial scale, and density dependence, again assuming annual variation was the predominant process driver. The first was a metapopulation simulation model that suggested a median time to extinction of about 85 years based in the dynamics of groups of rookeries in the Central Gulf of Alaska, Western Gulf of Alaska, Eastern Aleutian Islands, and the Central Aleutian Islands. The second model was exploratory rather than tied strictly to the retrospective analysis and considered population size and population growth rates corresponding to the lowest 5% of the frequency distribution of likely growth rates. This model suggested the time to extinction was about 62 years. Gerber and VanBlaricom (2001) concluded that results from their analysis were consistent with a population threatened with extinction.

Winship and Trites (2006) used counts of both pups and non-pups from 33 rookeries between 1978 and 2002 to estimate the combination of birth and survival rates operating during the population decline. They then projected each of the 33 rookery populations into the future using these estimated site-specific life tables (with associated uncertainties). Using Bayesian statistical methods to quantify uncertainty, Winship and Trites (2006) explored 3 scenarios that incorporated different assumptions about carrying capacities and the presence or absence of density-dependent regulation. Results of all 3 scenarios indicated an overall low risk of extirpation of Steller sea lions as a species in western Alaska in the next 100 years. However, most rookeries had high probabilities of going extinct if trends observed in the 1990s continued — while fewer were predicted to go extinct if trends observed since the late 1990s persisted. All simulations identified two clusters of contiguous rookeries that had relatively low risks of extinction if their dynamics continued to be independent of the rest— the Unimak Pass area in the western Gulf of Alaska / eastern Aleutian Islands, and the Seguam – Adak region in the central Aleutian Islands. Risks of rookeries going extinct were particularly small when density-dependent compensation in birth and survival rates was assumed. Winship and Trites (2006) did not include the more drastic decline rates from the 1980s in their analysis, thereby treating this time period as a catastrophic event which was unlikely to occur again. They did not provide a rationale for this approach in their paper; yet it is a major distinction between each of the PVAs discussed here and available for consideration[7].

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[7] Winship and Trites (2006) state: "We modeled the historic decline as a catastrophe, but did not model any future catastrophes. If another catastrophe occurred in the time frame of our future simulations (100 yr), the predicted risks of extinction would have been higher than those we estimated."

The report written by Dan Goodman and commissioned by NMFS (2006) used a Bayesian framework to quantify uncertainty in model parameters and propagate this through the risk calculation. However, Goodman treated the western Steller sea lions as a single population by combining counts made at all rookeries and regions of western Alaska, and treated the dominant environmental variation as occurring on a larger than annual time scale. Such population-wide estimates were available for 6 years over the 46 years that sea lions have been counted (i.e., 1958, 1977, 1985, 1989, 2000 and 2004). In this analysis the probability of sea lions persisting for 100 to 500 years depended upon assumptions about the past operation of anthropogenic factors that will not play such a large role in the future. These specific assumptions were a joint product of a subgroup of the recovery team. Overall, this model suggested significant probabilities of sea lions declining below a threshold of 4,743 individuals (i.e., quasi-extinction) for the population as a whole within 100 years. This model allows a parsing of how unfavorable parameter values and uncertainty about parameter values both play a role in the calculated risk.

There is some degree of consistency between the predictions of all four sets of PVA models (York *et al.* 1996, Gerber and VanBlaricom 2001, Winship and Trites 2006, NMFS 2006) due in large part to their use of some of the same base population data and to the fundamental assumption of all PVA models that populations will continue to behave as they have in the past after correction for factors that will be different in the future. As such, sea lion populations (i.e., individual rookeries, clusters of rookeries, or the entire western DPS) that declined at fast rates were predicted to go extinct sooner than populations that had declined slowly. Results from the four PVAs conducted to date indicate that the western Steller sea lions have a high probability of declining to a low level if they are considered as a single homogeneous population (by combining all rookery counts and assuming an overarching population trend). However, the prognosis for the species is considerably more optimistic if each of the 33 rookeries is considered as distinct, independent populations with its own probability of persistence, and assuming that differing environmental factors around the respective rookeries remain stationary for the long term (as opposed to the possibility of rolling declines). Under this scenario, PVA models at a spatial scale smaller than the DPS predict that many rookeries will go extinct, but that the species will persist on the time frame considered, most especially if assumed density dependence plays a positive role.

The large potential influence of assumed density dependence is a common feature in the literature of PVA applications, but the statistical estimation of the strength of operation of density dependence in any particular population is notoriously problematic. Density dependence has not been established empirically in the dynamics observed in the Steller sea lion western DPS over the past 40 years.

3.1.6 Terrestrial Habitat Use

Steller sea lions use a variety of marine and terrestrial habitats. Haulouts and rookeries tend to be preferentially located on exposed rocky shoreline and wave-cut platforms (Ban 2005, Call and Loughlin 2005). Some rookeries and haulouts are also located on gravel beaches. Rookeries are nearly exclusively located on offshore islands and reefs. Terrestrial sites used by Steller sea lions tend to be associated with waters that are relatively shallow and well-mixed, with average tidal speeds and gradual bottom slopes (Ban 2005). When not on land, Steller sea lions are seen near shore and out to the edge of the continental shelf and beyond.

Female sea lions appear to select places for giving birth that are gently sloping and protected from waves (Sandegren 1970, Edie 1977). Pups normally stay on land for about two weeks, then spend an increasing amount of time in intertidal areas and swimming near shore. Mothers spend more time foraging as pups grow older and less time on shore nursing (Milette and Trites 2003). Females with pups begin dispersing from rookeries to haulouts when the pups are about 2.5 months-of-age (Raum-Suryan *et al*. 2004, Maniscalco *et al.* 2002, 2006).

Haulout is the term used to describe terrestrial areas used by adult sea lions during times other than the breeding season and by non-breeding adults and subadults throughout the year. Sites used as rookeries in the breeding season may also be used as haulouts during other times of year. Some haulouts are used year-around while others only on a seasonal basis. Sea lions are sometimes seen hauled out on jetties and breakwaters, navigational aids, floating docks, and sea ice. Many animals also use traditional rafting sites, which are places where they rest on the ocean surface in a tightly packed group (Bigg 1985, NMFS unpublished data).

Although rookeries and haulouts occur in many types of areas, sea lions display strong site fidelity to specific locations from year to year. Factors that influence the suitability of a particular area may include substrate, exposure, proximity to food resources, oceanographic conditions, tradition of use, and season (Calkins and Pitcher 1982, Ban 2005), as well as the extent and type of human activities in the region (Johnson *et al*. 1989). Thermoregulatory factors may play an important role in site selection (Gentry 1970, Sandegren 1970).

3.1.7 Marine Habitat Use

Telemetry studies show that in winter adult females may travel far out to sea into water greater than 1,000 m deep (Merrick and Loughlin 1997), and juveniles less than 3 years of age travel nearly as far (Loughlin *et al*. 2003). The Platforms of Opportunity (POP) data base maintained by NMFS shows that sea lions commonly occur near and beyond the 200 m depth contour (Kajimura and Loughlin 1988, Figure 3.14). Some individuals may enter rivers in pursuit of prey (Jameson and Kenyon 1977). In summer while on breeding rookeries, adult females attending pups tend to stay within 20 nm of the rookery (Calkins 1996, Merrick and Loughlin 1997).

Studies using satellite-linked telemetry have provided detailed information on movements of adult females and juveniles (Table 3.12). Merrick and Loughlin (1997) found that adult females tagged at rookeries in the central Gulf of Alaska and Aleutian Islands in summer made short trips to sea (mean distance 17 km, maximum 49 km) and generally stayed on the continental shelf. In winter, adult females ranged more widely (mean distance 133 km, maximum 543 km) with some moving to seamounts far offshore. Most of the pups tracked during the winter made relatively short trips to sea (mean distance 30 km), but one moved 320 km from the eastern Aleutians to the Pribilof Islands. Adult females with satellite transmitters in the Kuril Islands in summer made short at-sea movements similar to those seen in Alaska (Loughlin *et al.* 1998).

Behavioral observations indicate that lactating females spend more time at sea during winter than in the summer. Attendance cycles (consisting of one trip to sea and one visit on land) averaged about 3 days in winter and 2 days in summer (Trites and Porter 2002, Milette and Trites 2003, Trites *et al.* 2006b, Maniscalco *et al*. 2006). Time spent on shore between trips to sea averaged about 24 hours in both seasons. The winter attendance cycle of dependent pups and yearlings averaged just over 2 days, suggesting that sea lions do not accompany their mothers on foraging trips (Trites and Porter 2002, Trites *et al.* 2006b). Foraging trips by mothers of yearlings were longer on average than those by mothers of pups (Trites and Porter 2002).

Additional studies on immature Steller sea lions indicate three types of movements: long-range trips (greater than 15 km and greater than 20 h), short-range trips (less than 15 km and less than 20 h), and transits to other sites. Long-range trips started around 9 months of age and likely occurred most frequently around the time of weaning while short-range trips happened almost daily (0.9 trips/day, n = 426 trips). Transits began as early as 2.5-3 months of age, occurred more often after 9 months of age, and ranged between 6.5 - 454 km (ADF&G unpublished data, Loughlin *et al.* 2003). Some of the transit and short-range trips occurred along shore, while long-range trips were often offshore, particularly as ontogenetic changes occurred.

Overall, the available data suggest two types of distribution at sea by Steller sea lions: 1) less than 20 km from rookeries and haulout sites for adult females with pups, pups, and juveniles, and 2) much larger areas (greater than 20 km) where these and other animals may range to find optimal foraging conditions once they are no longer tied to rookeries and haulout sites for nursing and reproduction. Loughlin (1993) observed large seasonal differences in foraging ranges that may have been associated with seasonal movements of prey, and Merrick (1995) concluded on the basis of available telemetry data that seasonal changes in home range were related to prey availability.

3.1.7.1 Foraging Behavior: Published Telemetry Studies

Adult foraging behavior

Limited data are available concerning the foraging behavior of adult Steller sea lions. Adult females alternate trips to sea to feed with periods on shore when they haul out to rest, care for pups, breed, and avoid marine predators. Conversely, territorial males may fast for extended periods during the breeding season when they mostly remain on land (Spalding 1964, Gentry 1970, Withrow 1982, Gisiner 1985). Females with dependent young are constrained to feeding relatively close to rookeries and haulouts because they must return at regular intervals to feed their offspring.

Merrick *et al.* (1994) and Merrick and Loughlin (1997) present information on the dive characteristics and foraging behavior of a small sample of adult Steller sea lions in Alaska; Loughlin *et al.* (1998) provided similar information for the Kuril Islands, Russia. Merrick *et al.* (1990) and Brandon (2000) presented information on attendance behavior of adult females with VHF radio-transmitters in the Kuril Islands and Alaska, respectively. Trites and Porter (2002) and Milette and Trites (2003) documented attendance patterns from behavioral observations. These studies showed that during the breeding season, adult female Steller sea lions generally spent about half their time at sea on relatively brief (about 0.8 days) foraging trips. Dives tended to be shallow (mean = 21 m), brief (mean = 1.4 min), and frequent (about 13 per hour) (Table 3.13). Observations during winter showed that females with suckling yearlings (19-21 months of age) had feeding trips of about 2.5 d while those with young-of-the-years (7-9 months of age) had trips lasting 2.0 d; time on shore for lactating females averaged 15.4 h (Trites and Porter 2002). Merrick and Loughlin (1997) found that during summer adult females made trips to sea that averaged 17 km from the rookery (range 3-49 km; SE = 4.6; Table 3.12). Outside of the breeding and pupping season, movements may be less constrained although animals still return to coastal haulouts to rest. For adult females tracked during winter by Merrick and Loughlin (1997), the mean trip duration was 204 hours and average distance moved offshore was 133 km (range 5-543 km; SE = 59.9).

In Southeast Alaska, adult females with pups made relatively brief foraging trips (mean 19.1 hr) while those with yearlings or without pups were much longer in duration; during winter female trips to sea had a mean of 56.1 hr with a maximum of 169 hr. (Swain 1996). Those females with pups remained within 20 nm of the rookery and mean foraging distance from the Hazy Island and Forrester Island rookery complex was 14.5 km offshore (Calkins 1996).

Additional research integrating three separate electronic devices has provided some fine-scale information on Steller sea lion foraging. The combined data (collected from a stomach temperature transmitter that indicates when Steller sea lions ingest prey, a data logger that records depth and velocity, and a SDR to determine locations) provide insights to when and where Steller sea lions may be foraging. Andrews *et al.* (2002) used this approach on adult females in summer at Forrester Island (SE) and Seguam Island (BSAI) in 1994 and 1997; the data indicated nearly all prey ingestion occurred when animals repeatedly exhibited deep dives (greater than 10m), and that prey was ingested during all at-sea trips that included such foraging dives. However, long periods of time often elapsed and large distances were covered between successful foraging events. Adult females began foraging dives greater than 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.

Juvenile foraging behavior

The need to understand the behavior of juvenile Steller sea lions has focused research effort in recent years and resulted in a relatively large sample data set for animals less than 3 years of age (Loughlin *et al.* 2003, Raum-Suryan *et al.* 2004, Rehberg 2005, Pitcher *et al.* 2005, Fadely *et al.* 2005) (Tables 3.12 and 3.13). In general, juveniles in their second year are capable of diving to adult depths but tend not to as often as older animals (Loughlin *et al.* 2003, Rehberg 2005). Rehberg (2005) found that young-of-year sea lions also tend to increase the greater relative proportion of their swimming and diving behavior from diurnal to nocturnal periods. Mean dive depth and duration increases with age and is predicted to increase in a positive relationship with body mass up to about 10 years of age (Pitcher *et al.* 2005). Tagged young-of-the-year animals during winter made trips offshore and along shore that averaged 15 hours long and extended to an average of 30 km (range 1-320 km; SE = 14.5). Loughlin *et al.* (2003) defined three types of movements that vary with age and body mass for juvenile Steller sea lions at sea: 1) transits between land sites with a mean distance of 66.6 km; 2), long-range trips (less than 15 km and greater than 20 hours); and 3) short-range trips (less than 15 km and less than 20 hours). Likewise, Raum-Suryan *et al.* (2002) reported that greater than 90% of round trips were less than 15 km from haul-outs and 84% were less than 20 hours in duration.

3.1.7.2 Foraging Behavior: Unpublished Dive-Filtered Telemetry Data

To investigate foraging behavior, an analysis of juvenile Steller sea lion dive locations was completed using satellite telemetry data obtained from 2000 to 2005 following the same methods used and presented NMFS (2003) (NMFS 2006b). The previous analysis was based on summarized telemetry data collected from 63 sea lions by the National Marine Mammal Laboratory (NMML) during 2000 to 2003. The current analysis was updated with data from satellite tag deployments performed by the Alaska Department of Fish and Game (ADFG) and NMML deployments since the time of the previous analysis, and updates text, tables, and graphic representations (NMFS 2006b). Results from the current analysis were used to update tables II-6 (Table 3.14), II-7 (Table 3.15), II-9 (Table 3.16) of NMFS (2003), and added Table 3.17.

NMML captured and equipped 23 juvenile Steller sea lions with satellite linked time depth recorders (SDRs) since 2003. Additionally, ADFG and NMML collaborated to combine their respective Steller sea lion satellite tagging databases. As a result of this effort 32 Steller sea lions captured by ADFG from 2000-2002 were also included. A total of 116 animals (63 previous, 53 new) ranging in age from 3-26 months old at time of capture were used in this updated analysis (Table 3.18).

The previous analysis in NMFS (2003) used 10,006 dive associated locations from the 63 animals. In this updated analysis all locations that were transmitted from land (based on the “akland polygon” GIS cover) were removed (NMFS 2006b). This reduced the 10,006 locations from the previous NMFS (2003) dataset to 8,141 at-sea locations. Also, the previous analysis used locations that had an Argos Location Class (LC) of 3, 2, 1, 0, or A, were associated with diving to >4 m, and were wet at the time of transmission.

Determination of wet or dry status at the time of transmission can be derived from two data sources: 1) land/sea status message, and 2) timeline data. The previous analysis determined whether the satellite tag was wet or dry from the land/sea data message only. However, including timeline data that indicated wet or dry status when the land/sea data did not added 172 correctly classified locations. This analysis uses both land/sea and timeline data to determine if a location was wet or dry at the time of transmission.

A total of 65,150 locations from all 116 animals were extracted from the database for processing and 14,441 (22.17%) were used in the new analysis presented in the new tables (Table 3.19) and figures (Figures 15-19). The remaining 50,709 locations were removed because they were LC B (14,587 or 22.39%), did not fit the dive >4 m criteria (12,335 or 18.39%), were on land locations (9,281 or 14.25%), were determined invalid due to duplicity, time of transmission, poor quality (LC Z) or were calculated prior to deployment (6,703 or 10.29%), were determined to be dry at the time of transmission (5,307 or 8.15%), or due to other error-checking (2,496 or 3.83%) (Table 3.19).

Compared to the data available for NMFS (2003), sample sizes for winter locations are doubled, Prince William Sound was added as a new area (Figure 3.15), and 17 new deployments were made in the Central Aleutian Islands (Figure 3.19). In general results suggest a slightly decreased proportion of dive-associated locations within the 0-10 nm zone, and increased use of habitats >20 nm from shore or nearest listed haulouts or rookeries (Table 3.14) compared to the NMFS (2003) analysis. Distributions of proportions of dive-associated locations were similar whether based on distance from shore or distance from the nearest listed haulout or rookery (Table 3.14), but it is important to note that these distance measures are not directly comparable. That is, though a location may have been >20 nm from a nearest listed haulout or rookery, that location could have been anywhere between adjacent to shore to >20 nm from the nearest point of land (see Figure 3.15 for examples). Tables 3.14-17 and Figures 3.15-19 are all based on distances of dive-associated locations from the nearest listed haulout or rookery. Most locations >20 nm from a listed haulout or rookery fell outside critical habitat (Table 3.14).

Juvenile sea lions >10 months old had a greater proportion of dive-associated locations in zones >10 nm than did 3-10 month olds in both summer and winter (Table 3.15). Juveniles >10 months old also showed nearly equal use of the 10-20 nm zone during summer and winter, but a much greater use of habitats >20 nm in summer compared to winter periods (Table 3.15).

Regional differences in habitat use were evident (Table 3.17, Figures 3.15-19). In particular, dive-associated locations in the Central-Western Aleutian Islands area showed a much greater use of habitats >20 nm from the nearest listed haulout or rookery than in other areas, and 22% of the >20 nm zone locations in summer were outside of critical habitat (Table 3.17, Figure 3.19). Most of these locations were in the Bering Sea (Figure 3.19).

3.1.8 Prey

Steller sea lions are generalist predators that eat a variety of fishes and cephalopods (Pitcher 1981, Calkins and Goodwin 1988, NMFS 2000, Sinclair and Zeppelin 2002), and occasionally other marine mammals and birds (Gentry and Johnson 1981, Pitcher and Fay 1982, Daniel and Schneeweis 1992, Calkins 1988). The feeding ecology of Steller sea lions has been described in detail in various NMFS documents including the initial Steller Sea Lion Recovery Plan (NMFS 1992), revised draft Steller Sea Lion Recovery Plan (NMFS 2006), and in previous Section 7 consultations under the ESA (NMFS 1998, 2000, 2001, and 2003). Readers are referred to those documents for additional information.

3.1.8.1 Prey Consumption

The diet of Steller sea lions in the eastern part of their range was not well studied prior to the early 1990s. In California and Oregon they are known to have eaten rockfish, hake, flatfish, salmon, herring, skates, cusk eel, lamprey, squid, and octopus (Fiscus and Baines 1966, Jameson and Kenyon 1977, Jones 1981, Treacy 1985, Brown *et al.* 2002). Principal prey in British Columbia has included hake, herring, octopus, Pacific cod, rockfish, and salmon (Spalding 1964, Olesiuk *et al.* 1990). The most commonly identified prey items in Southeast Alaska were walleye pollock, Pacific cod, flatfishes, rockfishes, herring, salmon, sand lance, skates, squid, and octopus (Calkins and Goodwin 1988, Trites *et al.* 2006d).

Considerable effort has been devoted to describing the diet of Steller sea lions in the Gulf of Alaska, Aleutian Islands, and Bering Sea (Table 3.20; NMFS 2000). In the mid 1970s and mid 1980s, Pitcher (1981; n = 250) and Calkins and Goodwin (1988; n = 178) described Steller sea lion diet in the Gulf of Alaska by examining stomach contents of animals collected for scientific studies. Walleye pollock was the principal prey in both studies; octopus, squid, herring, Pacific cod, flatfishes, capelin, and sand lance were also consumed frequently. Stomachs of Steller sea lions collected in the central and western Bering Sea in March-April 1981 contained mostly pollock and also Pacific cod, herring, sculpins, octopus, and squid (Calkins 1998).

Merrick and Calkins (1996) analyzed Kodiak Island region sea lion stomach contents (n = 263) data from the 1970s and 1980s for seasonal patterns of prey use (see NMFS 2000 their Table 5.2). They found a significant seasonal difference in diet for the 1970s. Walleye pollock was the most important prey in all seasons except summer in the 1970s, when the most frequently eaten prey type was small forage fishes (capelin, herring, and sand lance). No significant seasonal differences were found in the 1980s. Researchers noted that, overall, small forage fishes and salmon were eaten almost exclusively during summer, while other fishes and cephalopods were eaten more frequently in spring and fall.

NMFS (2000; their Table 4.4 and Figure 4.5) compiled all the available data on prey occurrence in stomach contents samples for the eastern and western Steller sea lion populations for the 1950s - 1970s and the 1980s. For both populations the occurrences of pollock, Pacific cod, and herring were higher in the 1980s than in the 1950s -1970s. These results suggest that the dominance of pollock in the Steller sea lion diet over much of its range may have changed over time. However, studies completed prior to the mid-1970s had small sample sizes and more limited geographic scope. As such, caution should be exercised when extrapolating from these limited samples to a description of the diet composition of Steller sea lions in the 1950s - 1970s.

At the far western end of the Steller sea lion range, Atka mackerel, sand lance, rockfish, and octopus were identified as important foods at the Kuril Islands in colletions made in 1962 (Panina 1966), and pollock, Pacific cod, saffron cod, cephalopods, and flatfish were the main prey of 62 animals collected near Hokkaido, Japan from 1994 to 1996 (Goto and Shimazaki 1998).

Stomach contents analysis indicates that Steller sea lions have a mixed diet. Although it is not uncommon to find stomachs that contain only one prey species, most collected stomachs contained more than one type of prey (Merrick and Calkins 1996, Calkins 1998). Merrick and Calkins (1996) found that the probability of stomachs containing only pollock was higher for juveniles than for adults, and small forage fish were eaten more frequently by juveniles while flatfish and cephalopods were eaten by adults more frequently.

Since 1990, additional information on Steller sea lion diet in Alaska has been obtained by analyzing scats collected on rookeries and haulouts (Merrick *et al.* 1997, NMFS 2000, Sinclair and Zeppelin 2002, NMFS 2006b, Womble and Sigler 2006). Scat data, like stomach contents, may be biased (e.g., prey species may have hard parts that are more or less likely to make it though the digestive tract; see Cottrell and Trites 2002, Tollit *et al.* 2003, 2004a), but they allow a description of prey used over a wide geographic range from Kodiak Island through the western Aleutian Islands and for both summer and winter (Table 3.20). Analysis of scats collected in the 1990s (Sinclair and Zeppelin 2002) and from 1999-2005 (Table 3.21 and Figure 3.20) show that pollock continue to be a dominant prey in the Gulf of Alaska and eastern Aleutians and that Atka mackerel was the most frequently occurring prey in central and western Aleutian Islands scats. Pacific cod is also an important prey, especially in the winter in the Gulf of Alaska, while salmon was eaten most frequently during the summer months. Results also indicated a wide variation; certain species that appear to be minor dietary items when data are tabulated for large regions may actually be highly ranked prey for specific rookeries and seasons (Sinclair and Zeppelin 2002, Womble and Sigler 2006).

Steller sea lion scat and stomach contents data have not been extensively examined for possible sex-related differences in diet. However, Trites and Calkins (unpublished data) collected scat on three rookeries and a nearby male haulout and found that salmon and herring dominated the summer scats of lactating females, while pollock and rockfish dominated the scat of breeding-age males.

3.1.8.2 Prey Characteristics

The primary prey of Steller sea lions are fish and cephalopods, which tend to have a broad, but predictable range in temporal, spatial, and seasonal nearshore availability. Typically, many prey species make predictable seasonal migrations from pelagic to nearshore waters where they form large spawning concentrations. Prey is then further concentrated by local transition boundaries such as frontal zones and bathymetric features such as submarine channels (Sinclair *et al.* 1994). Steller sea lions appear to have the foraging flexibility to take advantage of both the predictable behavioral traits of these prey species (Sigler *et al.* 2004), as well as the localized oceanographic conditions that enhance prey concentrations (Sinclair and Zeppelin 2002, Trites *et al.* 2006a). Steller sea lions are able to respond to changes in prey abundance. An example is the increase in consumption of arrowtooth flounder in the Gulf of Alaska between the 1970s (Pitcher 1981) and the 1990s (Sinclair and Zeppelin 2002). Another example is the geographic variation in diet observed during the 1980s and 1990s; east to west the primary prey varies from Pacific hake (Brown *et al.* 2002) to walleye pollock and then to Atka mackerel (Sinclair and Zeppelin 2002).

Prey species can be grouped into those that tend to be consumed seasonally, when they become locally abundant or aggregated when spawning (e.g., herring, Pacific cod, eulachon, capelin, salmon and Irish lords), and those that are consumed and available to sea lions more or less year-round (e.g., pollock, cephalopods, Atka mackerel, arrowtooth flounder, rock sole and sand lance; based on Pitcher 1981, Calkins and Goodwin 1988, Sinclair and Zeppelin 2002, Trites *et al.* 2006d, Womble and Sigler 2006). Some of the seasonal prey species occur most frequently in summer and fall (e.g., salmon and Irish lords) or winter and spring (e.g., herring, Pacific cod, eulachon, and capelin). There are also significant regional differences in the occurrences of some species (e.g., Atka mackerel are only in the Aleutian Islands, and arrowtooth flounder occur in the Gulf of Alaska).

Prey size varies greatly ranging from several centimeters in length for species such as sandlance and capelin to over 60 cm in length such as salmon, skates, Pollock and cod. Remains of pollock exceeding 70 cm in length have been recovered in Steller sea lion scats (Tollit *et al.* 2004b, Zeppelin *et al.* 2004). Walleye pollock otoliths recovered from stomachs collected in the Bering Sea and Gulf of Alaska have shown that all age classes of sea lions eat a wide range of sizes (Calkins and Goodwin 1988, Frost and Lowry 1986, Lowry *et al.* 1989, Merrick and Calkins 1996, Calkins 1998). The overlap in the size distribution of pollock and Atka mackerel taken by Steller sea lions and commercial fisheries was revisited by Tollit *et al.* (2004b) and Zeppelin *et al.* (2004). Their results indicate that sea lions consume larger fish than previously estimated and that the overlap in size was 68% for pollock and 53% for Atka mackerel (Zeppelin *et al.* 2004; samples from the winter of 1998 to the summer of 2000)(Figure 3.21). Analysis of scats containing Pacific cod (Table 3.22) indicates that in the summer 75% of the Pacific cod eaten are very large (35-60 cm) and in the winter 60% are very large (NMFS 2006b).

Prey quality is also an important factor which may change both seasonally and geographically. Schaufler *et al.* (2006) examined geographical variation in Steller sea lion prey quality between the western and eastern

DPSs. They collected and analyzed over 1,200 whole fish representing sea lion prey species from the Aleutian Islands and southeastern Alaska. Overall, the mean energy density for 22 forage species from southeastern Alaska (1.62 ± 0.02 kcal per g on a wet weight basis) was greater than that of 15 species from the Aleutians (1.44 ± 0.03 kcal per g). Arrowtooth flounder, sandfish and squid had significantly higher energy density in southeastern Alaska than the Aleutians. Pacific cod, on the other hand, had a significantly higher energy density in the Aleutians, as did rockfish. Overall, this study suggests that sea lions encounter (on average) a prey field in the Aleutian Islands with lower energy density than in Southeast Alaska. Pollock from both regions had similar estimated energy densities, which is of particular interest because some of the sharpest declines in sea lion populations have occurred in areas where pollock dominates the diet and pollock is a major component of the diet of both stocks. In other words, the results suggest that the quality of pollock in both regions is similar and is not likely to be a factor in the decline. Comparisons of average energy densities for other species collected from both regions revealed differences that could be attributed to factors other than geographical location. For instance, Aleutian Pacific cod were larger than those from Southeast Alaska. The size-related increases in energy density may be related to changes in energy allocation with age.

Kitts *et al.* (2004) examined the seasonal changes in proximate nutrients of pollock collected in the Bering Sea. Mean energy density (dry mass) of pollock peaked in October then declined and remained low throughout winter. Energy recovery occurred in the summer months (post-spawning) with strong recovery observed in female fish caught in July. Contrary to whole fish carcass energy contents, both total protein and moisture contents were at their highest levels in winter (January) when total crude lipid content was at its lowest ($p < 0.05$). This trend gradually declined to its lowest levels in the fall when lipid content was high. The decline in total lipids during winter seasons appeared to parallel gonad development during the pre-spawning period. The authors concluded that the nutrient content of walleye pollock may have some impact on the Steller sea lions that feed on them, particularly the energetic value that appears to be relatively low during important feeding periods.

3.1.9 Nutritional Requirements

The amount of food required to provide for energetic needs can vary greatly depending on the energy content of the food and physiological status of the animal (Innes *et al.* 1987). Steller sea lion pups grow rapidly during their first weeks of life and require a substantial intake of energy that is supplied by the mother. Nursing Steller sea lion pups at Año Nuevo Island consumed 1.5 to 2.4 liters of milk per day with a fat content of 23 to 25% (Higgins *et al.* 1988).

Nutritional requirements for free-ranging Steller sea lions have not been measured. Kastelein *et al.* (1990) provided data on food consumption of 10 animals kept in captivity and fed a diet that included several fish species and squid. Average daily consumption increased from 4 to 6 kg per day for 1 year olds to 10-13 kg per day at age 5, with males generally eating more than females. An adult male ate 18kg per day on average, and females increased their daily requirement by approximately 30% when they became sexually mature and produced pups

Keyes (1968) concluded that adult, non-pregnant, non-lactating pinnipeds would require 6 to 10% of their body weight in food per day. Similarly, captive feeding experiments with 1 to 2 year olds indicate that the daily maximum digestive limit of Steller sea lions (in terms of weight of prey consumed) is equivalent to about 14 to 16% of their body weight (Rosen and Trites 2004).

Kastelein *et al.* (1990) estimated that the amount of food found in Steller sea lion stomachs has usually been on the order of one-fourth of their average daily requirements but did not account for digestion suggesting that meal sizes may at times be much larger. The stomach of a 311 kg sea lion collected in the Bering Sea contained 24 kg of partially digested pollock, which amounted to 7.7% of the animal's body weight (L. Lowry unpublished data). Kastelein *et al.* (1990) also reported that after a day of fasting, captive Steller sea lions ate meals that were about 25% larger than their daily average leading the authors to surmise that large sea lions have a relatively large stomach capacity, which is probably an adaptation that allows them to feed at infrequent intervals.

Winship *et al.* (2002) used bioenergetic modeling to estimate the food requirements of free-ranging Steller sea lions. The model incorporated information on age- and sex-specific bioenergetics of individual animals, population size and composition, and the composition and energy content of the diet. Their model predicted that juvenile animals have higher mass-specific food requirements than adults (greater than 10% versus 5 to 6% of body mass per day) and that a lactating female needs to consume about 70% more food on average if her pup is entirely dependent on her for energy during its first year of life. The mean predicted food requirement of an average Steller sea lion consuming an average Alaskan diet was 17 kg per day.

When assessing the suitability of prey for Steller sea lions in the wild, the important issue is the net amount of nutrition that can be gained from time spent feeding. Nutrition to be gained must take into account energy value of the prey as well as protein, vitamins, minerals, and micronutrients. Quantifying the biological value of prey species and the physiological consequences of inadequate prey is an area where laboratory studies can provide important data. For example, the energetic differences between prey species cannot be solely calculated from measures of gross energy content. The differences in energy due to lipid and protein composition are exaggerated by even higher losses from the heat increment of feeding and digestive efficiency of pollock (Rosen and Trites 1997, 2000b).

Steller sea lions, at least adult females and juveniles, are unlike most marine mammals that store large amounts of fat to allow periods of fasting. Sea lions need more or less continuous access to food resources throughout the year as described in Figure 3.22, a schematic of the sea lion life cycle with an emphasis on reproduction. The sensitivity of sea lions to competition from fisheries may be higher 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 increased by harsh environmental conditions.

There are few data available to determine the global prey requirements for Steller sea lions within critical habitat. The best information available is the analysis that was presented in the 2001 Biological Opinion (NMFS 2001) in Section 5.3.3. In that analysis, NMFS investigated the amount of biomass available by area in the EBS, AI, and GOA and the amount of prey the local populations of Steller sea lions may consume. A number of assumptions were made in the analysis and the reader should review Section 5.3.3. of NMFS (2001) for details of that exercise.

The forage ratios in 2000 for the Eastern Bering Sea, Aleutian Islands, and Gulf of Alaska are provided in Table 3.23. The forage ratio for sea lions in the Eastern Bering Sea (Table 3.23) is 446, much higher than the ratio of 46 for a "healthy" stock of Steller sea lions foraging on a theoretical, unfished groundfish population. Such a high ratio indicates that forage may be plentiful in the Eastern Bering Sea at least at the gross annual assessment. The forage ratio for the GOA was 17 and AI was only 11, substantially lower than the EBS and also well below the theoretical "healthy" range. This represents 37% of the needed biomass in the GOA and 24% in the AI. Interpretation of these ratios is difficult without further information on the seasonal availability, distribution and patchiness, and the fishery removals. However, this does indicate that fishery removals are more likely to be adverse in the AI and GOA where prey biomass may already be below that necessary to support a recovered sea lion population. Recent oceanographic information on these areas generally agree with forage ratio results that these areas may be less productive and more sensitive to fishery removals, especially in the Aleutian Islands (Ladd *et al.* 2005, Hunt and Stabeno 2005, Stabeno *et al.* 2005).

3.1.10 Ontogeny of Steller Sea Lions - Physiology

Fundamental to an evaluation of the effects of commercial fisheries on Steller sea lions is an understanding of the physiological adaptations that underlie the sea lion's role in the Bering Sea and Gulf of Alaska ecosystems. Steller sea lions spend time on land at rookeries and haulout sites for reproduction, lactation, molting and resting, and undertake foraging trips to sea. The relative time spent at sea depends upon age and size, season, reproductive status, and the availability of forage (Boyd 1995 and 1996). Trips to sea may be made for a variety of reasons, for foraging but also for seasonal or age-specific movements along the coast. While foraging, swimming and diving behavior are controlled by a compromise between the necessity to breathe at the surface and to submerge to seek and consume prey. In addition to the abundance and distribution of prey, the time a sea lion spends submerged will depend upon physiological adaptations for maximizing time underwater. This will be a result of the how fast oxygen stores are utilized (i.e., metabolic rate), and how much oxygen is stored in the body, and the conflicting demands of diving and exercise (Castellini 1991, Boyd 1997). Pinnipeds exhibit many physiological strategies to increase dive duration (Boyd and Croxall 1996, Boyd 1997). A description of the physiological development of foraging is described below.

3.1.10.1 Physiology at Birth

The breeding season extends from May to early August and peak pupping occurs during late June (Merrick *et al.* 1995, Pitcher *et al.* 2001). Adult females spend 2 to 3 days on the rookery prior to parturition (Higgins *et al.* 1988) before giving birth to a single pup. Pups nurse within 2 hours of birth and durations of suckling bouts are similar for males and females, increasing from an average of 11 minutes during the first week of life to approximately 21 minutes by 5 weeks of age (Higgins *et al.* 1988). Overall, female pups ($\bar{x}$ = 26.2 kg, SE = 0.2) ranging in ages up to one month old are significantly lighter than male pups ($\bar{x}$ = 30.5 kg, SE = 0.3; Merrick *et al.* 1995). These results are similar to Brandon *et al.* (2005) who found that female neonates (1 to 5 days old) weighed an average of 19.6 kg (1.80 SD) at birth, which was 15 % less than that of males ($\bar{x}$ = 22.6 kg, SD = 2.21). Additionally, Brandon *et al.* (2005) found that standard length and axillary girth of female neonates were significantly less than corresponding data for male neonates. Both male and female pups gain 1.0 to 2.3% of their birth weight per day during the first six weeks, which is greater than growth rates reported for most species of otariids (Brandon *et al.* 2005). Because neonatal mass differed between males and females, but growth rates were similar, Brandon *et al.* (2005) suggested maternal investment was greater in male pups during gestation, but not during early lactation.

At birth, blood chemistry and hematology values are similar between males and females and neonates have greater levels of hematocrit (Hct), hemoglobin (Hb), and mean corpuscular hemoglobin concentration (MCHC) than older pups (Rea *et al.* 1998, Richmond *et al.* 2005). Richmond *et al.* (2005) examined the development of diving physiology for juvenile Steller sea lions (1-29 months old) and found that hematology values decreased after birth, reached a minimum in animals of approximately 3 months of age, and then increased until 9 months of age when values were similar to those of older age classes of Steller sea lions. Although it is difficult to determine whether differences in hematological values are a result of nutritional status or age, this trend is typical for other mammalian neonates (Rea *et al.* 1998). Plasma water content also increases with age as fat concentration in the milk decreases over the course of lactation (Rea *et al.* 1998).

After birth, mothers nurse their pups for 3-12 days before starting a series of trips to sea, which range in duration from 7-62 hours depending on geographic location (Higgins *et al.* 1988, Hood and Ono 1997, Brandon 2000). Pup gender does not appear to influence maternal attendance patterns (the cycle of time at sea and time on shore), but mothers increase their time at sea as pups get older (Higgins *et al.* 1988). Pups remain on the rookery for the first few weeks of life while females forage at sea (Gentry 1970, Higgins *et al.* 1988, Hood and Ono 1997, Trites and Porter 2002) and enter the water 2 to 4 weeks after birth to play in shallow water around the periphery of the rookery (Sandegren 1970). During this time there is a significant increase in time spent swimming as pups age (Hood and Ono 1997). Eventually, pups start accompanying their mother to sea on short trips when they reach approximately 1 month of age (Sandegren 1970).

3.1.10.2 Dispersal from Rookeries and Foraging

Steller sea lion pups presumably disperse from the rookery with their mother 2 to 3 months after birth (Calkins and Pitcher 1982, Merrick *et al.* 1988, Raum-Suryan *et al.* 2004). Female Steller sea lions and their pups adopt a strategy of central place and multiple central place foraging to deal with the temporal and spatial distribution of prey resources (Raum-Suryan *et al.* 2004). As pups get older, it is believed they make independent trips away from haulout sites while their mothers are at sea (Trites and Porter 2002). During winter, trips by females with pups and older juveniles average 2.0 and 2.5 days, respectively (Trites and Porter 2002). Timing of weaning is not well understood, but occurs as early as 4 months to as late as 3 years of age (Pitcher and Calkins 1981, Porter 1997, Loughlin 1998, Trites and Porter 2002). Studies based on physiological development (Richmond *et al.* 2005, 2006), changes in fatty acid profiles of pup blubber (Beck *et al.* in review), and changes in movements and dive characteristics (Loughlin *et al.* 2003, Fadely *et al.* 2005, Rehberg 2005) suggest that weaning occurs after 9 to 12 months of age. Raum-Suryan *et al.* (2004) found that changes in round trip distance and duration occurred from April to June for YOYs and older individuals, possibly indicating that annual timing of weaning may be less variable than age of weaning.

Studying the ontogeny of foraging behavior is crucial for understanding life histories (Horning and Trillmich 1999). Additionally, the development of movement patterns with age is important for understanding individual foraging patterns and how those patterns may be influenced by the availability of prey resources (Raum-Suryan *et al.* 2004). Telemetry has been an important tool for investigating the movements, foraging behavior, habitat selection, and ontogeny of juvenile Steller sea lions. Telemetry studies have indicated that trip duration and distance vary seasonally, but rarely exceed 20 h and 20 km, respectively (Merrick and Loughlin 1997, Loughlin *et al.* 2003, Raum-Suryan *et al.* 2004, Rehberg 2005, Fadely *et al.* 2005) and most locations at sea are associated with onshelf waters <100 m deep (Fadely *et al.* 2005). Previous researchers have found that trip distance and duration increases significantly with age and there also tends to be a marked increase in trip distance, trip duration, and haulout use once juveniles reach 10 months of age (Loughlin *et al.* 2003, Raum-Suryan *et al.* 2004). Telemetry studies have indicated that pups are capable of traveling 120 km from their natal rookery by the age of 2 months (Raum-Suryan *et al.* 2004) and brand resight studies have indicated that pups are capable of traveling more than 400 km by 5 months of age (Raum-Suryan *et al.* 2002). Juveniles (females: 1 - 2.9 years, males: 1 - 4.9 years) tend to disperse greater distances than pups (max = 1,785 km from natal rookery; Raum-Suryan *et al.* 2002) and their swimming ability is comparable to that of adults (Loughlin *et al.* 2003). Trip distance does not differ between sex (Loughlin *et al.* 2003, Raum-Suryan *et al.* 2004), but most long-range trips (500 to 1300 km) have been documented for males rather than females (Loughlin *et al.* 2003, Raum-Suryan *et al.* 2004). Interestingly, Raum-Suryan *et al.* (2004) reported that females had a significantly greater geometric mean trip duration ($\bar{x}$ = 2.7 h, 95% CI = 2.37, 3.03) than males ($\bar{x}$ = 2.2 h, 95% CI = 1.91, 2.52) and suggested females either were more selective than males when searching for prey or they had to spend more time attaining prey resources because they had less diving capabilities than males.

3.1.10.3 Development of Diving Ability

Knowledge of the progression of diving ability in relation to age is important for understanding the weaning and independent foraging strategies of pinnipeds (Pitcher *et al.* 2005). Overall, studies have indicated that dives of juvenile Steller sea lions are short and shallow (Table 3.13; Merrick and Loughlin 1997, Loughlin *et al.* 2003, Pitcher *et al.* 2005, Rehberg 2005). Merrick and Loughlin (1997) satellite-tagged 5 young-of-the-year (YOY) and 15 adult female Steller sea lions from the central Gulf of Alaska through the eastern Aleutian Islands and found that YOY Steller sea lions exerted less foraging effort and made shorter, shallower dives than adult females (Table 3.13). However, older juveniles dove more frequently and deeper and spent more time at sea than younger juveniles. Because YOY sea lions were diving within their calculated aerobic dive limit (cADL; 3.9 to 5.2 min) and did not appear constrained physiologically, Merrick and Loughlin (1997) suggested that it may require time for young sea lions to develop appropriate diving behaviors and knowledge of prey resources during development. Although Richmond *et al.* (2006) calculated a similar range of cADL values for juveniles, they suggested juveniles were constrained physiologically because they were consistently diving at the upper range of their aerobic scope.

During a dive, approximately 47% of a sea lion's oxygen stores are in blood, with 35% in muscle and the remainder in the lungs (Kooyman 1985). There is a considerable developmental component until the oxygen storage ability of an otariid is fully matured (Horning and Trillmich 1997), because of increases in blood volume, muscle myoglobin and body mass. Likewise, juveniles operate at metabolically higher rates than adults (Lavigne *et al.* 1986, Costa 1993). Thus, younger sea lions do not have the same capacity to stay submerged (and hence dive to as great of depths) as adults, which consequently affects their ability to acquire prey and thus choice of foraging strategies.

Loughlin *et al.* (2003) used a combination of satellite-linked time-depth recorders (SLTDRs) and satellite depth recorders (SDRs) to monitor the diving behavior of juvenile Steller sea lions and found that mean dive depth and duration did not differ between males and females, but both parameters displayed an ontogenetic trend. For example, 7-10 month old sea lions tagged in Alaska typically had a mean dive duration of <1 minute and a mean dive depth of approximately 10 m. However, these parameters nearly doubled by the time sea lions reached one year of age (11 to 12 months) when they appeared to be as capable as adults in their movement and diving behavior (Table 3.13). Changes in diving activity likely correspond to an increase in Hct, Hb, and blood oxygen stores, which are also similar to adults at approximately 9 months of age (Richmond *et al.* 2005, 2006). The oxygen-carrying capacity of muscle also increases with age and appears similar to adult females at approximately 17 months of age (Richmond *et al.* 2006). Pitcher *et al.* (2005) documented the ontogeny of diving performance of pups (<1 year of age) and juveniles (1-3 years of age) using SDRs and reported that YOYs (i.e. 6 months) were capable of diving to nearly 100 m, yearlings were capable of diving to 200 m, and older juveniles (i.e. 3 years) were capable of diving to depths greater than 400 m. On average, females appeared to dive deeper than males as they became older, but durations of dives were longer males (Pitcher *et al.* 2005). Mean dive duration increased with age, with maximum mean durations reaching approximately 4 minutes by 1 year of age, 5 minutes by 2 years of age, and 6 minutes by 3 years of age. Fadely *et al.* (2005) observed similar trends for 30 (n = 11 males and 19 females) immature Steller sea lions (5 to 21 months of age) tagged with SDRs in the eastern Aleutian Islands, but also found that time at depth (TAD), and dive rate (number of dives per time spent at sea within a 6 hour period) increased throughout the first 17 months of age. An increase in diving activity also coincided with increases in sea surface temperature and chlorophyll-a. Age differences in diving activity were more evident during winter months when juveniles dived more frequently, deeper, and spent more TAD than did pups. However, between 1-2 years of age there was an apparent leveling of dive ability as measured by dive rate and TAD.

Sea lions have a streamlined shape that minimizes the cost of transport while swimming (Feldkamp 1987, Stelle *et al.* 2000). Laboratory measurements of swim speed and drag in 3 year old Steller sea lions showed that they preferred to swim at a mean velocity of 3.41 m s-1 (2.9-3.4 m s-1), equivalent to 1.46 body lengths per second (Stelle *et al.* 2000), a speed found to be the minimum cost of transport for California sea lions (Feldkamp 1987). Williams *et al.* (1991) found that the average ventilation time did not change with swim speed in California sea lions. That is, time spent submerged did not change as swim speeds increased to 4.37 yd s-1 (4 m s-1). Because of anatomical adaptations, sea lions appear to require shorter times for lung tidal volume exchange than do seals (Williams *et al.* 1991). Skeletal muscles of pinnipeds (and sea lions) are adapted for aerobic metabolism of lipids during hypoxic conditions of diving and exercise (Kanatous *et al.* 1999). Lipid stores in swimming muscle were sufficient to meet the resting muscle metabolism for 17 hours in Steller sea lions (Kanatous *et al.* 1999).

3.1.10.4 Adult Females

Steller sea lions are sexually dimorphic with males being considerably larger (2-3 times) than females. Female Steller sea lions grow to an average of 2.3 m (max = 2.9 m) and weigh an average of 263 kg (max = 350 kg; Loughlin 2002). Thus, it is not surprising that adult females have significantly lower mass specific oxygen stores and total body oxygen stores than adult males. Furthermore, the cADL of adult females (7.5 minutes) is less than that of adult males (12.0 minutes; Richmond *et al.* 2006). Female Steller sea lions reach sexual maturity anywhere from 3-8 years, may breed into their early twenties, and may live for as much as 30 years. The ability to give birth at 3 years of age appears to be unusual, but has been documented a few times (Pitcher and Calkins 1981, Raum-Suryan *et al.* 2002). For example, branded females from 3 to 22 years of age have been observed with pups. Adult females appear to exhibit fidelity to specific areas and rookeries (Calkins and Pitcher 1982, Merrick *et al.* 1995, Raum-Suryan *et al.* 2002) and have been observed to pup at their natal rookery (Raum-Suryan *et al.* 2002).

Due to logistics associated with capturing and handling adult females, there is limited information pertaining to the foraging ecology of this age class. Merrick et al. (1994) deployed a SLTDR on one adult female near Kodiak, Alaska and one adult female from Akun Island, Alaska. Average dive depths for the two animals were 36.5 m (max = 164 m) and 42.9 m (max = 198 m), mean dive durations were 2.4 min (max = 6.0 and 11.0 min), and mean surface intervals (time spent at the surface) were 4 minutes (max = 42.2 and 160.0 min). Both females foraged within 20 km of land during summer, made brief trips (<2 days), and dove to shallow depths (<30 m). During winter, dives were deeper (often >250 m) and trips were greater in distance (as much as 300 km) and duration (up to several months). Similarly, Merrick and Loughlin (1997) satellite-tagged 15 adult female Steller sea lions from the central Gulf of Alaska through the eastern Aleutian Islands and found that adult females spent more time at sea, dived deeper, and had greater home ranges during winter than they did during summer (Table 3.13). These behaviors may have reflected reproductive status or changes in prey availability and distribution resulting from seasonal variability (Merrick and Loughlin 1997). Foraging behaviors of 8 adult females in Russia were similar to those in Alaska (Loughlin *et al.* 1998). Although one female traveled a distance of 263 km, 94% of all locations at sea were within 10 km of the island of capture. Overall, diving behavior varied among individuals, but dive depths were shallow and dive durations were short (Table 3.13).

To investigate the nutritional stress hypothesis, Andrews *et al.* (2001) used stomach temperature telemetry and satellite telemetry to monitor the behavior of 4 lactating Steller sea lions from the central Aleutian Islands (Seguam and Yunaska) and 5 lactating sea lions from areas near Forrester Island, Southeast Alaska. Similar to previous studies, foraging behavior varied among individuals, but metabolic rates and the percent of time spent submerged while at sea were similar between the two groups. However, the times spent at sea, trip durations, trip distances, and mean times from departure to first prey ingestion for females from the Aleutian Islands were shorter than those for females from Southeast Alaska. Additionally, dives performed by sea lions from the central Aleutian Islands were shorter and shallower, but more frequent than those by sea lions from Southeast Alaska. Because fish surveys of the two areas were conducted simultaneously with data collection for sea lions, Andrews *et al.* (2001) were able to demonstrate a correlation between prey availability, foraging success, and pup growth. With the development of new capture techniques, additional insight into the foraging ecology of adult females may be obtained in the future.

3.1.11 Foraging Ecology – Integration and Synthesis

Foraging patterns of Steller sea lions are still far from being completely described, especially for older juveniles (age 2-4) and adult females. 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 nearshore conducting shallow dives.
- Yearlings that have likely reached nutritional independence greatly increase their foraging area, and begin deeper diving.
- Food availability is important year-round, but particularly during the fall/winter for adult females (especially lactating females) when pregnancy increases energetic demands, and winter/spring for juveniles that are transitioning to nutritional independence.
- Dominant prey items vary with region and season, but pollock, Atka mackerel, Pacific cod and salmon are generally the most common or dominant prey.
- Steller sea lions consume a variety of demersal, semi-demersal, and pelagic prey, indicating a potentially broad spectrum of foraging styles probably based primarily on availability.
- 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 and through satellite telemetry indicates that sea lions forage at sites distant from rookeries and haulout sites.
- 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 is diminished, and population recovery is impeded.

3.1.12 Disease and Toxic Substances

Disease may include any pathogen of viral, bacterial, protozoan, or fungal origins, which are either known to Steller sea lions and related species or are unknown to Steller sea lions but zoonotic. Whereas disease occurs naturally in all animal populations, there are two ways in which disease could have negatively impacted Steller sea lion populations. Firstly, the occurrence of a contagious pathogen to a naive population could lead to a mass or unusual mortality event. Such events have been documented in other pinniped populations and are mentioned below. Secondly, several pathogens are known to result in reproductive loss, either through spontaneous abortions, embryonic or fetal resorption, or through rendering the female infertile. Both of these disease impacts have the ability to result in population level decreases, yet neither has been observed or measured in Steller sea lions. In addition, one of the reasons that diseases, or at least the diseases that have been examined, do not appear to be a major factor in the population decline is that the same diseases occurred at about the same rate in both the western and eastern DPSs. Nevertheless, with the current low abundance of sea lions the potential for disease to impede recovery should not be ignored.

Disease is a natural process, and the mechanism by which many animals die. The important question for sea lions is whether disease agents currently have the potential to reduce population growth through increased mortality or decreased reproductive output. Without question, an epidemic of phocine distemper virus was responsible for the deaths of thousands of seals in the northwest Atlantic during the 1980s (Heide-Jørgensen *et al.* 1992). Investigators have not seen large numbers of dying or dead Steller sea lions, although sick individuals are found on rare occasions. For example, two sick Steller sea lions that stranded in northern California and were brought in for treatment later died of acute bronchopneumonia of unknown etiology (Morgan et al. 1996).

Analysis of components of blood can give insight into the general health of animals. Bishop and Morado (1995) examined blood characteristics of Steller sea lions pups captured live on rookeries in Southeast Alaska and the Gulf of Alaska. White blood cell counts suggested mild physiological stress responses that were perhaps due to capture and handling. Red blood cell counts were suggestive of anemia, especially in animals sampled in the Gulf of Alaska. Zenteno-Savin *et al.* (1997) found higher levels of haptoglobin in Steller sea lion blood in the Aleutian Islands than in Southeast Alaska sea lions. In other animals, elevated haptoglobin levels are known to be associated with stress (e.g., trauma, infection), but no explanation was suggested for the results in Steller sea lions.

Several of the disease agents that sea lions have been exposed to are known to affect reproduction in other species. Alaskan Steller sea lions have been exposed to two types of bacteria, Leptospira and Chlamydia (Calkins and Goodwin 1988, Sheffield and Zarnke 1997, Burek *et al.* 2003), and one virus, the San Miguel sea lion virus, that have caused reproductive problems in other species. Specifically, San Miguel Sea Lion Virus and Leptospira have been associated with reproductive failures or neonatal deaths in California sea lions and northern fur seals (Smith et al. 1974, Gilmartin *et al.* 1976). Virtually nothing is known about the possible effects of Chlamydia on pinnipeds, but in other animals Chlamydia is known to cause abortion, stillbirths, and production of weak young (Shewen 1980).

In addition to the three disease agents listed above, other disease agents that Steller sea lions have been tested for include phocid herpesvirus, phocine and canine distemper viruses (Barlough *et al.* 1987, Zarnke *et al.* 1997, Sheffield and Zarnke 1997), morbilliviruses, canine parvovirus, Brucella, Toxoplasma, and influenza A (Sheffield and Zarnke 1997). There is no convincing evidence for significant exposure to influenza A, morbilliviruses, Brucella, canine parvovirus, or Leptospira (Burek *et al.* 2003, 2005). Examination and necropsy of dead Steller sea lions has shown some occurrences of hepatitis, Chlamydia, myocarditis, endometritis, tumors, and pneumonia (Gerber *et al.* 1993).

Burek *et al*. (2003, 2005) concluded that available serologic evidence does not support the possibility that a disease epidemic occurred during the sea lion decline of the late 1970s and 1980s. They noted, however, that due to sampling limitations the possibility could not be excluded completely. Further, although sea lions have been exposed to several endemic disease agents that could potentially impede recovery, the only available data are the prevalence of antibodies to the disease agents, and the potential for those agents to cause disease among Steller sea lions has not been documented (Burek *et al.* 2005).

Parasites of Steller sea lions include intestinal cestodes; trematodes in the intestine and bile duct of the liver; nematodes in the stomach, intestine, and lungs; acanthocephalans in the intestine; acarian mites in the nasopharynx and lungs; and an anopluran skin louse (Dailey and Hill 1970, Dailey and Brownell 1972, Fay and Furman 1982, Shults 1986, Gerber *et al.* 1993). The potential for parasitism to have a population level affect on sea lions is largely unknown. Whereas parasites may have little impact on otherwise healthy animals, effects could become significant if combined with other stresses (Haebler and Moeller 1993). Available information does not suggest that the sea lion decline was caused by parasitic infections, although there has not been adequate research to assess the relative nature and magnitude of parasitism in sea lion populations. Investigations of parasites require necropsy of carcasses that only occurs on a sporadic basis on beach cast animals.

Toxic substances have two major modes by which they can impact animals. Firstly, the acute toxicity caused by a major point source of a pollutant (such as an oil spill or hazardous waste) can lead to acute mortality and moribund animals with a variety of neurological, digestive and reproductive problems. Secondly, toxic substances can impair animal populations through complex biochemical pathways that suppress immune functions and disrupt the endocrine balance of the body, causing poor growth, development, reproduction and reduced fitness. Toxic substances come in numerous forms, with the most recognized being the organochlorines (mainly PCBs and DDTs), heavy metals, polycyclic aromatic hydrocarbons (PAHs) and the newer polybrominated diphenyl ethers (PBDEs).

Aside from the Exxon Valdez Oil Spill in 1989, which occurred well after the Steller sea lion decline was underway, no other events have been recorded that support the possibility of acute toxicity leading to substantial mortality of Steller sea lions (Calkins *et al.* 1994). However, results from several studies, both published and still being conducted, do not permit the complete rejection of toxic substances as a factor that may currently impact sea lion vital rates. These studies have been conducted on both Steller sea lions and other pinniped species, both sympatric and unrelated, and are briefly reviewed below by toxic category.

Sea lions exposed to oil spills may become contaminated with PAHs through inhalation, dermal contact and absorption, direct ingestion, or by ingestion of contaminated prey (Albers and Loughlin 2003). After the Exxon Valdez oil spill, Calkins *et al.* (1994) recovered 12 Steller sea lion carcasses from the beaches of Prince William Sound and collected an additional 16 Seller sea lions from haul out sites in the vicinity of Prince William Sound and the Kenai coast. The highest levels of PAHs were in animals found dead following the oil spill. Sea lions collected seven months after the spill had levels of PAH metabolites in the bile consistent with exposure and metabolism of PAH compounds (Calkins *et al.* 1994). However, histological examinations found no lesions that could be attributed to hydrocarbon contamination and, hence, no evidence of damage due to oil toxicity (Calkins *et al.* 1994).

Heavy metals are also contaminants of concern. Heavy metal concentrations measured in Steller sea lion livers were generally much lower than in northern fur seals (Noda *et al.* 1995). Mercury levels in the hair of young Steller sea lions from both the western and eastern DPSs were lower than for northern fur seals and were considered "relatively low" (Beckmen *et al.* 2002), yet concerns remained about possible effects on fetal development and interactive effects with other contaminants. Vanadium concentrations in Steller sea lion livers were positively correlated with levels of selenium, silver, and mercury (Saeki *et al.* 1999). Castellini (1999) found that zinc, copper, and metallothionien (a chelating compound) levels were comparable between sea lion pups sampled from both the western and eastern DPSs, and were lower than for captive sea lions. Kim *et al.* (1996) reported on the accumulation of butyltin in the liver of Steller sea lions from Alaska and Japan and found much lower levels in the Alaska samples than in those from Japan; they also suggested that butyltin degrades rapidly in sea lions and does not bioaccumulate. Although these studies are not comprehensive, they do not indicate that heavy metals were a significant factor in the decline of the Steller sea lions.

Organochlorine contaminants in marine mammals and other wildlife have been associated with reproductive failures (Helle *et al.* 1976, Reijnders 1986), population declines (Martineau *et al.* 1987), carcinomas, and immune suppression (de Swart *et al.* 1994, Ross *et al.* 1996). No toxicological studies have been performed on Steller sea lions to determine clinical ramifications of organochlorine contaminant burdens. However, organochlorines that cause health impacts in other species have been measured in subsets of Steller sea lion populations from Japan, the Russian far east, Aleutian Islands, Pribilof Islands, Gulf of Alaska and Southeast Alaska (Lee *et al.* 1996, Varanasi *et al.* 1992, Hoshino *et al.* 2006, Hong *et al.* 2005, Myers 2005). Most of these studies measured contaminants in the blubber or blood, although Krahn *et al.* (2001) used feces as the medium to measure organochlorines. Overall, the studies suggest a decline in organochlorine concentrations over time, which is consistent with that reported for other wildlife species. Organochlorine concentrations have been significantly different among some regions (Myers and Atkinson 2005, Hoshino *et al.* 2006), although not consistently so throughout all studies (Hong *et al.* 2005). Typically a few individuals with particularly high concentrations will skew the mean results, giving high deviations that render non-significant or in conclusive results. The studies that measured more than one organochlorine generally found that the PCB congeners and DDT metabolites were the most prevalent organochlorines measured in Steller sea lions. No studies have been published that report any PBDE congeners, however this is likely to change in coming years.

Studies of effects of known organochlorine contaminants have not been conducted on marine mammals in the US. Studies from Europe have provided threshold levels of organochlorines above which immunosuppression or reproductive problems can be expected (de Swart *et al.* 1994, Ross *et al.* 1996). Whereas these studies were conducted on harbor seals, the thresholds are often used for related species such as Steller sea lions. Several individual sea lions have been sampled and had concentrations above this threshold. Likewise, a threshold for reproductive failures (i.e., spontaneous abortions) has been extracted from the mass toxicity event of California sea lions reported in the 70's (DeLong *et al.* 1973, Gilmartin *et al.* 1976). No recent samples from Steller sea lions have approached this threshold, indicating a mass mortality from an acute toxicity event was not the cause of the sea lion decline.

3.1.13 Predators

Steller sea lions are eaten by transient killer whales (*Orcinus orca*) in both the western and eastern DPSs. The available information on transient killer whale populations and feeding ecology within the range of Steller sea lions and the likely impact of killer whale predation on sea lions is discussed in depth in Chapter 4.

Sharks represent another potential predator that may attack Steller sea lions. Although white shark predation on North Pacific pinnipeds has been well documented (LeBoeuf *et al.* 1982, Ainley *et al.* 1985, Long *et al.* 1996), these sharks occur rarely, if at all, in the range of the western DPS. Although salmon shark populations have increased since 1990, they are considered piscivorous and have not been reported to prey on Steller sea lions. Another species of large shark, the Pacific sleeper shark (Somniosus pacificus), is common in the Gulf of Alaska, Aleutian Islands, and Bering Sea (Orlov 1999). Current indices to sleeper shark relative abundance are based on a recent analysis of sleeper shark bycatch from sablefish longline surveys conducted on the upper continental slope and deepwater gullies of the continental shelf in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska from 1979-2000 (Courtney and Sigler unpublished data, also see Mueter and Norcross 2002). This analysis indicates sleeper sharks are substantially (about 10x) more abundant in the Gulf of Alaska than in the BSAI region. Further, a significant increase in the relative abundance of sleeper sharks occurred during 1989-2000 in the central Gulf of Alaska, driven largely by the increase of sharks in Shelikof Trough during 1992 and 1993. Most Pacific sleeper shark stomachs that have been examined contained remains of fish and invertebrates (Yang and Page 1998, Orlov 1999), but the remains of harbor seals and porpoises have also been reported (Bright 1959). A recent analysis of sleeper shark stomachs (n=198) collected in the GOA near sea lion rookeries when pups may be most vulnerable to predation (i.e., first water entrance and weaning) found that teleost fishes and cephalopods were the dominant prey (Sigler *et al.* in press). Tissues of marine mammals were found in 15% of the shark stomachs, but no sea lion tissue was detected. Overall, the study concluded that sea lions are unlikely prey of sleeper sharks, harbor seals are infrequent prey and may be consumed alive, and that cetaceans are a frequent diet item for larger sleeper sharks and commonly scavenged. A companion study documented that shark and sea lion home ranges overlapped (Hulbert *et al.* in review), and thus the results of these two studies, and others, indicate no scientific evidence presently exists to suggest that sleeper sharks actively prey on Steller sea lions.

3.1.14 Competitors

Steller sea lions forage on a variety of marine prey that are also consumed by other marine mammals (e.g., northern fur seals, harbor seals, humpback whales), marine birds (e.g., murres and kittiwakes), and marine fishes (e.g., pollock, arrowtooth flounder). To some extent, these potential competitors may partition the prey resource so that little direct competition occurs. For example, harbor seals and northern fur seals may consume smaller pollock than Steller sea lions (Fritz *et al.* 1995). Competition may still occur if the consumption of smaller pollock limits the eventual biomass of larger pollock for sea lions, but the connection would be difficult to demonstrate. Such competition may occur only seasonally if, for example, fur seals migrate out of the area of competition in the winter and spring months. Similarly, competition may occur only locally if prey availability or prey selection varies geographically for either potential competitor. Finally, competition between sea lions and other predators may be restricted to certain age classes, because diet may change with age or size. Further discussion of the impacts of competitors is provided in Chapter 4.

3.1.15 Nutritional Stress in Steller Sea Lions

In the sections above we discussed various topics such as sea lion vital rates, nutritional requirements, foraging ecology, prey, etc. In this section we synthesize this information to evaluate the evidence for nutritional stress. Nutritional stress is defined as the result of a species being unable to acquire adequate energy and nutrients from their prey resources. This can be manifested through acute nutritional stress (e.g., emaciation, rapid mortality through starvation, large scale breeding failures) and chronic nutritional stress (e.g, reduction in fecundity, reduced body size, higher juvenile and adult mortality, increased predation risk)(Trites and Donnelly 2003, NMFS 2000).

Inadequate prey intake by Steller sea lions will eventually be manifested at some level as nutritional stress (chronic or acute) with various changes in vital rates (see Bowen *et al.* 2001 [their Table 1], NRC 2003 [their Table 6.2]). Nutritional stress is a physiological response to suboptimal quantity and/or quality of available food, and may be acute (e.g., starvation occurring over a period of weeks) or chronic (e.g., suboptimal consumption over a period of months or years) (Trites and Donnelly 2003). Nutritional stress has been considered a leading hypothesis to explain the rapid decline of the western DPS of Steller sea lion (NMFS 2000), and has been the subject of considerable debate (NRC 2003, Trites and Donnelly 2003, Fritz and Hinckley 2005). However, it has been a difficult hypothesis to test due to a lack of data for Steller sea lions during the period of decline, the difficulty of working with these animals in remote locations, the long-term nature of the problem, and a poor understanding of the basic nutritional biology of Steller sea lions.

When assessing the potential for nutritional stress in Steller sea lions it is important to distinguish between early and late periods of the decline as well as recent population trends. The decline in the number of Steller sea lions in the western DPS was rapid through the 1980s, but slowed during the 1990s. In terms of testing the nutritional stress hypothesis, this means that the animals currently available in the wild for study may no longer be affected by the factors that caused their initial population decline. Many of the biological indicators of past (or current) nutritional stress may therefore no longer be measurable in direct ways. Nutritional limitation as indicated by reduced body size and reduced late term pregnancy rates during the rapid decline of the 1980s contrasts with recent studies of Steller sea lions from the western DPS (Table 3.24). Yet, if survival has been greatly reduced, then there is potential to have affected animals under-represented in the sample. Modeling results by Malavear (2004) suggests that juveniles less than one year old may die off fairly rapidly, whereas the older juveniles respond by slower growth and maturation times. Frid *et al.* (2006) suggest that because of interactions between energy status, predation risk and prey availability the body condition of animals could remain high while food resources are indeed declining. The marked acute nutritional effects observed for immature and adult otariids when prey biomass is reduced during El Niño events (Trillmich and Ono 1991, Soto *et al.* 2004) have not been observed for Steller sea lions (Table 3.24). Therefore, if nutritional stress is acting on the western DPS, then we must look for evidence for/against chronic nutritional stress as opposed to acute nutritional stress (Trites and Donnelly 2003).

3.1.15.1 Evidence During The Rapid Decline – The 1980s

Steller sea lions collected in the Gulf of Alaska during the early 1980s showed evidence of reproductive failure and reduced rates of body growth that were consistent with nutritional limitation (Calkins and Goodwin 1988, Pitcher *et al.* 1998, Calkins *et al.* 1998). Lactating females were less likely to become pregnant than non-lactating females during the early decline, indicating that the energetic stress of nursing while being pregnant with another pup may have prevented a significant number of females from giving birth each year (Pitcher *et al.* 1998). During the 1970s and 1980s, 100% and 95%, respectively, of all sexually mature females in the western DPS were pregnant in early gestation. The percentage of those females that carried their pregnancy to late gestation was only 55% to 67% during the 1970s and 1980s and was not statistically different between periods (Pitcher *et al.* 1998). However, among lactating females with higher energy demands, 63% carried their pregnancies to late gestation in the 1970s compared to only 30% in the 1980s, and this difference was significant. Better body condition was found to increase the probability that a female would maintain pregnancy. Comparatively low birth rates for females from the western DPS during the 1970s and 1980s (Pitcher and Calkins 1981) coupled with elevated embryonic and fetal mortality, appear to have contributed to decreased reproductive performance during the period of early decline (Pitcher and Calkins 1981, Calkins and Goodwin 1988, Pitcher *et al.* 1998, NMFS 1998b, 2000). Age-structured models fit to observed time series of pup and non-pup counts suggest that declines in reproductive performance of females in the western DPS continued through the 1990s and into the 2000s within the western DPS (Holmes and York 2003, Fay 2004, Winship and Trites 2006).

Food limitation resulting from the lack of availability of prey, or reduced quality, can result in reduced body size in marine mammals (Scheffer 1955, Laws 1956, Read and Gaskin 1990, Trites and Bigg 1992).

Another indication that the western DPS may have been nutritionally compromised during the period of rapid decline in the 1980s was a reduction in average body size (Perez and Loughlin 1991, Castellini and Calkins 1993, Calkins *et al.* 1998). Steller sea lions from the central Gulf of Alaska during the 1980s were smaller in length, girth, and weight compared to the 1950s (Calkins *et al.* 1998, Fiscus 1961, Mathisen *et al.* 1962) and 1970s (Perez and Loughlin 1991, Castellini and Calkins 1993, Calkins and Goodwin 1988). Female sea lions over age 9 in the 1950s were significantly larger (standard length and axillary girth) than in the 1970s and 1980s (Calkins *et al.* 1998).

Since body size is influenced most during the first 8 years of life (Calkins and Pitcher 1982), Calkins *et al.* (1998) backdated 8 years from their mid-1980s sample to determine the break point for the reduction in size—the late 1970s, or just after the 1977 regime shift. Ages of sea lions from the 1958 collection (Fiscus 1961, Mathisen *et al.* 1962) ranged from 9 to 22. Backdating 9-22 years from 1958, to see when growth was important to setting the size of the older females collected then, yields 1936-1944 as the critical years for the oldest females and 1949-1957 for the youngest. Thus, female sea lions collected in 1958 grew to large sizes from 1936-1957; this was a period when diets, for at least a portion of the interval, apparently were dominated by gadids and flounders (Imler and Sarber 1947). Applying the same procedure to the size data from the mid-1970s yields 8-year growth intervals of approximately 1959-1967 for the oldest (16 years) and 1968-1976 for the youngest; or from 1959-76 for all ages. The oldest animals underwent their 8 critical growth years during a period of what is thought by some to have been rich in high quality prey (Trites and Donnely 2003), yet they were smaller than those animals from the preceding gadid-rich era of the mid-1940s.

Such a change in morphological indices from animals in the wild (Pitcher *et al.* 2000) is consistent with sub-optimal nutritional status in the 1980s compared with the 1970s. Further, adult females in the 1970s were themselves smaller than in the late 1950s (Calkins *et al.* 1998), indicating that nutritional stress may have occurred prior to the regime shift of the mid-1970s. Sea lions feeding on a gadid-dominated diet in the 1940s appeared larger than in later samples during the 1970s. This is contrary to the prey quality hypothesis for nutritional stress.

3.1.15.2 Evidence During the Slower Decline – The 1990s

Much of the research from 1990-2004 to determine the extent to which nutritional stress (either acute or chronic) could be a factor in the decline of the western DPS Steller sea lions involved comparing individual animals from the western and eastern DPS. Many of the studies focused on pup condition, as well as maternal attendance patterns, foraging biology and adult dietary analyses. Contrary to what would be expected for animals experiencing acute nutritional stress, Steller sea lion pups in the early 1990s were heavier in the areas of population decline (i.e. the western DPS) than in rookeries where the population was increasing (Merrick *et al.* 1995). Pups at two rookeries within the area of decline were heavier in 1992-93 than prior to the decline in 1965 and 1975. Similar results were reported by Davis *et al.* (1996, 2004) who found no significant differences in pup birth sizes between declining and stable populations in the 1990s; nor were there differences in adult female body mass or composition. Rea *et al.* (2003) found no indication of poor body condition (based on percent total body lipid) in pups from either area. Paradoxically, Adams (2000) found pup growth rates were higher and females were larger by mass and length in declining western DPS areas (see also Brandon 2000).

Using a similar comparative protocol, researchers observed no differences or opposite than expected trends for Steller sea lion milk composition (Davis *et al.*1996, Adams 2000), pup milk intake rates (Adams 2000), pup growth rates (Davis *et al.* 1996, Adams 2000), maternal attendance patterns and foraging trip duration (Brandon 2000, Milette and Trites 2003, Andrews *et al.* 2002) between the western and eastern DPS for Steller sea lions. Results from all of these studies suggest that adult females at rookeries in the declining population did not have difficulty finding prey during the summer.

Furthermore, no apparent difference was observed between average winter attendance cycles of females from the declining western DPS (Marmot Island and Cape St. Elias) and increasing eastern DPS (Timbered Island) haul out populations (Trites *et al.* 2006b). In the 21st century, no evidence has yet been found of exceptional pup mortality, low birth weights in the western DPS, or poor growth of pups in the area of decline. Body fat contents were highly variable in both areas at 15 months of age (Rea *et al.* 2003). Fadely *et al.* (2004) compared growth rates of 29 sea lions captured in a longitudinal survey captured in Alaska from 2000-2003, that growth rates for juveniles were higher in the western DPS than for the eastern DPS.

Blood chemistry and hematological parameters, including blood urea nitrogen (BUN), ketone bodies (e.g., b-HBA), hematocrit and hemoglobin concentration, show characteristic patterns with changes in nutrition (Keyes 1968, Rea 1995), and have been experimentally induced in fasted Steller sea lion pups and juveniles (Rea *et al.* 1998b, Rea *et al.* 2000). However, Rea *et al.* (1998a) found no evidence of nutritional stress based on these parameters in wild Steller sea lions from areas with the greatest population declines. Red blood cell data from a study by Bishop and Morado (1995) reported elevated target cells and depressed poikilocyte levels in pups from the western DPS compared to those in the eastern DPS, indicative of anemia in the western DPS. Conversely, Castellini *et al.* (1993) reported no obvious differences in hematocrit or hemoglobin levels in pups during the 1990s from the western DPS compared to reference values. In evaluating serum haptoglobin levels (an indicator of acute stress response) in Steller sea lions, Zenteno-Savin *et al.* (1997) reported elevated serum levels in the western DPS compared to the east, but were careful to avoid speculation on the cause of these differences.

The general conclusion from these physiological studies comparing the eastern and western DPS during the 1990s has been that acute nutritional stress was not evident in the adult females or pups. Whether this was due to inherent biases in the study design is not known. One potential confounding factor in these studies may be habitat differences between the study sites. This would affect prey aggregation (Lowe and Fritz 1997) and thus foraging times for sea lions (Andrews *et al.* 2002). The large reduction in the western DPS Steller sea lion population by 1990 would likely affect relative prey availability for individuals through reduced competition (Winship and Trites 2003). Despite poor knowledge of the underlying mechanisms, morphological (Williams unpublished data) and survey (Fritz and Stinchcomb 2005) data indicate a trend towards improvement for Steller sea lions in the western DPS relative to conditions in the late 1970s and 1980s, while other demographic evidence (Holmes and York 2003, Fay 2004, Fay and Punt 2006) suggests a lingering chronic impact (low fecundity) that could affect the ability of the western DPS to recover.

3.1.15.3 Energetic Demands: Captive Diet Studies Debunking The Junk Food Hypothesis

Changes in the structure of fish communities in the North Pacific Ocean (Hollowed and Wooster 1992, 1995, Anderson and Piatt 1999) could alter the quality or availability of prey for Steller sea lions. Alverson (1992) proposed that changes in the structure of the Bering Sea and Gulf of Alaska ecosystems resulted in the dominance of pollock and other gadids (e.g. Pacific cod), and that the shift to ecosystems dominated by pollock had been the overriding factor in the Steller sea lion decline. He suggested a link between the changes in ecosystem trophic structure and the decline of sea lions based on the notion that pollock are a low quality food and the western population of sea lions has not been able to sustain itself with a larger fraction of its diet comprised of pollock. This has become known as the “junk food hypothesis.” (Rosen and Trites 2000a, Trites and Donnelly 2003).

A number of short-term diet manipulation studies on captive pinnipeds have been conducted to determine the effect of nutritional status on sea lion health. One such study reported that young Steller sea lions raised in captivity did not substantially increase food intake when switched from an ad libitum diet of herring to one of pollock (Rosen and Trites 2000a). The implication from this study was that the captive immature sea lions did not consume sufficient quantities of low-energy fish to maintain energy homeostasis, and thus lost weight during the experiments. A similar finding was reported for immature harp seals (Kirsch *et al.* 2000). When mature harbor seals were switched from high-fat herring to low fat herring, there was no difference in digestibility values, suggesting that digestibility may be more dependant on prey species and less dependant on nutrient composition of any particular type of prey (Stanberry 2003). In addition this harbor seal study showed that adult harbor seals can maintain body condition and health over a short period on a low-fat diet, mainly by slightly increasing their food intake (Stanberry 2003). Fadely *et al.* (1994) found that California sea lions maintained mass equally well on a diet of pollock or herring.

The maximum weight that a Steller sea lion can digest per day on a sustainable basis appears to be about 14-16% of their body mass (Rosen and Trites 2004). This finding is based on offering 1-2 year old captive Steller sea lions as much high-energy (herring) or low-energy (capelin) fish as they could eat every day, or every second day. In this study, young sea lions feeding on low energy prey needed to consume more fish than they were physically capable of to meet their energy requirements. In contrast, older sea lions could consume the extra calories required without hitting the upper ceiling on digestive capacity. This was due in part to the lower relative energy needs of the older sea lions compared to young animals (Winship *et al.* 2002). Rosen and Trites (2002, 2004, 2005) found that Steller sea lions could alter their food intake in response to short-term changes in prey quality or availability and that food restrictions are likely to result in a “foraging response” rather than a “fasting response” which could produce a higher net energy deficit than first suspected (Rosen and Trites 2005). A diet composed of predominantly low energy prey combined with an interrupted schedule of feeding (i.e. on alternate days) necessitated food intake levels that apparently exceeded the physiological digestive capacities of young animals (Rosen and Trites 2004). However, Calkins *et al.* (2005) conducted feeding experiments with 3 juvenile sea lions and concluded that sea lions were able to compensate for lower quality prey without reaching satiation as described by Rosen and Trites (2004).

In comparison to adults, juvenile Steller sea lions on a constant “maintenance” level diet of either pollock or herring for 5 weeks over several seasons demonstrated marked seasonal effect on both body mass and composition (Rosen and Trites 2002, Kumagai 2004, Kumagai *et al.* 2006). Sea lions maintained on a low-lipid pollock diet lost significantly more body lipid reserves during periods of high-energy utilization (i.e., growth) than animals on a high-lipid herring diet. Similarly, juvenile Steller sea lions on calorically equivalent, sub-maintenance diets of low lipid Atka mackerel showed a greater reduction in lipid reserves than when fed sub-maintenance quantities of high lipid herring (Rosen and Trites 2002, 2005). While the sea lions fed Atka mackerel lost more of their lipid energy reserves, the sea lions fed herring lost more lean body mass (e.g., muscle). If sea lions in the wild are similarly restricted in their energy intake, it could have detrimental effects on individual fitness regardless of the prey type. However, these theoretical effects remain to be demonstrated in free-ranging populations which do not have mono-specific diets.

The duration of nutritional limitation, age of the animals, seasonal changes in energetic demands and effects of captivity appear to be important factors when evaluating the effects of diet on pinniped physiological responses. The aforementioned studies involved relatively short-term (2-6 week) changes in the diets of juvenile pinnipeds held in permanent captivity. Calkins and Trites (unpublished data) evaluated the effects of diet on free-ranging juvenile sea lions held in temporary captivity. One group of seven 1-2 year old sea lions was fed only pollock while another group of eight was fed a mixed diet composed primarily of herring for 2 months. All animals gained weight on both diets, and there were no significant differences in the rate of mass increase between the two groups, nor were there any negative health consequences detected in the treatment (pollock) group. In a four-month study of juvenile and adult harbor seals, Trumble *et al.* (2003) found no overall changes in body mass or composition attributed to ad libitum pollock/herring diet changes. The longest study conducted to date was conducted by Castellini (2002) and Calkins *et al.* (2005) and evaluated three different diets on three sea lions over a three-year period. The diets were designed to reflect the pre- and post-decline diets in the Kodiak area and that of sea lions in Southeast Alaska where the population has increased. Changes in body mass of one adult male and two adult females were not significantly different on the three diet regimes, which led the authors to conclude that sea lions could compensate for low energy prey by increasing their ingestion provided sufficient quantity was available. They found that changing seasonal physiology is likely to have more impact on body condition than quality of prey, provided sufficient quantities are available (Calkins *et al.* 2005)

Despite the differences in study designs and limited sample sizes, concurrence is developing between the various captive animal feeding trials. It appears that there are no differential effects between high-lipid and low-lipid (or low-protein and high-protein) prey on sea lion body composition when animals are able to consume sufficient prey to meet their energy demands. Therefore, instead of pollock being bad for sea lions (Alverson 1992), gadids are likely to have been an important component of a healthy sea lion diet for decades (Calkins *et al.* 2005, Fritz and Hinkley 2005). Nutritional stress may result from the inability of sea lions to acquire sufficient prey to meet the energetic demands, especially during reproduction or seasonal growth. Juveniles are susceptible to nutritional stress due to their high metabolic requirements, potential consumptive limitations as reported by Rosen and Trites (2003), and limited foraging abilities. Females during the summer breeding season (on rookeries) appear to be able to attain adequate energy to nurse their pups. However, pregnant females with and without pups may be experiencing chronic nutritional stress after leaving the rookery, as evidenced by decreased pregnancy rates of lactating females (Pitcher *et al.* 1998), and decreased natality rates overall (Holmes and York 2003, Fay 2004, Holmes *et al.* in review).

3.1.15.4 Correlation of Diet Studies with Wild Steller Sea Lions and Other Otariids

Low energy prey such as pollock or capelin is part of normal Steller sea lion diets. Winship and Trites (2003) concluded that the key difference between the diets of increasing and decreasing sea lion populations in the North Pacific is the overall amount of low energy prey consumed by sea lions in each region (i.e., the average energy density of each meal). Dietary data available for the 1990s (Sinclair and Zepplin 2002) further indicates that higher rates of population decline correlated with meals that had overall lower energy densities. However, pollock makes up a significant portion of the diet of increasing populations of sea lions in Southeast Alaska (Trites *et al.* 2006d), and Pacific hake (*Merluccius productus*) is dominant in the diet of sea lions in Oregon (Riemer and Brown 1997). Furthermore, several stable and increasing populations of otariids including California sea lions (Bailey and Ainley 1982, Riemer and Brown 1997, Gearin *et al.* 1999), Cape fur seals (Punt *et al.* 1995), and South American sea lions (Dans *et al.* 2004) have diets with a high proportion of relatively low energy prey (e.g., gadids).

3.1.15.5 Research Challenges

A critical research challenge for Steller sea lion researchers is demonstrating the mechanistic links between prey availability, nutritional stress of the individual, and changes in survival and reproductive rates that would lead to population level effects. Table 3.24 illustrates the myriad potential biological effects that could occur in immature and adult Steller sea lions if individuals were nutritionally limited. The effects range from morphological, physiological, and behavioral changes to alterations in vital rates that would affect population trends. A comparison of how these effects may have changed across the 1980s, 1990s, and 2000-2004 identifies many of the data gaps that need to be filled to assess current nutritional status for the western DPS of Steller sea lions. For most categories, available data sets are of such limited geographical and temporal scope that evaluating the role of nutritional stress in the decline of Steller sea lion populations or in its recovery has been hampered. For example, other than numbers of individuals from population counts, no measurements have been made for adult Steller sea lions in the Alaska portion of the western DPS since the 1990s. Consequently, changes in body condition, reproductive success or foraging parameters that would be direct indicators of acute or chronic nutritional stress are currently unknown for adults, except for those estimated by demographic models (Holmes and York 2003, Fay 2004, Fay and Punt 2006, Holmes *et al.* in review).

To date, the focus of nutritional research has been on the effects of nutritional status on individual sea lion behavior, health, and physiology. Proximate dietary mechanisms under investigation include: 1) decreased energy intake due to changes in the availability or energy content of prey, 2) changes in the energy requirements of the predator, 3) deficiency of other nutrients (i.e., protein or specific aminoacids) or essential elements, 4) physiology of metabolic homeostasis, and 5) assessment of nutritional stress responses for different age classes. Part of the difficulty in assessing chronic nutritional stress lies in determining the temporal or spatial scale of study: i.e., how does system wide or localized availability of prey affect Steller sea lion foraging ecology?

The evaluation of body condition in Steller sea lions remains problematic due to the inability to safely capture large animals, difficulty of working in remote locations, and poor knowledge of natural variation in body condition that occurs between seasons, geographical region, age, and gender. Indices of body condition include body mass, standard length, axillary girth and additional girth rings, and percent body fat. Good evidence exists for losses in body mass during complete fasting, but there are difficulties associated with the criterion of body mass in a sexually dimorphic species. The sexes must be examined separately in each geographic area, and longitudinal data (e.g., mean growth rates of branded pups recaptured as juveniles) should be examined. Steller sea lions lose body fat while fasting, but there are also problems peculiar to each of the methods used to measure blubber reserves (direct measure, ultrasound, skinfold calipers, isotope dilution, and bioelectrical impedance analysis).

A series of critical data gaps exist regarding the determination of 1) whether rates of natality have indeed continued to decline, 2) whether it is due to reduced prey biomass, abundance, and nutritional stress, and 3) how females respond to nutritional stress in their relative energy expenditures on lactation, pregnancy and their own maintenance. Declines in fecundity estimated in the 1990s at a few rookeries were significant (about 30%; Holmes and York 2003, Winship and Trites 2006a), but the mechanisms involved (e.g., nutritional stress, disease contaminants) are unknown.

3.1.15.6 Summary

Sea lions in the 1970s and 1980s exhibited possible symptoms of nutritional stress (Calkins *et al.* 1998, Pitcher *et al.* 1998, Trites and Donnelly 2003), but there is no comparable evidence that nutritional stress was responsible for the continued decline of the western DPS during the 1990s. This may be due in part to differences in methodologies between decades, and the focus on comparing increasing and decreasing populations of sea lions during the 1990s rather than comparing pre- and post-decline conditions.

In terms of acute nutritional stress, there is no indication at any time (1970s–2005) of emaciated juveniles or adults, of a decrease in pup body size, or of lactating females spending more time searching for prey (Table 3.24). However, total birth rates at some rookeries and overall survival rates appeared to be lower during the 1990s. This and a well-documented continued drop in the number of pups and adults counted through the 1990s could be caused by chronic poor nutrition among other causes. The 1990s data suggest that (1) although diet composition of western animals had not changed, adult females appeared to secure enough food to adequately nurse their pups within the first 4-6 weeks of lactation, and (2) if food limitation was a major cause of continued declines (either through a shortage of prey or a low abundance of high energy prey) it may have affected reproductive performance of adult females. Analysis and synthesis of data collected more recently (2000-2005) is underway, but information that could be used to directly assess the nutritional status of Steller sea lions during this period is not yet available.

3.1.16 Summary of status: population projections and variability

3.1.16.1 Population variability

Populations change as a function of births, deaths, immigration, and emigration. During the non-reproductive 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, modeling (York 1994, Holmes and York 2003) and mark-recapture experiments (Chumbley *et al.* 1997) indicate that the most likely problem leading to the decline in the 1980s was decreased juvenile survival, but lower reproductive success is almost certainly a contributing factor (Holmes and York 2003, Pendleton *et al.* 2006; Holmes *et al.* in review). Survivorship of both adults and juveniles have increased since the early 1980s and has contributed to the current relative population stability (Holmes *et al.* in review).

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, but also slow to rebound following a large decline in numbers or large changes in the population age structure or natality. Thus, the observed decline of the western population over the past two to three decades is not consistent with the naturally occurring fluctuations expected for a K-selected species, and suggests that the combined effect of those factors causing the decline has been severe. The ability of the population to recover (e.g., to its optimum sustainable population (OSP), to a level allowing down- or delisting under the ESA) and the rate at which it recovers will be determined by the same K-selected characteristics (longevity, delayed reproduction, and low fecundity), as well as its metapopulation structure. Its maximum recovery rate will likely be limited to no more than 8% to 10% annually (based on its life history characteristics and observed growth rates of other Otariids), which means that recovery could require 20 to 30 years, even under optimal conditions. The metapopulation structure of the western population may enhance or deter recovery. Dispersal of populations provides some measure of protection for the entire species against relatively localized threats of decline or extinction and rookeries that go extinct may be more likely recolonized by sea lions migrating between sites. On the other hand, the division of the whole population into smaller demographic units may exacerbate factors that accelerate small populations toward extinction (e.g., unbalanced sex ratios, Allee effects, inbreeding depression). Such acceleration has been referred to as an “extinction vortex” (Gilpin and Soulé 1986).

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

3.1.16.2 Historic population change

There appear to be two very distinct phases in the decline of the western DPS. The population declined about 70% between the late 1970s and 1990, but the initial decline likely began as early as the late 1950s in some areas. The rate of decline in the 1980s was very rapid, reaching about 15% per year during 1985-89. During this period, mortality incidental to commercial fishing was thought to contribute to perhaps as much as 25% of the observed decline. In addition, during that period it was legal for fishermen to protect their gear and catch by shooting Steller sea lions. Unfortunately, adequate records on the magnitude of such takes are not available. Some evidence indicates that animals in this population were nutritionally stressed during this time period, while other sources of mortality (e.g., predation by killer whales, mortality associated with disease) cannot be quantified due to a lack of information. There were distinct differences in the rates and pattern of decline in the six subareas used to monitor this population; eastern Gulf, central Gulf, western Gulf, eastern Aleutians, central Aleutians, and western Aleutians. Therefore, it is possible that several factors were important in driving the population decline during this time period.

In the 1990s, the rate of decline decreased from 15% to 5% per year. This followed further environmental changes in the 1990s and the implementation of extensive fishery regulations intended to reduce direct impacts such as shooting and indirect impacts such as competition for prey. During this decade, the Steller sea lions did not appear to be nutritionally stressed to the same extent they were in the 1980s. The primary factors associated with the decline during this period have not been identified. As was the case in the 1980s, the pattern and rate of declines in abundance varied significantly by subregion.

Steller sea lions were first listed as threatened under the ESA in 1990 due to the significant unexplained population declines. This listing conveyed that the species was likely to become endangered within the foreseeable future throughout all or a significant portion of its range. In 1997, the species was separated into western and eastern populations, and the western population was listed as endangered. At the time of this listing, the population was considered to be in danger of extinction in all or a significant portion of its range. Single population PVA models published in the mid-1990s indicated that the western population would be extinct in 100 years if the population trend at that time remained unchanged. Subsequent analyses, particularly those that considered the metapopulation structure, estimated less extinction risk for the western population as a whole because of greater persistence within one or more subregions that showed greater stability through the 1990s.

The U.S. portion of the western population continued to decline through the 1990s at about 5% annually. Since 2000, the population has increased at about 3%, with most portions of the range showing signs of recovery. The increase appears to be driven by increases in juvenile survival while pup production may still be in decline or possibly beginning to stabilize. The increasing trend in the population has only been observed in two surveys and thus must be observed for at least two more surveys before we can affirm that the population is indeed recovering. Because this population still faces substantial threats, and the observed increases are very short compared to the long time period of decline, it is still considered to be at risk of extinction within the next 100 years.

The western population of Steller sea lion sustains some direct mortalities from bycatch in commercial fisheries, subsistence harvest, illegal shootings, and entanglements in fishing gear. These human activities clearly have an adverse affect to individuals in the western population; however, the population-level consequences of these anthropogenic stressors are potentially low compared to competition for prey with commercial fisheries or natural changes in the availability or abundance of prey. Because of the relatively low number of animals (compared to historic observations), the population is considered vulnerable to catastrophic and stochastic events that could result in significant declines, threaten viability, and increase the species' risk of extinction. It is important to note that abundance estimates alone cannot be relied upon as accurate measures of population recovery without a long-term understanding of demographic parameters of the population, variability in the population trends and the effects of natural and anthropogenic stressors on the status of the population

In the late 1990s and early 2000s NMFS reviewed federally managed groundfish fisheries in Alaska, in a series of consultations under section 7 of the ESA. Two of those consultations resulted in a determination that the commercial fisheries were likely to jeopardize the continued existence of the western DPS of Steller sea lion and adversely modify its critical habitat. Therefore, as required under the ESA, additional conservation measures were implemented to avoid jeopardy and adverse modification. These measures were expected to promote the recovery of Steller sea lions in areas where potential competition from commercial fisheries may have contributed to the population decline.

It is plausible that the conservation measures implemented since 1990 are positively affecting the recovery of the western DPS. A positive correlation exists between increasing trends and fishery conservation measures; however, it is not known whether the increasing trend is a result of management actions, natural changes in the ecosystem, or some other factor.

3.1.16.3 Reproduction potential

Using the age-structured model by Holmes *et al.* (in review) and observations of Steller sea lions from aerial surveys, we can construct potential scenarios for population growth based on underlying vital rates estimated from these pieces of information (NMFS 2006b). The key question is whether the current increasing trend is likely to continue or whether it is just a temporary increase which will be followed by further declines. This analysis also provides insight into which components of the population would drive that potential population trajectory.

The Holmes *et al.* (in review) age-structured model provides an estimate of the numbers of female Steller sea lions at each age (through 31 years old) in the central Gulf of Alaska population (Table 3.25). These are females that will almost exclusively breed on rookeries at Chirikof, Chowiet, Marmot, Sugarloaf and Outer Islands. Counts of adult females and juveniles in each region in 2004 were available from the medium format aerial survey. An estimate of the observed total female population in each region was made by assuming a 50:50 sex ratio for juveniles, and adding half the juvenile count to the adult female count. Comparisons of the estimated and counted adult and all females in the central Gulf of Alaska (below) indicate that 44-45% of all females in the population are counted in the survey, which agrees well with independently obtained estimates of the proportion on-land (Trites *et al.* 2006).

Rates of "successful natality" are defined here as the total number of live pups estimated in late-June/early July divided by the total number of mature females in the region. Successful natality is a product of the late-term pregnancy rate of adult females, rates of late-term abortion/stillbirth, and early (~first month of age) neonate mortality. In 2005, a medium-format survey of pup production was conducted of all rookeries and major haul-outs on which greater than 10 pups had been observed in previous surveys. Applying the 2004 adult female observation rate (44%) to the 2005 adult female count on rookeries in each sub-area, the total number of adult females on rookeries in each sub-area was estimated (Table 3.26). Dividing sub-area pup counts on rookeries by the estimated adult female population on rookeries yields an estimate of successful natality (birth rate plus 1-month pup survival) for adult females on rookeries (Table 3.26). For the entire western stock in Alaska, rates of "successful natality" averaged 36% on rookeries, but ranged as low as 26% in the western Aleutians to as high as 39% for the central Aleutians. The four sub-areas in the Kenai-Kiska area had rates of "successful natality" ranging from 35-39%, but the central Gulf was at the lower end of this range.

To estimate successful natality of all adult females in each sub-area, it is necessary to estimate the total number of pups born as well as the total number of adult females in each sub-area. While most adult females were counted on rookeries in 2004, a significant proportion of adult females (22%) were on haul-outs. Applying the adult female observation rate (44%) to the sub-area counts of adult females on haul-outs in 2004, the total number of adult females on haul-outs in each sub-area was estimated and summed to get the total for the western stock in Alaska (Table 3.27). Also from the 2004 survey, 95% of all pups were counted on rookeries, while only 5% were counted on haul-outs. In 2005, there were a total of 9,616 pups counted on rookeries in the western stock, which yields an estimated total pup production of 10,090, with an estimated 474 born on haul-outs (based on the 2004 ratios). Dividing the estimated number of pups born on haul-outs in 2005 by the estimated number of adult females using haul-outs (in 2004) yields an estimated successful natality rate of only 6%; this is less then 1/5 of the rate of adult females on rookeries, which is not unexpected. For all adult females in the western stock in Alaska in 2005 (estimated N=34,221), the average rate of successful natality (estimated N = 10,090 pups) was 29%, but ranged from a low of 26% at the edges of the range in the eastern Gulf and western Aleutians, to a high of 32% in the central Aleutians. Rates of successful natality were highest from the Kenai Peninsula to Kiska Island, but within this area, were lowest in the central Gulf (29%).

Holmes et al (in review) estimated that the rate of successful natality declined by 34% from 1976 to the period between 1998 and 2004. Applying this change to the current rate of 29% yields an estimate of successful natality in 1976 of 44%. This is the baseline rate of successful natality and is the assumed rate for the entire western DPS in Alaska for 1976. Based on this assumption, a comparison of current rates to the 1976 rate is provided in Table 3.27. The regional pattern of changes in rates of successful natality suggests that rates have declined the most at the edges of the range, in the eastern Gulf and western Aleutians (currently only 52-53% of 1976 rates), and less in the Kenai-Kiska area (66-74% of 1976 rates). This also suggests that within the core of the range, rates of successful natality declined more in the central and western Gulf than in the eastern and central Aleutians.

3.1.16.5 Population projections

In the Alaskan western DPS, index counts of non-pups increased at about 3% per year between 2000 and 2004 (Fritz and Stinchcomb 2005). In this same period in the central GOA, however, non-pup counts declined slightly but at a slower rate than in the 1990s. The results of Holmes et al. (in review) suggest that the lessening of the rate of decline in non-pup numbers observed since 2000 in the central GOA is due entirely to increases in survivorship of juvenile and to a lesser extent adult Steller sea lions, since natality rates had declined. Therefore, in order to achieve 3% per year increases between 2000 and 2004 in the wDPS as a whole, one or more vital rates had to be greater in other regions than in the central GOA. Little is known about regional changes in survivorship, but regional ratios of pups to adult females (adjusted for observability) from the 2004-2005 MF aerial surveys revealed a regional trend in natality rates: natality was highest in the central Aleutians (39%) and declined slightly to the east (38% in the EAI, 36% WGOA, and 35% CGOA); natality rates were lower outside the Kenai-Kiska area (26% in the WAI and 29% in the EGOA).

The size of the Alaskan wDPS female Steller sea lion population was projected through 2015 by making assumptions about changes in juvenile and adult survivorship and rates of successful natality. The year 2015 was chosen because it represents the end of a 15-year period of increase suggested by the Steller Sea Lion Recovery Team when the population's status relative to the draft down-listing criteria will be assessed. A current (2004/5) estimate of the female population of Steller sea lions in the western DPS was made by NMFS (2006a; Table 3.25). This was based on the Holmes et al (in review) estimate of the numbers of females at age in the central Gulf of Alaska in 2004, a life table for the CGOA population (age-specific rates of survivorship and natality; Table 3.28) for the mid-1970s, and data from the 2004-2005 medium format aerial surveys of the Alaskan wDPS. To make projections for the entire western DPS through 2015;

- the 2004 age-structure of the female population in the central GOA was applied to each of the six sub-areas of the Alaskan portion of the western DPS (Table 3.25),
- region-specific rates of natality were calculated based on both the changes from the mid-1970s estimated for the central GOA (Holmes and York 2003; Holmes *et al.* in review) and the ratio of pups to adult females in each sub-region from medium-format aerial surveys conducted in 2004 and 2005 (Table 3.26 and 3.28),
- region-specific natality rates were multiplied by a scalar to yield rates across the western DPS that were +10%, 0%, -10%, -20%, -30%, -33%, and -40% of those estimated for the mid-1970s (-33% was similar to the rate estimated for the central Gulf), and\
- adult survivorship across the wDPS was fixed at integer rates (2-7%) greater than mid-1970s rates for all ages 4-31 (trend observed in Holmes and York (2003), Fay and Punt (2006), and Holmes *et al.* (in review);
- thus, for all combinations of changes in rates of successful natality and adult survivorship, the change in the rate of juvenile survivorship necessary to achieve western population growth rates of 0%, 1%, 2%, and 3% per year was calculated.

Population projections were made with the following constraints on changes in vital rates:

- No single rate of juvenile survival could be greater than 95%
- No single rate of adult survival could be greater than 98%
- No single rate of natality (female pups per female per year) could be greater than 0.48

Table 3.29 contains the changes in juvenile survivorship that are necessary across the wDPS to achieve population growth rates of 0-3% given changes in adult survivorship and natality. The best available information from brand-resight analyses and modeling exercises indicates that juvenile survivorship in the central GOA is currently (since 2000) about 95% of rates observed in the late 1970s (though it has increased substantially since the early 1980s)(NMFS 2006b, Holmes *et al.* in review). If this is true for the rest of the western DPS and if the western DPS is to have a sustained (through 2015) population growth rate of at least 1%, then:

- adult survivorship must be considerably greater than in the 1970s (as much as 7% greater), and
- declines in natality must only be modest (ca. -10%).

This is largely because there is only limited improvement possible between the mid-1970s rates of adult survivorship (maximum at age 4 of 91%) and a realistic cap of 98%. The recent population increases were achieved largely with increases in survivorship and in spite of a decline in natality. If these trends in vital rates continue, this is likely to yield only a temporary population increase due to the unstable age structure created. Improvements in adult survivorship may be possible considering the number of management actions taken to reduce direct mortality of sea lions (shooting ban, greatly reduced incidental take, declining subsistence harvest). However, without corresponding increases in natality, sustained increases in population size appear to be difficult to achieve.

3.2 Steller Sea Lion Critical Habitat

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

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

On August 27, 1993 NMFS published a final rule to designate critical habitat for the Steller sea lion (58 FR 45269). The areas designated as critical habitat for the Steller sea lion were determined using the best information available at the time (see regulations at 50 CFR part 226.202; Table 2.39 and 2.40), including 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 first Steller Sea Lion Recovery Team, independent marine mammal scientists invited to participate in the discussion, and the public (Figure 2.14 and 2.15).

3.2.1 Designated critical habitat

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 and major haulouts in Table 2 along with associated terrestrial, air, and aquatic zones). NMFS recognizes that more accurate locations for the sites listed in 50 CFR §226.202 are available. Advances in technology and repeated surveys to these areas have resulted in more precise and accurate location estimates. NMFS intends to update these locations as soon as practicable. However, the current inaccuracy in some of the locations in 50 CFR §226.202 does not substantially diminish the utility of those designations, rather, more accurate locations would aid those citizens attempting to navigate or fish near these listed sites.

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.

First, areas around rookeries and haulout sites were chosen based on evidence that many foraging trips by lactating adult females in summer may be relatively short (20 km or less; Merrick and Loughlin 1997). Also, mean distances for young-of-the-year in winter may be relatively short (about 30 km; Merrick and Loughlin 1997, Loughlin *et al.* 2003). These young animals are just learning to feed on their own, and the availability of prey in the vicinity of rookeries and haulout sites must be crucial to their transition to independent feeding after weaning. Similarly, haulouts around rookeries are important for juveniles, because most juveniles are found at haulouts not rookeries. Evidence indicates that decreased juvenile survival may be an important proximate cause of the sea lion decline (York 1994, Chumbley *et al.* 1997) and that the growth rate of individual young sea lions was depressed in the 1980s (Calkins and Goodwin 1988). These findings are consistent with the hypothesis that young animals were nutritionally stressed. Furthermore, young animals are almost certainly less efficient foragers and may have relatively greater food requirements, which, again, suggests that they may be more easily limited or affected by reduced prey resources or greater energetic requirements associated with foraging at distant locations. Therefore, the areas around rookeries and haulout sites must contain essential prey resources for at least lactating adult females, young-of-the-year, and juveniles, and those areas were deemed essential to protect.

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

In summary, designated critical habitat for Steller sea lions throughout their range (eastern and western DPSs) includes:

- A terrestrial zone that extends 3,000 feet (0.9 km) landward from the baseline or base point of each major rookery and major haulout
- 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.
- 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'N/157°26'W) and the southwestern tip of Tugidak Island (56°24'N/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 Status of Steller sea lion critical habitat

3.2.3 Important Steller Sea Lion Habitat

In this section we describe important Steller sea lion habitat areas based on usage patterns. This includes the determination of important sites not previously designated as critical habitat under the ESA, a review of rookeries, and a description of the seasonal usage of both ESA and non-ESA designated sites.

Long-used rookery sites were likely selected by sea lions for a variety of reasons, including substrate and terrain, protection from land-based and marine predators, protection from harsh wave or surf conditions, and local availability of prey. Successful reproduction for the species depends on the availability of rookery sites where animals can aggregate for sufficiently long periods of time to give birth, mate, and raise their young until the young are able to survive at sea. As the reproductive period requires at least several months, food supplies in the vicinity of the rookeries must be sufficient to meet the energetic needs of animals involved in reproduction (adult females and males and pups). Once the reproductive season and the need for social aggregation is over, and pups have gained sufficient competence at sea, then animals (including mothers with pups) may not disperse to other haulout sites. Throughout the remainder of the year, the local availability of prey remains a crucial factor (probably the most important factor) in determining their movements and distribution. Mothers with dependent pups are still likely to be constrained in their foraging distribution. All pups are susceptible because they have limited reserves compared to adult animals. Pups in the process of weaning are likely poor foragers that may be susceptible to reductions in prey availability. Pups are likely dependent on nearshore prey resources while they make the difficult transition to independent foraging. Juveniles, older but still immature, must continue to develop their foraging skills over time, but probably remain particularly sensitive to reductions in available prey. Like other, older animals, they may range more widely, but their distribution and haulout patterns must be determined, in large part, by the availability of prey.

The foraging success of these animals, whether based on rookeries or haulouts, is determined by their ability to balance the gains from foraging with the costs of daily activities, including the act of foraging itself (i.e., energy balance). If the prey resources around rookeries and haulouts are inadequate for their needs (potentially reduced or depleted), then they are forced to increase the time and energy expended to find sufficient prey. As a result, they are more likely to fail in securing the resources necessary for growth, reproduction, and survival. Population recovery will likely depend upon increased reproduction and juvenile survival.

3.2.3.1 Determination of important sites not designated as critical habitat

In a 1998 biological opinion (NMFS 1998), NMFS identified nineteen Steller sea lion sites which were not designated as critical habitat but which required special management measures in order to avoid jeopardizing the western DPS. The determination was based on historical population counts in which at least one recorded count of non-pup Steller sea lions exceeding certain criteria during the breeding (greater than 200 non-pups from May-August) or non-breeding seasons (greater than 75 non-pups from September-April; Table 2.26). The database queried for the 1998 analysis was the Alaska Adult Count database maintained by NMML and available on the NMML website. The original 19 sites were not designated as critical habitat, but were included for management purposes as part of the Revised Final Reasonable and Prudent Alternative (RFRPA) process (NMFS 1999).

The analysis was repeated again in March 2006 (NMFS 2006b). The criteria for breeding season haulout use remained the same (>200 non-pups), but the non-breeding season threshold count was raised from 75 to 100 non-pups. This was based on the Sease and York (2003) finding that non-breeding season counts were approximately half those of breeding season counts. The threshold number of 200 was used previously during critical habitat designation to determine which haul-outs were “major” using almost exclusively counts conducted during the breeding season. Therefore, the 200 non-pup breeding season count was retained as the threshold, and the non-breeding season count of 100 was used to identify non-breeding season haulouts.

Analysis of non-pup count data collected through 2005 indicates that Samalga Island and Amchitka/Cape Ivakin (listed in bold in Table 3.30) should be removed from the list of 19 important sites because:

- Samalga had only 1 breeding season count > 200 (490 in 1985, but no more than 10 in any single survey since 1989).
- Amchitka/Cape Ivakin had only 1 one breeding season count > 200 (450 in 1959, and no more than 2 in any single survey since 1989).

Ugamak/Round (in italics in Table 3.30) failed to meet either criteria since 1990, but should be retained as an important site for management purposes. It is an integral part of the Ugamak Island rookery complex (Ugamak/Ugamak Bay and Ugamak/North) and represents a significant terrestrial site within that complex.

An additional 21 haul-out sites were identified as meeting the criteria for an important site. However, only five sites met the criteria since 1990 and should be included as an important site:

- ELIZABETH/CAPE ELIZABETH had 112 non-pups in March 1993
- FLAT had 174 non-pups in Dec 1994 and 125 in March 1999
- UNGA/ACHEREDIN POINT had 264 non-pups in June 2004
- TAGALAK had 150 non-pups in March 1999
- SEMISOPOCHNOI/TUMAN POINT had 154 non-pups in March 1993

Fourteen additional sites met the criteria, but all had only 1 or 2 counts that met the criteria and all but two occurred prior to 1966. Therefore, while they technically meet the criteria, there is no evidence that these sites have been important since 1985, and should not be considered as an important site:

- USHAGAT/ROCKS SOUTH (breeding 1985)

- UGAIUSHAK (breeding 1956)
- UNIMAK/OKSENOF POINT (non-breeding 1960)
- AKUN/AKUN HEAD (non-breeding 1960)
- AKUTAN/NORTH HEAD (non-breeding 1957)
- EGG (non-breeding 1957)
- UNALASKA/CAPE STARICHKOF (non-breeding 1960 and breeding 1977)
- UNALASKA/SPRAY CAPE (non-breeding 1960)
- CARLISLE (breeding 1960 and breeding 1965)
- AMLIA/CAPE MISTY (breeding 1959)
- IKIGINAK (breeding 1959)
- IGITKIN/SW POINT (breeding 1959)
- SKAGUL/S. POINT (breeding 1959)
- GARELOI (breeding 1960).
- USHAGAT is the island on which USHAGAT/SW is located, and the latter is both an ESA-listed haul-out and an RFRPA site
- AMATIGNAK is the island on which AMATIGNAK/NITROF POINT is located, and the latter is both an ESA-listed haul-out and an RFRPA site.

The sites listed in Table 3.31 meet the minimum thresholds of non-pup counts in the breeding and non-breeding seasons since 1990, are not ESA-listed critical habitat sites, and are considered to be important sites. The list includes 22 sites: 17 of the original 19 important sites (NMFS 1999; Table 3.30), plus 5 additional sites identified in this analysis (NMFS 2006b).

3.2.3.2 Determination of important rookeries

Rookeries are terrestrial locations where sea lions breed and give birth. While this may occur to some extent on a large number of sites, a site has previously been designated as a “rookery” when a minimum number of pups have been born and certain demographic and behavioral characteristics have been observed including: bulls defend territories occupied by adult females with pups, there is a low proportion of juvenile animals, and sub-adult males occupy the area outside of defended territories. It is important to identify these rookery sites such that appropriate management can be applied to rookeries which are more vulnerable to stressors during the summer pupping and breeding season.

For this analysis, rookeries were defined as sites with a pup count of at least 50 since 1978. In support of this value, the age and sex composition of the sea lion population occupying these rookeries was compared with that on haulouts based on analysis of medium format photographs taken in 2004 (NMFS 2006b). Based on the analysis (NMFS 2006b), five new sites[8] should be considered a rookery, for conservation purposes, based on the following evidence (NMFS 2006b):

- Chiswell Islands: N = 58 pups in 2000
- Jude Island: N > 50 pups in 2002-2005
- Kanaga/Ship Rock: N > 50 pups in 2004-2005
- Lighthouse Rocks: N > 50 pups in 1978 (N=250) and 1979 (N=112)
- Ushagat/SW: N = 55 pups in 2005

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[8] These 5 sites are designated critical habitat haulouts under the ESA (50 CRR part 226.202). Although the designation includes a determination of haulout or rookery for each site, no specific action is required in the ESA designation. However, the type of site is important when considering whether the habitat is being conserved under Section 7 of the ESA. Therefore, accurate description of whether a site is a haulout or rookery is important and must be updated occasionally as usage patterns change due to population demographics and environmental changes.

Four sites previously designated as rookeries should be considered as haulouts because none have had a pup count >50 (NMFS 2006b; Agligadak, Semisopochnoi/Pochnoi, Semisopochnoi/Petrel, Amchitka/East Cape). The remaining 34 ESA-listed rookeries should retain their rookery status, and the five sites listed above should be added to this list for a total of 39 rookeries:

Area	Rookeries
Western Aleutians (N = 4)	ATTU/CAPE WRANGELL, AGATTU/CAPE SABAK, AGATTU/GILLON POINT, and BULDIR
Central Aleutians (new N = 12)	KISKA/CAPE ST STEPHEN, KISKA/LIEF COVE, AYUGADAK, AMCHITKA/COLUMN ROCK, ULAK/HASGOX POINT, TAG, GRAMP ROCK, ADAK/LAKE POINT, KASATOCHI/NORTH POINT, SEGUAM/SADDLERIDGE, and YUNASKA [**add KANAGA/SHIP ROCK**]
Eastern Aleutians (N = 7)	ADUGAK, OGCHUL, BOGOSLOF/FIRE ISLAND, AKUTAN/CAPE MORGAN, AKUN/BILLINGS HEAD, UGAMAK COMPLEX, and SEA LION ROCK (AMAK)
Bering Sea (N = 1)	WALRUS
Western Gulf (new N = 6)	CLUBBING ROCKS, PINNACLE ROCK, CHERNABURA, and ATKINS [**add JUDE and LIGHTHOUSE ROCKS**]
Central Gulf (new N = 6)	CHOWIET, CHIRIKOF, MARMOT, SUGARLOAF, and OUTER (PYE) [**add USHAGAT/SW**]
Eastern Gulf (new N = 3)	WOODED (FISH) and SEAL ROCKS [**add CHISWELL ISLANDS**]

3.2.3.3 Determination of Seasonal Usage Patterns

The selection of important sites and seasons is based on the requirement to provide the protection necessary for recovery and conservation of the species. Beginning with the protection requirements contained within the RPA from the 1998 Biological Opinion, NMFS has approached protection for important sites based on a seasonal evaluation of usage patterns (NMFS 1998, 1999, 2000). However, in 2001 (NMFS 2000, 2001), conservation measures moved away from the seasonal approach to an annual one in which critical habitat of various zones (e.g., 0-10 nm, 10-20 nm) was of equal value within a zone and across the range. To further refine this approach, NMFS has re-analyzed the count database to assess which sites are currently (using data from 1990-2005) important, and which sites may be utilized to a lesser extent or only in certain seasons (NMFS 2006b). To determine the potential fishery effects on Steller sea lions important habitat should be examined based on location, numbers of animals, and seasonal usage patterns as well as by zone (distance from a site).

The analysis evaluates important sites and seasons based on seasonal counts from 1990-2005. NMFS used a count of 200 non-pups as the threshold for determining whether a site was important during the summer (May – October) and a count of 100 as the threshold for November - April. Two thresholds were used because haulout use patterns change between these periods. The 200 non-pup threshold had previously been used by Steller Sea Lion Recovery Team as a criterion for identifying major sites to be included in the critical habitat designation. Their concern was related, in part, to a judgement that to remain viable, a subpopulation of animals at a particular site should contain 50 or more adult females, which was not likely unless the entire subpopulation consisted of at least 200 animals. The threshold for the winter period was lowered to 100 animals for the following reasons. First, Sease and York (2003) evaluated winter sea lion counts and found that roughly half the number of sea lions were observed during the winter surveys. Second, sea lions disperse more widely in winter to find sufficient prey and, on average, aggregations are likely to be smaller. Third, they may be required to spend more time at sea and less time at haulouts where they would be counted. And fourth, only three counts have been conducted during this period, and those counts were conducted in recent years (1993, 1994, and 1999). The counts are the best available data for assessing the potential importance of haulout sites. Nevertheless, the counts are also limited (especially the winter counts), and may underestimate the value of haulout sites to sea lions. The results of the analysis are provided in Table 3.32. The list includes all of the sites designated as critical habitat as well as the additional 22 sites identified above. The list includes 34 sites which did not meet either seasonal criteria during this time period, and reflects the changes described above to which sites are currently functioning as important rookeries.

- Surveys were not conducted every year. Summer surveys were conducted in 1990, 1991, 1992, 1994, 1996, 1998, 2000, 2002, and 2004. Partial intermittent surveys were conducted in 1981-1984 and 1986-1988. As noted above, winter surveys were conducted only in 1993, 1994, and 1999. In general, surveys were less common during the 1980s (when the population was larger) than in the 1990s (after the steepest part of the decline). Therefore, these data would be more likely to miss historically important sites.

- In almost every year in which a survey was conducted, only a single count was made. Literally, that count represents a snapshot of a haulout at a particular time. If the count occurred at an important site when few animals were ashore (due to weather or other factors), then the value of the haulout would not have been reflected in the count. For example, the summer counts at Cape Barnabas have revealed zero or one sea lion on the site since 1989. However, incidental counts at Cape Barnabas in December 1993 and March 1994 revealed 124 and 31 animals, suggesting considerable variation in the use of sites within the year (and indicating that this is still an important site to sea lions). Such within-year variation is not measured when counts are conducted once a year.

- The main counting period (about two weeks in late June and early July) was selected because the counts on rookeries are thought to be at their maximum during that brief period. Therefore, these counts are not particularly good indicators of the importance of haulout sites that are in use the remainder of the year.

Therefore, while these counts are the best available data for the purpose of identifying important haulout sites, they are both limited and biased. The tendency of these data would be to under-represent the importance of haulout sites to sea lions and, on that basis, should not be considered overly conservative.

It is important to protect haulout sites (to some extent) where few or even no animals have been counted in recent years. The protection of these sites is essential and is based on the general importance of habitat conservation to the recovery of protected species. Recovery can not occur if the habitat essential to support a recovering or recovered population is not available. That is, the essential habitat must be available before recovery can occur. The importance of habitat protection is underscored by the requirements of the ESA. The ESA recognizes the crucial link between habitat and recovery, and therefore requires that every federal agency not only avoid jeopardy to such species, but also avoid "destruction or adverse modification of critical habitat." The notion of delaying protection of habitat until after a species has recovered is therefore inconsistent with our understanding of the link between a species and its habitat, with our understanding of the recovery process, and with the requirements of the ESA.

Finally, factors other than the decline could have altered the distribution patterns of Steller sea lions and the relative importance of their haulouts. However, the best available scientific and commercial data are not sufficient to describe such a change in haulout patterns as a result of changes in oceanographic parameters or changes in composition of the prey community. As described above, the existing data on haulout patterns is sufficient to indicate some hauling sites that have been or are currently important to sea lions, but not sufficient to detect shifting patterns of use that could be attributed to any general factor such changes in prey distribution.

3.3 Humpback Whale

3.4 Sperm Whale

4 BASELINE

The environmental baseline is an analysis of the effects of past and ongoing human-caused and natural factors leading to the current status of the species or its habitat and ecosystem within the action area. Environmental baselines for biological opinions include past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). 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.

The Environmental Baseline for this biological opinion includes the effects of a wide variety of human activities and natural phenomena that may affect the survival and recovery of threatened and endangered species in the action area. NMFS recognizes that natural phenomena and many human activities have contributed to the current status of populations of threatened and endangered species in the action area. Some of those activities have occurred in the past but no longer affect these species. Other activities may have affected, and continue to affect populations of listed species in the action area.

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

4.1 Ecosystem Dynamics in the Action Area

In the North Pacific Ocean, Steller sea lions inhabit a diverse and complex ecosystem, which they share with many other species. Detailed descriptions of physical and biological characteristics of the Gulf of Alaska and Bering Sea have been compiled by Hood and Calder (1981), Hood and Zimmerman (1986), National Research Council (1996), Trites *et al.* (1999, 2006a), Loughlin and Ohtani (1999), and Guenette and Christensen (2005).

Physical aspects of the environment obviously determine whether or not an area is suitable for sustaining Steller sea lions, or any other life form. Physical parameters that may be important to sea lions include coastal geomorphology, air and water temperatures, wind speeds, wave conditions, tides, currents, etc. A few recent studies have addressed how such factors may influence sea lion distribution and abundance. One showed that the terrestrial sites used by Steller sea lions tend to be associated with waters that are relatively shallow and well-mixed, with average tidal speeds and less-steep bottom slopes (Ban 2005). Another study identified patterns in ocean climate that are consistent with the patterns of sea lion distributions, population trends, numbers and diets (Trites *et al.* 2006a). Thus, there appears to be a linkage between Steller sea lions and the physical environment, which likely plays a major role in determining the northern and southern limits of the Steller sea lion range.

Physical characteristics of the ecosystems inhabited by sea lions are not static, but rather show variations on several time scales (Schumacher and Alexander 1999, Trites *et al.* 2006a). Considerable attention has recently been given to abrupt decadal scale changes in long term data series that describe the climate, oceanic conditions and abundances of a number of species in the North Pacific. The largest such change recorded this past century occurred in the mid-1970s (Ebbesmeyer *et al.* 1991, Graham 1994, Francis *et al.* 1998). In some cases fluctuations in fish, bird, and mammal populations seem to correlate with these decadal scale climate changes (Springer 1998, 2004, Benson and Trites 2002, Polovina 2005, Trites *et al.* 2006a). Food web interactions (Trites 2003), predation (Barrett-Lennard *et al.* 1995) and disease (Burek *et al.* 2003, Goldstein 2004) are all biotic components of the ecosystem that are important to Steller sea lions as they function as food, competitors, predators, parasites, and disease agents.

Human exploitation of marine mammals and fishes in the North Pacific Ocean over the past 250 years has undoubtedly modified the environment that Steller sea lions occupy (NRC 2006). The precise effects on Steller sea lions have been impossible to determine, but have likely been substantial, variable over time, and both top-down and bottom-up in nature. Large-scale removals of competitors of prey, such as some species of great whales, northern fur seals, and perhaps some fishes may have provided additional food and for some period of time may have increased sea lion carrying capacity. The relationship of Steller sea lions with their primary predator, killer whales, has also likely varied over time with the exploitation of alternative prey such as great whales, northern fur seals, and sea otters (Springer *et al.* 2003, DeMaster *et al.* 2006). Combining this with climatic variability and commercial fisheries that could potentially affect the carrying capacity for Steller sea lions yields an extremely complex history.

Ecosystem models are available for the Aleutian Islands, Eastern Bering Sea and Southeast Alaska; these models can be used to decipher the combined effects that fishing, predation, ocean climate change, and interspecies interactions have had on Steller sea lions and their ecosystems as a whole (Trites *et al.* 1999, Guenette and Christensen 2005). These models indicate that bottom-up and top-down processes occur simultaneously and suggest that Steller sea lions have been both positively and negatively affected by changes in their food base (due to fishing and ocean climate change), as well as by competition with large flatfish, and by the effects of predation by killer whales (particularly when sea lion numbers are low). Further work is continuing with these models to assist in better understanding the complex ecosystem interactions underway in the North Pacific. Ecosystem-level effects of fishing are evident, although they may not be de-coupled from natural environmental changes or reversible (NRC 2006).

4.1.1 Environmental Variability

On a large spatial and temporal scale, the major mode of physical variability in the North Pacific has been identified as the Pacific Decadal Oscillation (PDO), which was described in the 1990s (Francis and Hare 1994, Mantua *et al.* 1997), but as of late 2003 may no longer be considered oscillatory (Bond *et al.* 2003). In brief, this may be a coupled ocean atmosphere phenomenon (some argue that it's a true coupled system oscillation like ENSO (Latif and Barnett 1996), but the physical mechanisms are largely undescribed) which results in sea surface temperature (SST) and sea level pressure (SLP) anomalies and altered circulation in the entire North Pacific ocean. Clear "regime shifts" with fundamentally different SST and SLP patterns in space manifested in the atmosphere ocean system do appear on a decadal scale, in particular in 1946-47 and in 1976-77. The U.S. west coast, eastern tropical Pacific, and the Gulf of Alaska shelf were warmer and the Central North Pacific was cooler post 1977 compared with the decades before (Zhang *et al.* 1997). An additional regime shift has been identified in 1925 (Mantua *et al.* 1997). The decadal variability in the mid latitudes may be related to and definitely interacts with the better understood tropical atmosphere ocean variability that results in the El Nino Southern Oscillation (ENSO), which has an inter-annual timescale. However, it has been pointed out that there have been other reversals in the patterns of SST and SLP which are just as dramatic from a physical standpoint as those in the early 1940s and late 1970s, but which did not persist as long and therefore have not been termed regime shifts in retrospect (e.g. 1957-58, Zhang *et al.* 1997). "Regime shift" may therefore be interpreted as not a purely physically defined phenomenon, but one which requires an associated biological shift to be described in order to receive official recognition. Therefore, it is important to look at the type and spatial scale of physical forcing, as well as its persistence with respect to biological communities, because it seems feasible that species with certain life histories would respond to any multi-year shift in physical conditions while others would require at least decadal variability to respond, and the interaction between these species throughout the responses would also contribute to ecosystem dynamics.

Localized physical characteristics of the Gulf of Alaska continental shelf ecosystem are important to understanding the spatial and temporal variability in the biological communities as well, especially since many of its environmental parameters do not appear to display any decadal signal over the past 50 years (Stabeno *et al.* 2004). Perhaps the two most important broad circulation features in the coastal Gulf of Alaska are the Alaska Stream and the Alaska Coastal Current (Reed and Schumacher 1987). The Alaska Stream runs relatively narrow and fast along the shelf break from the Northern GOA off Cape St. Elias towards the Aleutian Islands in the west. The position and strength of this current and its interaction with bottom topography is thought to alter the nutrient supply to phytoplankton on the shelf, along with seasonal wind driven cross shelf (Ekman) transport and entrainment due to freshwater runoff (Parsons 1987, Sambrotto and Lorenzen, 1987). Recent information indicates that the Alaska Stream is relatively steady within a season, but exhibits variability on interannual timescales (Hermann *et al.* 2002). The Alaska Coastal Current is a weaker flow in general, running parallel to the Alaska Stream closer to shore and through Shelikof Strait, but it is seasonally quite variable due to changes in freshwater runoff, which usually peaks in September-October (Stabeno *et al.* 2004). Runoff also changes surface salinity and therefore water column stratification on the GOA shelf seasonally and locally, contributing to spatial and temporal variation in productivity. Vertical flow of water from surface to bottom (downwelling) and deep waters to surface (upwelling) can maintain or dispupt the flow of nutrients to the better lit surface waters where marine plants (phytoplankton) reside—therefore, downwelling and upwelling are important processes for biological production (Valiela 1995, Mann and Lazier 1991). Both seasonal downwelling and upwelling occur locally on the GOA continental shelf as a result of the interactions of these currents, runoff, and seasonally as well as locally varying winds (Stabeno *et al.* 2004). In general, downwelling dominates the system during the winter seasons, and (sporadic) upwelling predominates during the summer (Parsons 1987), although the duration and strength of summer upwelling varies locally with the wind field, so that some areas of the shelf may only experience upwelling regimes for 1 to 2 months of the year (Reed and Schumacher 1987). On the northern Gulf of Alaska shelf, upwelling not attributable to broad-scale physical forces may also be caused by localized wind stress curl (Hermann pers comm. 2005). In addition, mesoscale (~200 km diameter) eddies form as a result of both bottom topography (e.g. the Sitka eddy) and the interaction of the Alaska Stream and Alaska Coastal Current (Reed and Schumacher 1987, Hermann *et al.* 2002, Ladd *et al.* 2005). These eddies are most common in spring and are often anticyclonic (Hermann *et al.* 2002), therefore producing localized downwelling where they occur. Thus the physical conditions on the Gulf of Alaska continental shelf are complex and variable at several temporal and spatial scales, so we might expect considerable spatial and temporal variation in the biological community due to physical forcing alone, in addition to variability imposed by biological dynamics.

Changes in the Gulf of Alaska continental shelf assemblage of benthic invertebrate and fish predators, including groundfish, invertebrates, and salmon, have been demonstrated and at least hypothetically attributed to climate regime shifts (Orensanz *et al.* 1998, Anderson and Piatt 1999, Mantua *et al.* 1997, Francis *et al.* 1998, Hare and Mantua 2000). The proposed mechanism for climate change forcing the observed change in productivity at higher trophic levels often involves “bottom up” forcing due to a change in phytoplankton and zooplankton production in response to changed physical condition such as mixed layer depth and temperature (Francis *et al.* 1998). There have been several studies which have modeled a lower trophic level response to changes in mixed layer depth and temperature associated with climate change: Polovina *et al.* (1995) used the 1985 Evans and Parslow model, and Haigh *et al.* (2001) used a more complex combination of the Evans and Parslow (1985) model and the Fasham (1995) model which included a detrital loop to evaluate the response of pelagic plankton communities to physical changes associated with decadal climate oscillations. However, none of these studies address the Gulf of Alaska shelf ecosystem specifically, where the observed changes in shrimp and groundfish productivity have occurred. The lack of a clear PDO signal in the physical conditions on the continental shelf (Stabeno *et al.* 2004) makes physically mediated bottom-up forcing arguments difficult to support by the mechanisms listed above for the open oceanic Gulf of Alaska. Further, no direct evidence of increased primary and secondary productivity within the shelf ecosystem has been identified in relation to the 1977 regime shift, in part because the time series are inadequate to address the question. However, knowing that large scale physical shifts have occurred, and finding that fishing mortality contributes relatively little to some groundfish stock's total mortality and production, the regime shift paradigm finds more and more support through correlative analyses despite a modest supply of mechanistic connections.

4.1.2 Climate and Biological Regime Shifts

There is evidence for past climate regime shifts[1] and ecosystem responses to those shifts in the EBS and GOA (mid-1940s, 1977 and 1989); although evidence for a recent climate regime shift (1999) is unclear. Based on basin-wide North Pacific climate-ocean indices, there appear to have been major climate/ocean regime shifts in the mid-1940s and in 1976/77, and a minor climate regime shift in 1988/89 (Boldt 2005a, Hare and Mantua 2000, King 2005). For the earlier climate regime shifts, the mid-1940s and 1977, the pattern of sea surface temperature spatial variability implied a west-east dipole (Boldt 2004, Bond et al. 2003). Since 1989, the pattern of spatial variability has been dominated by a second pattern of sea surface temperature variability, which implies a north-south dipole. At regional scales the responses to these basin-scale changes may not be as coherent (Boldt 2004). Given the variability in the indices since 1998, there is some uncertainty if there was a climate regime shift in the late 1990s (Rodionov *et al.* 2005).

It is important to note that regimes cannot be characterized by only two possible states (King 2005). It is currently not possible to reliably predict when a regime shift will occur. There are multiple physical and ecological processes underlying regime shifts that are currently not well understood. Different statistical models fitted to data provide divergent predictions of future conditions (King 2005).

4.1.2.1 Bering Sea

The Bering Sea (BS) has shown three multidecadal regimes in surface air temperatures (SAT) fluctuations: 1921-1939 (warm), 1940-1976 (cold), and 1977-2005 (warm) (Rodionov *et al.* 2005). The Bering Sea was subject to a change in the physical environment and an ecosystem response after 1977, a minor influence from shifts in Arctic atmospheric circulation in the early 1990s, and persistent warm conditions since 2000 (see Tables 2 and 3 in Boldt 2005b). A major transformation, or regime shift, of the Bering Sea occurred in atmospheric conditions around 1977, changing from a predominantly cold Arctic climate to a warmer subarctic maritime climate as part of the Pacific Decadal Oscillation (PDO) (see Tables 2 and 3 in Boldt 2005b). This shift in physical forcing was accompanied by a major reorganization of the marine ecosystem on the Bering Sea shelf over the following decade. Surveys show an increase in the importance of pollock to the ecosystem. Weather data beginning in the 1910s and proxy data (e.g. tree rings) back to 1800 suggest that, except for a period in the 1930s, the Bering Sea was generally cool before 1977, with sufficient time for slow growing, long-lived, cold-adapted species to adjust. Thus the last few decades appear to be a transition period for the Bering Sea ecosystem.

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[1] Atmospheric scientists often refer to decadal-scale changes in the climate as climate regime shifts. This type of regime shift is different than a biological regime shift. There are observed decadal-scale changes in some biological components of the North Pacific, and these are often referred to as biological regime shifts. Climate regime shifts may be observed in the physical conditions of the ocean and may affect the biology; however, the mechanisms by which the biology might be influenced are largely unknown. In this analysis we have attempted to distinguish between climate and biological regime shifts.

A comprehensive report (NAS 1996) attributes the ecosystem reorganization toward pollock to the combination of fishing and the 1976/77 climate regime shift. They hypothesize that fishing of large whales increased the availability of planktonic prey, fishing on herring reduced competition, and fishing on flatfish reduced predation. The modeling study of Trites *et al.* (1999) noted that the increase in pollock biomass could not be explained solely by trophic interaction from these removals, and favored environmental shifts as an explanation. While the physical shift after 1976 was abrupt and pollock biomass increased rapidly, the ecosystem adjustment probably took a prolonged period as relative biomass shifted within the ecosystem. Biodiversity measures (richness and evenness) of roundfish, excluding pollock, decreased throughout the 1980s and were stable in the 1990s (Hoff 2003). Jellyfish, which share a common trophic level with juvenile pollock and herring, may have played a role in the ecosystem adjustment as their biomass increased exponentially beginning in the late 1980s, but decreased to lower levels in 2001-2005 (see Tables 2 and 3 in Boldt 2005b).

A specific Arctic influence on the Bering Sea began in the early 1990s, as a shift in polar vortex winds (the Arctic Oscillation – AO) reinforced the warm Bering conditions, especially promoting an earlier timing of spring meltback of sea ice. Flatfish increased in the mid-1980s due to changes in larval advection (Wilderbuer et al. 2002), but the AO shift to weaker winds after 1989 have since reduced these favorable conditions (Overland *et al.* 1999).

Warm conditions tend to favor pelagic over benthic components of the ecosystem (Hunt et al. 2002, Palmer 2003). Cold water species, i.e. Greenland turbot, Arctic cod, snow crab and a cold water amphipod, are no longer found in abundance in the SE Bering Sea, and the range of Pacific walrus is moving northward. While it is difficult to show direct causality, the timing of the reduction in some marine mammal abundance levels suggests it is due to some loss of their traditional Arctic habitat. Although physical conditions appear mostly stable over the last decade, the warmest water column temperatures have occurred in 2001 to 2005 on the southeast Bering Sea shelf, despite considerable year-to-year variability in the AO and PDO.

The overall climate change occurring in the Arctic, as indicated by warmer atmospheric and oceanic temperatures and loss of 15% of sea ice and tundra area over the previous two decades, is hypothesized to make the Bering Sea less sensitive to the intrinsic climate variability of the North Pacific. Indeed, when the waters off of west coast of the continental U.S. shifted to cooler conditions after 1998, the subarctic did not change (Victoria pattern), in contrast to three earlier PDO shifts in the 20th century.

4.1.2.2 Aleutian Islands

Climatic conditions vary between the east and west Aleutian Islands around 170 deg W: to the west there is a long term cooling trend in winter while to the east conditions change with the PDO. This is also near the first major pass between the Pacific and Bering Seas for currents coming from the east. Biological conditions in the Aleutian Islands have changed since the 1980s, and it is too soon to discern if there was a change associated with the 1998 climate regime shift. Pollock and Atka mackerel productivity do not appear to vary on a decadal-scale; however, the biomass of pollock appears to be higher than it was in the 1980s. Pacific ocean perch population dynamics vary on a decadal-scale. For example, Pacific ocean perch survival changed at approximate times of climate regime shifts, 1975 and 1989. There is not enough information on the early life history of Pacific ocean perch to define a mechanism for the observed variations.

4.1.2.3 Gulf of Alaska

Evidence suggests there were climate regime shifts in 1977 and 1989 in the North Pacific. Ecosystem responses to these climate shifts in the Gulf of Alaska (GOA) were strong after 1977, but weaker after

1989. Initially it was hypothesized that there was a climate regime shift in 1998/99 as well, however, evidence for this shift is unclear. Variation in the strength of ecosystem responses to climate shifts may be due to the geographical location of the GOA in relation to the spatial pattern of climate variability in the North Pacific. Prior to 1989, climate forcing varied in an east-west pattern, and the GOA was exposed to extremes in this forcing. After 1989, climate forcing varied in a north-south pattern, with the GOA as a transition zone between the extremes in this forcing. The 1989 regime shift did not, therefore, result in strong signals in the GOA.

There were both physical and biological responses to climate regime shifts in the GOA; however, the primary reorganization of the GOA ecosystem occurred after the 1977 climate shift. After 1977, the Aleutian Low intensified resulting in a stronger Alaska current, warmer water temperatures, increased coastal rain, and, therefore, increased water column stability. The optimal stability window hypothesis suggests that water column stability is the limiting factor for primary production in the GOA (Gargett 1997). A doubling of zooplankton biomass between the 1950s- 1960s and the 1980s indicates production was positively affected after the 1977 climate regime shift (Brodeur and Ware 1992). Recruitment and survival of salmon and demersal fish species also improved after 1977 (see Tables 4 and 5 in Boldt 2005b). Catches of Pacific salmon in Alaska increased, recruitment of rockfish (Pacific ocean perch) increased, and flatfish (arrowtooth flounder, halibut, and flathead sole) recruitment and biomass increased. There are indications that shrimp and forage fish, such as capelin, were negatively affected after 1977, as survey catches declined dramatically in the early 1980s (Anderson 2003; see Tables 2 and 3 in Boldt 2005b). The decline in marine mammal and seabird populations, observed after 1977, may have been related to the change in forage fish availability (Piatt and Anderson 1996).

After 1989, water temperatures were cooler and more variable in the coastal GOA, suggesting production may have been lower and more variable. After 1989, British Columbia (BC) salmon catches and survival were low and Queen Charlotte Island (northern BC) herring declined. Salmon catches in Alaska, however, remained high. Groundfish biomass trends that began in the early 1980s continued, with increases in flatfish biomass. By the late 1980s arrowtooth flounder, rather than walleye pollock, were the dominant groundfish. Large groundfish biomass estimates resulted in negative recruit per spawning biomass anomalies of demersal fish.

Initially, there was some indication that the GOA ecosystem may have weakly responded to the suspected 1998 climate regime shift. Increased storm intensity from 1999 to 2001 resulted in a deeper mixed layer depth in the central GOA, and coastal temperatures were average or slightly below average. After 1998, coho survival increased in southern BC, shrimp catches increased in the northern GOA (but have since declined again in 2003), and the 1999 year class of both walleye pollock and Pacific cod was strong in the northern GOA.

4.1.3 Changes in Biological Productivity

Conners *et al.* (2002) present an analysis of bottom trawl survey data from 1963-2000. Three index areas with good survey coverage through the full time span were selected; one area includes Steller sea lion critical habitat north of Unimak Island. A robust index of median CPUE was used as an indicator of regional groundfish abundance. Time series for total catch and for several major groundfish groups showed substantial increases in the early- to mid-1980s in all three index areas (Figure 4.1). Time series for walleye pollock, Pacific cod, rock sole, flathead sole, cartilaginous fishes (skates) and benthic invertebrates showed substantial increasing trends. The timing of change in trawl CPUE is consistent with effects of the strong regime shift observed in climate indices in 1976-1977. The similarity in trends both across the region and across both commercial and unexploited groups suggests that a widespread reorganization of benthic and demersal food webs may have taken place. There is little evidence of similar biological responses to smaller climate shifts in the 1990s. These results are also consistent with recently documented shifts in ecosystem dynamics resulting from changes in ice cover and thermal structure in the eastern Bering Sea. This analysis indicates that there was a much higher biomass of groundfish at all three sites during 1980-2000 than in 1960-1980. These results provide strong evidence against the hypothesis that the decline of Steller sea lions was due entirely to a decrease in overall productivity of the eastern Bering Sea (NMFS 2006b).

The NMFS's bottom trawl survey does not effectively sample pelagic forage fishes such as capelin, herring, and eulachon, which are important prey fish for sea lions. Data from inshore surveys in the Gulf of Alaska (Anderson and Piatt 1999) suggest that abundance of these species declined dramatically following the 1976-77 regime shift. There are no data available on whether a similar decline occurred in the Bering Sea. It is entirely feasible that the reorganization in food webs indicated in the retrospective study also affected pelagic food webs or the balance of demersal/pelagic production. There does not appear to have been a substantial decline in overall productivity in the EBS, but there could well have been a substantial shift in how production is distributed through the food web.

From 1954 to 1998, Eastern Bering Sea (EBS) summer zooplankton biomass data, collected by the Hokkaido University research vessel T/S Oshoru Maru and re-analyzed by Hunt *et al.* (2002) and (Napp *et al.* 2002), showed no discernable trends in any of the four EBS geographic domains (Napp *et al.* 2002; see Figure 41 in Boldt 2005). The updated time series, however, depicts a strong decrease in biomass in the past 5 years (2000-2004). What is remarkable is that the decrease occurred in all four domains (see Figure 41 in Napp and Shiga 2005). Part of the decrease in biomass over the middle shelf may be due to recent decreases in the abundance of *Calanus marshallae*, the only "large" copepod found in that area (Napp, in prep.). It is not clear what might be the cause of declines in other regions.

Annual surplus production (ASP) indices, the sum of new growth and recruitment minus deaths from natural mortality, suggest high variability in groundfish production in the EBS and a decrease in production between 1978 and 2004 (Mueter 2005; see Fig. 135 in Boldt 2005). Production in the GOA was much lower on average, less variable, and decreased slightly from 1978 to 2004. Because trends in ASP indices are largely driven by variability in walleye pollock in the EBS and variability in walleye pollock and arrowtooth flounder in the GOA, the index was also examined without these stocks included. The results suggest a strong, significant decrease in aggregate surplus production of all non-pollock species from 1978 – 2004 in the Bering Sea and a similar decrease in surplus production aggregated across stocks (excluding pollock and arrowtooth) in the GOA over this period (Mueter 2005; see Fig. 137 in Boldt 2005). These trends reflect decreases across many species and are not driven by the next dominant species alone. In the Bering Sea, surplus production of all species except Atka mackerel and northern rockfish has decreased from 1978-2004 (Mueter 2005). In the Gulf of Alaska, long-term trends in ASP were less pronounced but declines were evident for 5 out of the remaining 9 species, while three species showed no obvious long-term trends and (besides arrowtooth flounder) only thornyhead production increased notably from the late 1970s to the 1990s (Mueter 2005). Long-term declines in ASP and low production in recent years in the EBS are a result of low recruitment, reduced growth, increased natural mortality or some combination thereof (Mueter 2005). These declining trends suggest that substantial reductions in total catches may be necessary in the near future. It is unclear whether existing levels of precaution implemented at the single-species level will be sufficient to deal with declines in overall system productivity when trying to meet multi-species or ecosystem objectives (Mueter 2005). Reductions in carrying capacity or production as measured by groundfish stock assessments may represent either an overall decline in ecosystem production (i.e. declines in lower trophic level production) or may be indicative of a "top-down" phase in a larger ecosystem cycle (e.g. the Oscillating Control Hypothesis described for the eastern Bering Sea in Hunt *et al.* (2002), or the shift from bottom-up to top-down control described in Bailey (2000). As shown in Figure 4.2, while the overall biomass of the main groundfish in the Bering Sea has increased since the late 1970s, the populations have also aged and grown larger; this trend is particularly pronounced in the 1990s. This aging population would be expected to have a decreased ratio of production to energy consumption, although this does not take into account possible importance of contributions of high natality individuals in the larger sizes.

4.1.4 Steller Sea Lion Prey Response to Climate and Regime Changes

4.1.4.1 Recruitment Response to Regime Changes

Eastern Bering Sea Pollock

To evaluate EBS pollock recruitment relative to a suite of putative regimes, sets of years were included within the integrated stock assessment model to provide estimates of uncertainty. For the period 1963-1976 the average age-1 recruitment appears to be substantively lower than that for all other periods (Figure 4.3). The coefficients of variation for these estimates was relatively low (except for the cohorts from 1999-2004; Table 4.1). In conclusion, there appears to be evidence of higher recruitment post 1976 compared to the earlier period. Evidence of significant differences from subsequent putative regimes is apparently lacking.

Gulf of Alaska pollock

Recruitment of pollock in the Gulf of Alaska is highly variable on multiple time scales (Dorn *et al.* 2005). On an interannual time scale, recruitment of Gulf of Alaska pollock is more variable (CV = 1.06) than Eastern Bering Sea pollock (CV = 0.61). Among North Pacific groundfish stocks with age-structured assessments, GOA pollock ranks third in recruitment variability after sablefish and Pacific Ocean perch (http://www.afsc.noaa.gov/refm/stocks/estimates.htm). Unlike sablefish and Pacific Ocean perch, pollock have a short generation time (<10 yrs), so that large year classes do not persist in the population long enough to have a buffering effect on population variability. High recruitment variability implies a large environmental component to forcing, since biotic factors such as density dependence or predation tend to change more gradually. On decadal time scales, there is also variability in pollock recruitment. Mean recruitment increased by approximately five times from the 1960s to the 1970s, then declined in the 1980s, and declined further in the 1990s (Table 4.2).

In the Gulf of Alaska, climatic regime shifts occurred in 1977 and in 1989 based on persistent changes in Pacific Decadal Oscillation (PDO). As noted earlier, the term climatic regime shift refers to persistent changes in atmospheric conditions and the physical condition of the ocean, not to the biological response to those changes. Although correlation analyses (or other related approaches) can be used to relate climate forcing to biological response, often the mechanistic link must be hypothesized because environmental data are not available at appropriate temporal and spatial scales (Baumann 1998).

There are several hypotheses about how the 1977 regime shift might have affected pollock recruitment in the GOA. First, the shift from cool temperatures to warm temperatures may have favored better larval pollock survival through one or more indirect mechanisms (Bailey 2000). A second hypothesis is that the Spring zooplankton bloom shifted earlier in the year, favoring winter spawners such as pollock (Andersen and Piatt 1999). A final hypothesis is the optimal stability "window" (Gargett 1997), which hypothesizes that changes in strength of the Aleutian Low associated with the 1977 regime shift affected water column stability, resulting in an increase in primary production in coastal areas of the Gulf of Alaska. While all of these hypotheses seem reasonable, oceanographic time series in the Gulf of Alaska are too short to establish observational proof. Further, Stabeno *et al.* (2004) did not find a strong PDO signal in physical conditions of coastal waters of the Gulf of Alaska, raising questions about the importance of basin-scale climatic patterns in physical forcing at spatial and temporal scales important to pollock recruitment.

A more important question is whether the pattern of pollock recruitment changed after the regime shift. Although pollock recruitment shows a clear pattern of increase and decline over the period 1959-2004, there are no obvious changes occurring immediately after the 1977 or the 1989 regime shift (Figure 4.4). The 1970's stand out as a decade of very strong recruitment for GOA pollock, but five out the eight strong year classes (> 1.0 billion age-2 recruits) in the 1970's occur prior to 1977. In the twenty-five years since 1980, strong year classes have recruited to the population every five years on average. Hollowed et al. (2001) found that GOA pollock exhibited higher incidence of strong recruitment during years when El Niño conditions propagated into the Gulf of Alaska, but did not find a relationship between the 1977 phase change in PDO and pollock recruitment. Support for the hypothesis that the climatic regime shift in 1977 resulted in improved conditions for pollock recruitment is not compelling.

Pacific cod

In the EBS and GOA Pacific cod models (Thompson and Dorn 2005a, Thompson and Dorn 2005b), recruitment estimates are obtained for each year class from 1964 through 2004, and the effects of the 1976-1977 regime shift are modeled explicitly by estimating separate median recruitment levels for the two portions of the time series.

The EBS Pacific cod model estimates average numbers at age 0 for the 1964-1976 and 1977-2004 time periods at values of 261 million fish and 691 million fish, respectively (i.e., the pre-1977 average is 62% lower than the post-1976 average). Of the 13 pre-1977 cohorts, the point estimate exceeds the post-1976 average in only 1 case (1976), and the 95% CI overlaps the post-1976 average in only 2 cases (1974, 1976). Of the 28 post-1976 cohorts, the point estimate falls below the pre-1977 average in only 1 case (1987), and the 95% CI overlaps the pre-1977 average in only 7 cases (1980, 1983, 1986, 1987, 1993, 2001, 2003).

The GOA Pacific cod assessment estimates average numbers at age 0 for the 1964-1976 and 1977-2004 time periods at values of 89 million fish and 302 million fish, respectively (i.e., the pre-1977 average is 71% lower than the post-1976 average). Of the 13 pre-1977 cohorts, the point estimate exceeds the post-1976 average in only 1 case (1973), and the 95% CI overlaps the post-1976 average in only 2 cases (1972, 1973). Of the 28 post-1976 cohorts, the point estimate never falls below the pre-1977 average, and the 95% CI overlaps the pre-1977 average in only 3 cases (2001, 2002, 2003).

Although the effects of the 1976-1977 regime shift on Pacific cod recruitment are estimated to be very substantial in both areas, the procedure used to estimate these parameters unfortunately does not result in an estimate of the covariance structure of the estimated mean recruitments in the two portions of the time series, so an alternative method must be used to determine if the estimated differences are statistically significant. A simple, "difference between two means" test can be used as a first approximation. The same test can also be applied to the hypothesized 1988-1989 and 1998-1999 regime shifts. In all cases, however, it should be emphasized that some assumptions inherent in the test are being violated (e.g., the variances associated with the individual estimated recruitments are not equal). The results of these tests are shown below:

EBS
The 1976-1977 shift is significant at any level greater than about 0.6%.
The 1988-1989 shift is significant at any level greater than about 30%.
The 1998-1999 shift is significant at any level greater than about 29%.

GOA
The 1976-1977 shift is significant at any level greater than about 0.004%.
The 1988-1989 shift is significant at any level greater than about 29%.

The 1998-1999 shift is significant at any level greater than about 10%.

On the basis of this simple test, it appears that the difference in mean recruitment before and after the 1976-1977 shift is statistically significant at any reasonable level of significance in both the EBS and GOA, but the differences in mean recruitment before and after the 1988-1989 or 1998-1999 shifts are not. These results are similar to those obtained by Boldt and Conners (2004), with the exception that the assessment results available to Boldt and Conners did not include estimates of pre-1977 cohorts.

Atka mackerel

It is unclear to what extent if any, that recruitment of Atka mackerel follows expectations of good vs. bad environmental conditions based on regime shift theory. Until we understand the mechanisms, processes and environmental linkages that contribute to successful recruitment, we cannot know how recruitment is related to regime shift theory. The recruitment history of Atka mackerel is characterized by variable but fairly good recruitment throughout the time series of stock assessment estimates. The strong 1977 year class is most notable followed by the 1988, and 1999 year classes (Lowe *et al.* 2005). The most recent stock assessment estimates above average (greater than 20% of the mean) recruitment from the 1977, 1986, 1988, 1992, 1995, 1998, 1999, 2000, and 2001 year classes (Lowe *et al.* 2005). Based on basin-wide North Pacific climate indices, there appears to have been a major regime shift in 1976/77, and a minor regime shift in 1988/89 (Boldt 2005, Hare and Mantua 2000, King 2005). There is some uncertainty if there was a regime shift in 1999 given the variability in environmental indices since 1998 (Rodionov *et al.* 2005). These hypothesized regime shifts coincide with the three strongest Atka mackerel year classes, however, it should noted that the mechanisms which produce successful recruitment are unknown.

In an analysis by Boldt *et al.* (2004), climate regime-scale variability in recruit per spawner time series was not detected in roundfish (pollock, cod, and Aleutian Islands Atka mackerel). The conclusion from this analysis was that the survival of roundfish does not appear to be related to decadal-scale climate variability as defined by the hypothesized 1976/77, 1988/89, or 1998 years of regime shifts.

4.1.4.2 Response of Major Pollock Spawning Aggregations

A comparative approach was used within the stock assessment to evaluate whether fishing impacts or other factors (i.e., environmental changes) were likely to have caused observed patterns of recruitment and biomass. Over the last 12 years, harvest rates in the three areas show good contrast (Ianelli *et al.* 2005a, Ianelli *et al.* 2005b, Dorn *et al.* 2005). The Bogoslof area has barely been fished at all during this period, but has shown the greatest percent decline (Figure 4.5). The continued decline in survey biomass after major fishery impacts ceased in 1991 is contrary to what would be expected if fishing within the Bogoslof area was the primary factor controlling stock abundance. Harvest rates have been similar between the GOA and EBS, and are low compared to fisheries for other gadids (Brander 2003). Survey biomass has been stable to slightly increasing in the EBS, but has declined in Shelikof Strait. The differing survey trends under similar fishing impacts is also contrary to what would be expected if fishing were the primary factor controlling stock abundance in the EBS and GOA.

An important question is why pollock abundance has declined in the Gulf of Alaska if pollock have been consistently harvested at less than F_{MSY}. This question was explored by "replaying" the population dynamics without fishing. The simplest approach is to replay the population dynamics with the same recruitment time series. This approach does not take into account the potential impact of fishing on recruitment due to changes in stock biomass (potentially fewer recruits at low stock size, or more cannibalism on pre-recruits at high stock size).

To evaluate the potential impact of higher spawning biomass, we also replayed the stock dynamics with a rescaled recruitment time series based on a stock-recruit relationship (NMFS 2006b).

Results, based on a single species perspective, showed that a significant decline of pollock abundance from the peak in the1980's would have occurred even without fishing (Figure 4.6). This suggests that other factors such as environmental variability may be a more significant driver for the stock abundance. Another explanation is that Gulf of Alaska pollock are extremely unproductive; however analysis of available stock-recruit data suggests that this alternative has relatively low probability (Dorn *et al.* 2003). Other factors include ecosystem dynamics which were considered above.

The relationship between both Bogoslof and Shelikof spawning aggregations and larger regional populations is not well established. There is no evidence that these aggregations are genetically distinct populations, and some exchange likely takes place between these aggregations and pollock populations in other parts of the eastern Bering Sea and the Gulf of Alaska. The extent of exchange is unknown. One possibility for observed pattern of decline in the Bogoslof area and in Shelikof Strait is a change in spatial patterns of spawning. Winter surveys of spawning aggregations in other parts of the Gulf of Alaska provide evidence a significant amount of pollock spawn outside of Shelikof Strait (Dorn *et al.* 2003, Dorn *et al.* 2005). Attempts have been made to identify environmental factors influencing the spawning migration into Shelikof Strait, but so far models with environmental variables have poor predictive power (Boldt *et al.* 2002). However, it is also possible that fishing may have impacted the Shelikof Strait spawning aggregation, but this is not predicted by the single species models which generally assume no negative impacts of removing large pre-spawning fish.

Based on the assessment results, recruitment variability is highest in the Bogoslof area (CV = 1.54), high in the Gulf of Alaska (CV = 1.06), and relatively stable in the eastern Bering Sea (CV = 0.61). The recruitment time series for the Bogoslof area is notable for an exceptionally strong 1978 year class that was still the most abundant year class at age 14 in the 1992 survey. High recruitment variability suggests strong environmental component to forcing and a highly dynamic environment. The range of recruitment variability for pollock in the Gulf of Alaska, the Bogoslof area and the eastern Bering Sea is consistent with the observation that the Gulf of Alaska and Aleutian Island ecosystems are more open, dynamic systems than the eastern Bering Sea shelf.

Pollock have a relatively short generation time (<10 yrs[2]), so that large year classes do not persist in the population long enough to have a buffering effect on population variability. Therefore, the typical pattern of biomass variability for pollock stocks with high recruitment variability will be sharp increases due to strong recruitment, followed by periods of gradual decline until the next strong year class recruits to the population. Pollock in the Bogoslof area and in the Gulf of Alaska are more likely to show this pattern than other groundfish stocks in the North Pacific due to the combination of a short generation time and high recruitment variability.

A simulation model was used to evaluate stock biomass variability under the current harvest policy for Gulf of Alaska pollock. Simulations were conduced using a stock recruitment relationship such that $F_{MSY} = F_{35\%}$ and modeled recruitment variability and autocorrelation based on historical patterns. A graph of 1000-year subsample of a simulation run demonstrates that even for a harvest policy appropriate to stock productivity, variability around mean stock size will be large (Figure 4.7). A typical pattern of variability consists of a sharp increase in stock size due to the recruitment of one or more strong year classes, followed by a sustained decline. The observed decline in pollock abundance in the Gulf of Alaska does

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[2] Generation time is defined in this opinion as the average age of all reproductive females in the population. While average age of first reproduction is about 5 years of age for sea lions.

not appear unusual in the 1000-year subsample. These patterns can be obtained with a stationary stock-recruit relationship without invoking "regime shifts" or decadal shifts in stock productivity.

4.1.4.3 Response of Aleutian Islands Pollock to Environmental Changes and Fishing Prohibitions

Fishing for Aleutians Island pollock was prohibited in 1999 under the Steller sea lion conservation measures and was allowed again outside of critical habitat in 2005. The long term biomass trend for AI pollock had been decreasing until about 1999. Given the extensive closure area for this stock, it provides a unique opportunity to evaluate the effects of prohibiting fishing and observing how environmental conditions may naturally impact recruitment in the absence of fishing pressure.

Although the 2000 and 2002 summer bottom trawl surveys purport an increase in the pollock biomass in the Aleutian Islands area from the 1997 estimate (Table 4.3), these surveys are highly imprecise (CV = 28% and 38% respectively) and unreliable indices of abundance given the variability in vertical distribution of Alaska pollock (Barbeaux *et al.* 2005). The 2004 summer bottom trawl survey shows a decline in abundance from 175,000 t in 2002 to 130,000 t in 2004, but the variance in the 2004 estimate (CV = 78%) is substantially higher than any previous estimate. These data are therefore insufficient to reliably discern abundance trends post-1999.

If the bottom trawl survey pollock abundance estimates were accurate and precise ($q = 1.0$), the catch levels estimated for the 1990's fishery (Table 4.4) would be unsustainable since under this assumption, the catch to biomass ratio would be between 28% and 75%. Indications are that the summer bottom trawl survey assesses only one component of the pollock stock in the Aleutian Islands and that this component may not include that taken by the fishery during winter. Also, the large catches during the early and mid-1990s primarily consisted of the 1978 year class and later the 1989 year class (Table 4.5). The 1978 year class was only surpassed in catch weight by the 1989 year class in the 1995 fishery, but still remained a significant proportion of the catch through 1998 (7%). Pollock recruitment processes that led to the 1978 year-class event throughout the Aleutian Islands and eastern Bering Sea are poorly understood. The high variability in Aleutian Islands pollock recruitment is likely due to environmental conditions. The degree to which Aleutian Islands pollock abundance depends on movement from the EBS is also unknown. While it is possible that the EBS fishery causes some interception of potential Aleutian Islands recruitment, the exploitation rates within the EBS appear to be at sustainable levels (single species). It may be that the Aleutian Islands pollock stock depends on extremely favorable recruitment conditions such as that observed from 1978 and 1989.

In March and April 2006 a cooperative acoustics research survey was conducted in the Aleutian Islands to assess the abundance of pollock in the region during spawning. Preliminary results suggest that, in the area surveyed, pollock biomass was lower than that available during the 1990s. Importantly, this study provides direct observation of localized abundance levels that have long been considered important for Steller sea lion conservation concerns. Current stock assessment models only deal with highly aggregated data and provide highly aggregated (and uncertain) results. In addition, the observed distribution and behavior under fishing suggests that a high catch-per-unit-effort could be achieved in this area even at low levels of abundance (NMFS 2006b). The pollock were concentrated on the shelf break and became more concentrated as the experimental fishery progressed. Such "hyperstability" in catch rates highlights the potential risk of interpreting commercial data. For example, depletion experiments may not be valid if the stock shows this stability in catch rates even though the actual biomass is small and being depleted, because the experiment would come to a completely opposite conclusion. These results are preliminary and further analysis is required before they can be considered conclusive. However, its does highlight the sensitivity of the Aleutian Islands to fishing pressure and the potential for long term impacts on the stock which may not be detectable from the single species perspective or through depletion experiments.

4.1.4.4 Changes in the Distribution of Important Prey

To evaluate changes in fish distribution for the Eastern Bering sea (pollock and Pacific cod) station-specific CPUE data from NMFS summer bottom-trawl surveys were used. Average CPUE was computed by 1 degree longitude by 0.5 degree latitude quadrangles and contoured to evaluate annual changes. Results indicate that interannual spatial variability is high for both pollock and Pacific cod, but with Pacific cod having a somewhat broader but lower density overall than pollock (Figures 4.8-13). Pollock summer bottom-trawl concentrations within Steller sea lion critical habitat area show considerable variability with some years having relatively low densities (e.g., 1982, 1988, 1991, 1997-1999) and of other years having high concentrations in critical habitat (Figures 4.8-10). In recent years, (since 2000) moderate densities of pollock have been consistently present in critical habitat. For Pacific cod, the relative density in critical habitat was higher in the 1980s compared to later years (Figures 4.11-13).

To further summarize these densities relative to changes in fish distribution, central concentrations of pollock and Pacific cod was computed and mapped by year to ascertain if certain groups of years were different than others. This involved computing the CPUE-weight average location of pollock and Pacific cod. Results show that the centers of pollock distributions by year were more variable over years (spreading northwest to southeast) than that for Pacific cod (Figure 4.14). The 1993-1995 surveys show a tendency for pollock to be most dense towards the southeastern part while other years are mixed. This can be attributed to the relatively high abundance of the 1989 year class in the south-eastern regions. Pacific cod shows a marked north-northwest shift in distribution during the period 2000-2005. This is consistent with the lower densities of Pacific cod observed in the southeastern regions during these years.
The summer NMFS bottom-trawl survey data were also evaluated for CPUE patterns within and outside of Steller sea lion critical habitat areas. Mean values of CPUE were computed inside the critical habitat and compared to the mean CPUE outside of this region over time. Figure 4.15 shows a high degree of inter-annual variability of the relative CPUE inside Steller sea lion critical habitat compared to outside, especially for pollock (top panel). The bottom panel of this figure is the same data but aggregated into 5-year blocks. This shows that there appears to be a downward trend in Pacific cod CPUE within the critical habitat relative to outside. Pollock, on the other hand, appears to show a stable to increasing trend in relative CPUE within critical habitat.

The distribution of winter spawning pollock have shifted in the Bogoslof Island management district from near Bogoslof Island during the late 1980s and early 1990s to closer to Samalga pass and north-east of Umnak Island (Figure 4.16). Such relatively fine-scale shifts in spatial distribution suggests that environmental conditions may have changed to favor spawning habitat closer to the Aleutian Islands chain than in the past.

Shifts in distribution of pollock in the Aleutian Islands appear to coincide mostly with a connection to the “Aleutian Basin” stock (as indexed by the Bogoslof region) and that of the EBS shelf region. Specifically, the highest recorded historical catches occurred during winter months in the eastern most part. These pollock were thought to be comprised of mainly the 1978 and 1989 year classes and currently pollock abundance in the eastern region of the Aleutian Islands remains low, despite limited directed pollock fishing in this region since 1999. The changes in distribution of Pacific cod in the Aleutian Islands rely on summer biennial bottom trawl surveys and these show a high degree of variability.

Atka mackerel in the Aleutian Islands region also shows considerable variability over time based on summer bottom trawl surveys (Figures 4.17 and 4.18). As with many groundfish species, Atka mackerel is particularly prone to having high variance estimates, especially when broken down to finer management areas. This is due to the patchy distribution of this species. Nonetheless, trends for Atka mackerel in general suggest increased abundances throughout their range, particularly in the eastern and western management areas. This abundance pattern extends in recent years into the GOA where directed fishing for Atka mackerel is prohibited.

Pacific cod in the GOA also show a high degree of CPUE variability (Figure 4.19). Pacific cod in general are thought to be relatively mobile groundfish species based on the tagging studies of Shimada and Kimura (1994). Results from evaluating GOA survey patterns are consistent with a mobile species. Apparent long-term shifts in GOA Pacific cod abundances from summer survey data are difficult to ascertain.

GOA pollock spatial distributions have been evaluated regularly, particularly for patterns of spawning concentrations. For example, the annual winter Shelikof Strait surveys of spawning pollock have traditionally been considered to represent the majority of the GOA stock. Modeling efforts of the population have shown that about 67% of the pollock spawning occurs in the Shelikof region (on average) and about 20% in the Shumagin Islands region with the balance in other locations. There are trends in these data that suggest the Shelikof Strait spawning contribution has been below average for a number of years (2002-2005; Dorn *et al.* 2005). Relative pollock biomass in the GOA during the summer shows variability among regions (Figure 4.20). In some years the majority of the biomass appears in the Kodiak Island region while in other years, the Shumagin region appears to have the highest levels.

4.1.5 Changes in the Carrying Capacity for Western DPS Steller Sea Lion

Populations can experience abrupt and dramatic declines because of dramatic reductions in environmental carrying capacity (Odum 1971). Periodic shifts in oceanic and atmospheric conditions may have major effects on the productivity and structure of North Pacific ecosystems, with cascading effects on some prey fish populations. The manner and mechanism by which such "regime shifts" and altered fish populations would affect marine mammals, including Steller sea lions, is poorly understood and remains unresolved. 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.

The carrying capacity of the North Pacific for Steller sea lions likely fluctuates in response to changes in the environment (Hare *et al.* 1999, Overland *et al.* 1999, Stabeno *et al.* 2001, Benson and Trites 2002, Hunt *et al.* 2002, Shima *et al.* 2002, Trites and Donnelly 2003). Changes in the North Pacific fish community structure stemming from the regime shift in 1976-77 may have been substantial enough to result in a dominance of pollock and other gadids. However, it is unclear whether this environmental variability and the associated diet shifts were outside the limits of natural variability in the history of Steller sea lions in the North Pacific and were principal factors in their population decline. Gadids have been and are likely to continue to be a principal component of the diet of sea lions (Table 4.6). The 1976-77 regime shift likely affected species differently (Section 4.1.4.1). In an analysis by Boldt *et al.* (2004) , climate regime-scale variability in recruit per spawner time series was not detected for pollock, Pacific cod, and Atka mackerel. It is likely that the groundfish community changes, with some regimes or time periods more/less favorable for sea lions. Current data does not support the theory that the regime shift of 1976-77 resulted in a total re-organization of the prey field for Steller sea lions[3]. Available evidence indicates that the current fish community structure is similar (in composition but not necessarily relative biomass amounts) to that of earlier time periods and changes in sea lion diets between regimes were unremarkable. Another shift may have occurred in 1989 and 1998 (Hare and Mantua 2000, Bond *et al.* 2003), yet sea lions may still be unable to acquire sufficient energy from their prey resources due to

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[3] The reorganization is described in Anderson and Piatt (1999) and countered by Fritz and Hinckley (2005).

continued declines in natality observed through 2002 (as observed in the Central GOA; Holmes and York 2003, Fay 2004, Holmes *et. al. in review*).

In addition to the environmental changes, the removal of prey by many fisheries increased markedly in the 1980s and could have exacerbated natural changes in carrying capacity, possibly in non-linear and unpredictable ways (Calkins 1998, Goodman *et al.* 2002, NRC 2006). 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, NRC 2003, NRC 2006).

4.1.6 Global Climate Change

Climate change has received considerable attention in recent years, with growing concerns about global warming and the recognition of natural climatic oscillations on varying time scales. Global air and ocean temperatures during this century and before are warming, and evidence suggests that the productivity of the North Pacific is affected by changes in the environment (Quinn and Niebauer 1995, Mackas *et al.* 1998).

Increases in global temperatures are expected to have profound impacts on arctic and sub-arctic ecosystems, and some of these impacts have been documented over the last several decades. Specifically, (1) winter temperatures in Alaska and western Canada have increased as much as 3-4 C over the past half century, (2) precipitation, mostly in the form of rain, has increased primarily in winter resulting in faster snowmelt, (3) sea ice extent has decreased about 8% over the past 30 years, with a loss of 15 to 20% of the late-summer ice coverage in the arctic, and (4) glacial retreat, particularly in Alaska, has accelerated contributing to sea level rise (ACIA 2004). These impacts, and others, are projected to accelerate during this century.

The effects of these changes to the marine ecosystems of the Bering Sea, Aleutian Islands, and the Gulf of Alaska, and how they may specifically affect Steller sea lions are uncertain. Warmer waters could favor productivity of certain species of forage fish, but the impact on recruitment dynamics of fish of importance to sea lions is unpredictable. Recruitment of large year-classes of gadids (e.g., pollock) and herring has occurred more often in warm than cool years, while the distribution (with respect to foraging sea lions) and recruitment of other fish (e.g., osmerids) could be negatively affected. Whether these patterns will continue as overall temperatures increase is uncertain, as are the effects on the duration and strength of atmospheric and oceanographic regimes (Trenburth and Hurrell 1994, Hare and Mantua 2000).

Climate-driven changes in productivity and community structure due to warming oceans may already be underway in the northern portion of the Bering Sea and Bering Strait, where sea ice plays a major role in structuring the food web and the ecosystem is particularly vulnerable to rapid system reorganization under global warming. Reduced seasonal sea ice cover, changing hydrographic conditions, and reduced primary production in the northern Bering Sea may be associated with apparent declines in ice-associated benthic species of mollusks and amphipods since the 1990s (Grebmeier *et al.* 2006). Benthic-feeding walrus, bearded seals, gray whales and diving sea-ducks such as Spectacled eider are all threatened by these changes, as are Arctic Native communities whose traditional subsistence culture has relied on these ice-associated mammals and birds for thousands of years. This ecosystem has short, simplified food chains; thus the potential for trophic cascades is higher. Warming seawater in the north could expand the range of groundfish from the south, putting more pressure on the benthic prey base. The northern Bering Sea may be poised for the sort of trophic cascade and system reorganization anticipated by GLOBEC as a consequence of global warming at high latitudes (Grebmeier *et al.* 2006).

Warmer temperatures could shift the distribution of sea lions northward. The eastern DPS increased in size at a rate of approximately 3% per year from the early 1980s through 2004, despite a decline in the size of the breeding population at the southern extent of its range in California. All of the increase in the eastern DPS occurred north of California, and new rookeries established in the 1990s (White Sisters and Hazy Island) were near its northernmost extent in southeast Alaska.

As temperatures warm and global ice coverage decreases, sea levels will rise. This will directly affect terrestrial rookery and haulout sites currently used by Steller sea lions as well as those that may be used by a recovering population. Presumably, sea lions using terrestrial sites will simply move upslope as sea levels rise, assuming that the terrain at the site is suitable. However, sites on some islands with low relief (e.g., Agligadak Island) may be submerged. The net effect of a rise in sea level on overall terrestrial sea lion habitat amount or availability is uncertain, but at the projected rate it is unlikely to have a significant effect for many years.

Fluctuations or cycles in physical and biological characteristics of marine ecosystems may not necessarily affect higher trophic levels because of strategies for survival they have evolved to buffer them against environmental uncertainty. Based on their analyses of possible causes of the sea lion decline, Pascual and Adkison (1994) concluded that environmental cycles were unlikely to have caused declines of the magnitude and duration observed. Shima *et al.* (2000) did a comparative analysis of population dynamics of four species of pinnipeds in similar variable environments (Steller sea lions in the Gulf of Alaska, Cape fur seals in the Benguela Current, harp seals in the Barents Sea, and California sea lions in the California Current) and found a major decline only for Gulf of Alaska Steller sea lions. They concluded that the success of the other populations suggests that pinnipeds in general have the ability to adapt to environmentally driven changes in prey resources, and that other factors were involved in the decline of Steller sea lions.

4.2 Natural Factors Affecting the Status of Steller Sea Lions in the Action Area

4.2.1 Climate and Oceanography

Periodic shifts in oceanic and atmospheric conditions appear to have had major effects on the productivity and structure of North Pacific ecosystems (Francis and Hare 1994, Francis *et al.* 1998, Hunt *et al.* 2002, Mackas *et al.* 1998, Anderson and Piatt 1999, Trites *et al.* 2006a) with cascading effects on some prey fish populations (Quinn and Niebauer 1995, Hollowed and Wooster 1992, 1995). For example, the size of available habitat for pollock, one of the primary prey species of Steller sea lions, reportedly increased with changes in the mixed layer depth in the Gulf of Alaska associated with climatic changes during the 1980s (Shima *et al.* 2000). Increases in pollock and other gadids (e.g. Pacific cod) in the Gulf of Alaska and Bering Sea (Alverson 1992), and their relatively low nutritional quality (Alverson 1992, Rosen and Trites 2000a) led to the “junk food hypothesis” for the decline of the western DPS of Steller sea lion.

In the junk food hypothesis, the quantity of prey available to the declining population of Steller sea lions was thought to be high overall, but the prey community switched from one dominated by high energy prey (e.g., herring and osmerids) to low energy species (e.g., gadids and flatfish; Alverson 1992, Rosen and Trites 2000a). As originally articulated by Alverson (1992), pollock and other gadids were presumed to be equally poor foods for all age classes of sea lions (i.e., both juveniles and adults). However, results of subsequent feeding experiments, mathematical models, and field observations suggested that adult sea lion growth and condition should be relatively unaffected by the low energy content of gadids (Rosen and Trites 2000b, 2004, Trites 2003, Trites *et al.* 2006a, Malavear 2002). Instead, low energy prey may detrimentally affect juvenile Steller sea lions more than mature individuals due to their relative inexperience at foraging (Merrick and Loughlin 1997), their higher relative energy requirements (Winship *et al.* 2002), an upper limitation on the amount of food that a sea lion can physically digest to meet its daily energy requirements (Rosen and Trites 2004), or the availability of sufficient prey (Malavear 2002).

Fritz and Hinckley (2005) concluded that patterns and time series of fish abundance, fish recruitment, and sea lion food habits did not support the hypothesis that the regime shift triggered changes in the prey community that, on their own, would have been deleterious to Steller sea lions. In addition, feeding experiments at the Alaska SeaLife Center have shown no negative consequences to juvenile sea lions fed only pollock (Calkins *et al.* 2005). This is consistent with published studies showing that there are no different effects between high-lipid and low-lipid (or low-protein and high-protein) prey on sea lion body composition when animals are able to consume sufficient prey to meet their energy demands (Rosen and Trites 2004, 2005).

It is likely that Steller sea lions may have lived through many climate/biological regime shifts in the few million years that they have existed. What may be different about this most recent shift (1977-78) is the coincident development of extensive fisheries targeting the same prey that sea lions depend on during warm regimes. Fisheries in the Bering Sea and Gulf of Alaska expanded enormously in the 1960s and 1970s. The existence of a strong environmental influence on sea lion trends does not rule out the possibility of significant fisheries-related effects. The cause of the sea lion decline need not be a single factor. To the contrary, strong environmental influences on Gulf of Alaska and Gulf of Alaska ecosystems could increase the sensitivity of sea lions to fisheries or changes in those ecosystems resulting from fisheries.

Given an 80% reduction in the western population of Steller sea lions and the lack of evidence suggesting sustained high levels of anthropogenic removals, it is likely that the environmental carrying capacity has been reduced either through natural environmental changes or human induced changes. Given the equivocal data surrounding the dietary needs of Steller sea lions, the consequences of climate regime shifts, and massive population declines, it is highly unlikely that natural environmental change has been the sole underlying cause for the decline of Steller sea lions. Therefore, this consultation looks to other possible causes of the decline recognizing that environmental change is an important component in this equation, and may combine with other factors to contribute to the past and continuing decline of Steller sea lions.

4.2.2 Disease, Parasites, and Toxic Substances

Available serologic evidence does not support the possibility that a disease epidemic occurred during the sea lion decline of the late 1970s and 1980s; however, due to sampling limitations the possibility can not be excluded completely. Although sea lions have recently been exposed to several endemic disease agents that could potentially impede recovery, the only available data are the prevalence of antibodies to the disease agents, and the potential for those agents to cause disease among Steller sea lions has not been documented. Disease and parasitism are common in all pinniped populations and have been responsible for major die-offs (e.g., Osterhaus *et al.* 1997), but such events are usually relatively short-lived and provide more evidence of morbidity or mortality. The potential for parasitism to have a population level affect on sea lions is largely unknown. Although parasites may have little impact on otherwise healthy animals, effects could become significant if combined with other stresses. Available information does not suggest that the sea lion decline was caused by parasitic infections, although there has not been adequate research to assess the current relative nature and magnitude of parasitism in sea lion populations. The ramifications of disease and parasitism remain a concern, both as primary and secondary problems, but do not appear to be significant impediments to recovery at this time or on the basis of the information currently available.

Steller sea lions have shown relatively low levels of toxic substances as well as heavy metals, and these substances are not believed to have caused high levels of mortality or reproductive failure. However, there are no studies on the effects of toxic substances at the population level to determine their impact on vital rates and population trends. Chronic exposure to toxic substances may result in reactive metabolites that could cause damage to DNA, RNA, and cellular proteins. Sea lions exposed to oil spills may become contaminated with polycyclic aromatic hydrocarbons (PAHs) through inhalation, dermal contact and absorption, direct ingestion, or by ingestion of contaminated prey. Newer contaminants such as PBDEs have not been measured in Steller sea lions. Thus, overall, there is still some concern that toxic substances may have indirect impacts on individual vital rates.

4.2.3 Impacts of Killer Whale Predation

4.2.3.1 Killer Whale Ecology

In the North Pacific Ocean three ecotypes of killer whales have been recognized by their genetics, morphology, acoustics, association patterns, and feeding ecology, including their prey (Bigg *et al.* 1987, Frost *et al.* 1992, Ford *et al.* 1998, Ford *et al.* 2000, Ford and Ellis 1999, Barrett-Lennard 2000, Hoelzel *et al.* 1998, Matkin *et al.* 2006). Differences in the movement patterns among killer whale ecotypes have led, in part, to their names; i.e., “resident”, “transient”, and “offshore.” Specifically, residents have the smallest home range and typically return each year to predictable locations, transients have larger home ranges and have less predictable movements as they transit through local areas quickly, and offshores have the largest home ranges that include areas farther offshore.

Resident killer whales are known to be fish-eaters, in contrast to transients that feed on marine mammals. For offshores, relatively few feeding observations are available, and the limited data indicate these whales appear to prey primarily on fishes, including sharks. However, until the diet of offshores is better understood, the possibility exists that offshores may kill other marine mammals, including Steller sea lions, at least in some regions or seasons. As the currently available information indicates that transient killer whales are the only ecotype that influences the abundance of sea lions, the remaining information on abundance, movements, and diet pertains primarily to transients.

Limited information is available to assess the population structure of transient killer whales within the range of the western DPS, and less information is available for Russian waters. Currently two stocks of transient killer whales have been recognized: (1) the AT1 stock, which occurs from Prince William Sound west through the Kenai Fjords, and (2) the Gulf of Alaska, Aleutian Islands, and Bering Sea (GOA/AI/BS) stock (2004 SAR’s). The abundance and stock structure of the AT1 stock have been well documented, and the abundance of this isolated population has declined from 22 whales in 1989 to only 8 whales in 2004 (Matkin *et al.* 1999, Angliss and Outlaw 2005). In contrast, relatively few data exist for the GOA/AI/BS transient stock, particularly for waters west of Kodiak Island.

Surveys conducted by NMFS in the western Gulf of Alaska, Aleutian Islands, and Bering Sea since 2001 have documented that all three ecotypes use these western Alaska waters. Preliminary analyses of photo-id and genetic data from within the coastal survey area from Kenai Fjords to Tanaga Pass provide insights on possible movements of transient killer whales, and also suggest that there may be some finer scale population structuring of transients. Specifically, no movements of individual transients have been documented by photo-id between the central and eastern Aleutians (NMFS unpublished data), with a preliminary dividing line at Samalga Pass (170 degrees West longitude). Preliminary analysis of mtDNA sequences supports this inference, as different haplotypes have been sampled on either side of this possible structural boundary (NMFS unpublished data). However, both genetic and photographic sample sizes are low for the central Aleutians. Similarly, whales from the Gulf of Alaska and those from the

Aleutian Islands do not generally appear to overlap in distribution, with a gap in distribution between the Shumagin Islands and Kodiak (NMFS unpublished data). However, there have been a small number of photographic matches of individual whales from the Unimak Pass area in the eastern Aleutians to the northeast side of Kodiak Island (NMFS and North Gulf Oceanic Society, unpublished data). Further samples and analyses are needed to assess the significance of these preliminary findings.

4.2.3.2 Abundance and Diet of Killer Whales

The abundance of transient killer whales has recently been estimated through (1) line transect surveys, which provide an estimate of the number of whales present, during the sampling period, in the region surveyed and (2) mark-recapture analyses based on whales identified through photo-id, which provide an estimate of the total number of individual killer whales in the region surveyed across the entire survey period. Analysis of line transect survey data collected between 2001 and 2003 indicate that the abundance of transients in the coastal waters between the Kenai Fjords in south-central Alaska and Tanaga Pass in the central Aleutians is approximately 251 whales (95% CI 97-644) during the summer months (Zerbini *et al.* 2006). The density of transients appears to vary regionally, with higher densities from the Shumagin Islands through the eastern Aleutians. However, the minimum count of transients in this area from the combined NMFS and North Gulf Oceanic Society (NGOS) photo-id catalogues is currently 314 whales (Angliss and Outlaw 2005), and preliminary mark-recapture estimates for transients based on photo-identification data are also higher than the line transect estimates (NMFS unpublished data). Current abundance estimates and photo-id cataloguing only refer to coastal waters within approximately 30 nm of the Aleutian Islands and adjacent coasts of southwestern Alaska. The abundance and population structure of transient killer whales in offshore areas in the Pacific and Bering Sea are still relatively unknown. Thus, the minimum number of transient killer whales in the U.S. portion of the western DPS is 314, and the estimated abundance will increase when analyses are completed and survey effort increases.

The diet of AT1 transients is relatively well understood. Based on more than 20 years of field observations, these whales are thought to feed primarily on harbor seals and Dall's porpoise (Saulitis *et al.* 2000, Heise *et al.* 2003). The feeding habits of GOA/AI/BS transients are less well known in general and essentially unknown during the period fall-spring. Stomach contents of two stranded carcasses contained a harbor seal, Dall's porpoise, and Steller sea lion remains (Heise *et al.* 2003). Observations of feeding by GOA/AI/BS transients have been limited to date, but observed prey include fur seals, gray whales, minke whales, and Steller sea lions (Matkin *et al.* 2006, NMFS unpublished data). The analysis by Herman *et al.* (2005) of blubber biopsy samples from eastern North Pacific killer whales indicate that profiles for fatty acids, carbon and nitrogen stable isotopes, and organochlorine contaminants were consistent with previously reported dietary preferences; i.e., fish for resident whales and marine mammals for transients. Regional stable isotope ratios varied considerably, indicating prey preferences may be region-specific, in addition to ecotype-specific. Thus, some groups of GOA/AI/BS transients may specialize on certain prey species, including sea lions, as AT1 transients specialize on harbor seals and Dall's porpoise. The measured stable isotope values, which reflected diet for the mid-April through mid-July period, for all three killer whale ecotypes were consistent with published dietary preferences based on visual observations. For example, measured stable isotope values for AT1 transients were very similar to modeled stable isotope values, which were based on visual observations (i.e., primarily harbor seals (56%), Dall's porpoises (38%) and harbor porpoises (6%); Herman *et al.* 2005). Measured stable isotope values for GOA, AI, and BS transients indicated the primary prey items were dominated by animals at lower trophic levels than Steller sea lions and harbor seals (Herman *et al.* 2005).

4.2.3.3 Hypotheses and Modeling Attempts

To explore the potential impact of killer whale predation on Steller sea lions, Barrett-Lennard *et al.* (1995) constructed a simulation model. A range of values for transient killer whale abundance, killer whale energy requirements, and killer whale prey selection parameters was explored because of the substantial uncertainty in the current empirical data for these parameters. Steller sea lion parameters in the model include initial population abundance, sex and age distributions, age specific vulnerability to predation, and a density dependent growth rate. The model assumes an unknown 'baseline' level of sea lion mortality due to killer whale predation in a stable sea lion population. Simulations examine changes in sea lion abundance, due to mortality completely additive to baseline mortality, from an increase in either killer whale abundance or the percentage of sea lions in the diet of killer whales. Based on parameter values consistent with current empirical data from the range of the western DPS of sea lions, simulation results suggest that: 1) killer whale predation did not initiate the decline of the sea lion population; 2) killer whale predation could cause a continued decline in sea lion numbers in western Alaska based on the estimated abundance of sea lions in 2000; and 3) killer whale predation is not likely to drive the sea lion population to extinction (Barrett-Lennard *et al.* 1995). Further, when the abundance of sea lions declined to 100,000 to 150,000, the additional mortality (above baseline mortality) from killer whale predation could have been sufficient to drive the decline. Sensitivity analyses indicate changes in sea lion abundance were influenced primarily, and equally, by the number of transient killer whales and the proportion of their diet provided by sea lions, followed by sea lion age-specific vulnerability to predation. When the estimated abundance of sea lions and killer whales in the range of the eastern DPS is used with the parameter combinations that cause a moderate impact on the western DPS of sea lions, the model predicts that killer whale predation would result in a fairly rapid decline of eastern DPS sea lions which, as noted earlier, has not been the case.

A comparative bioenergetics and demographic model was used by Williams *et al.* (2004) to assess the potential impacts of killer whales on Steller sea lion populations in the Aleutian Islands. Four types of energetic information were measured or estimated: 1) the caloric needs of individual killer whales, taking into account differences in body mass and reproductive status; 2) the caloric value of individual prey including adult sea lions and pups; 3) the digestive efficiency of killer whales, which determined the ability of the animal to utilize energy in prey tissue; and 4) the likely or possible prey preferences of individual killer whales. This information on individual bioenergetics was then compared to population-level estimates of the number of killer whales (NMFS unpublished data), the abundance of sea lions before and during the decline (see Chapter 3), and the demographic rates governing the sea lion population (York 1994). The population-wide losses to predation needed to generate the observed changes in the Steller sea lion population, if all losses occurred from predation, were then estimated. From these data, Williams *et al.* (2004) reported that an average adult killer whale would require 2 - 3 sea lion pups per day or approximately 840 pups per year when feeding exclusively on young Steller sea lions. In comparison, only one third to one half of an adult female sea lion per day (approximately 160 per year) would be needed to satisfy the killer whale's metabolic needs. Nearly 1,200 Steller sea lions would be eaten per year to meet the caloric requirements of one killer whale pod consisting of 5 individuals, assuming 16% pups and 84% juvenile and adult sea lions consumed, based on the life table for sea lions (York 1994). The annual number of sea lions eaten increases to 39,644 for an estimated population of 170 transient killer whales, approximately three times the highest annual removal rate needed to drive the observed sea lion declines in the 1980s. Despite the conservative estimates of energetic needs and the abundance of transient killer whales, the model calculations demonstrated that relatively minor changes in killer whale feeding habits could account for the decline of Steller sea lion populations observed for the Aleutian Islands. The caloric demands of as few as 27 male or 40 female killer whales (minimally 23% of transients) could account for the estimated 10,885-11,575 sea lions lost per year at the height of the decline. Furthermore, predation losses to a single pod of five killer whales could theoretically prevent the present Steller sea lion population from recovering.

Examining the potential impact of killer whale predation on Steller sea lions on a broad ecosystem basis, Springer *et al.* (2003) presented a hypothesis that predation was paramount among top-down forces contributing to the sea lion decline. Their "Sequential Megafaunal Collapse" hypothesis is based on the premise that post-World War II industrial whaling depleted large whale populations in the North Pacific, depriving killer whales of an important prey resource. Killer whales thus began feeding more intensively on smaller marine mammals, and this predation resulted in the sequential decline of harbor seals, northern fur seals, Steller sea lions, and northern sea otters in the northern North Pacific Ocean and southern Bering Sea. Due to the acknowledged lack of direct evidence that killer whale predation drove the pinniped declines, Springer *et al.* (2003) explain the declines based on a logical interpretation of known patterns and feasibility analyses of the hypothesized causal process. They suggest current predator prey dynamics are unlikely to provide evidence for the sequential pinniped declines, because prey populations are relatively smaller and comparatively stable, and the abundance of killer whales also may be much reduced.

The Sequential Megafaunal Collapse hypothesis has generated considerable interest and debate concerning the role of killer whale predation in the ecosystem dynamics of the North Pacific. Several studies examined the hypothesis, and indicate alternative interpretations of available data:

> DeMaster *et al.* (2006) concluded that the available data do not support the assumption that some species of large whales were important prey for killer whales, and the available qualitative data indicate that although the biomass of some large whale species likely declined in abundance, those declines were offset by increasing abundances of other large whale species in the 1960s and 1970s. Further, DeMaster *et al.* concluded that statistical tests do not support the assumption that the pinniped declines were sequential.
>
> Mizroch and Rice (2006) show that there was actually a several year lag between the decline in whale catches and the start of the decline of pinnipeds. Because of the extraordinary whale biomass removals in the mid-1960s, any whaling-related prey shifting should have started by 1968, not the mid-1970s as suggested by Springer *et al.* (2003). Mizroch and Rice (2006) also examined data on the contents of killer whale stomachs, and observational records of killer whale interactions with large whales, and refute the Springer *et al.* (2003) assumption that North Pacific killer whales depended on large whales as prey either prior to or concurrent with the whaling era.
>
> Trites *et al.* (2006c) showed that populations of seals, sea lions and sea otters increased in British Columbia following commercial whaling, unlike the declines noted in the Gulf of Alaska and Aleutian Islands. They argue that a more likely explanation than the Springer *et al.* (2003) hypothesis for the seal and sea lion declines and other ecosystem changes in Alaska stems from a major oceanic regime shift that occurred in 1977. They additionally note that killer whales are unquestionably a significant predator of seals, sea lions and sea otters — but not because of commercial whaling.
>
> Finally, Wade *et al.*(*in press*) argued that available data do not support the Springer *et al.* (2003) hypothesis. A summary of their arguments is the following. Large whale biomass in the Bering Sea did not decline as much as suggested by Springer *et al.* (2003), and much of the reduction occurred 50-100 years ago, well before the declines of pinnipeds and sea otters began; thus the need to switch prey starting in the 1970s is doubtful. With the sole exception that the sea otter decline followed the decline of pinnipeds, the reported declines were not in fact sequential. Given this, it is unlikely that a sequential megafaunal collapse from whales to sea otters occurred. The spatial and temporal patterns of pinniped and sea otter population trends are more complex than Springer *et al.* (2003) suggest, and often inconsistent with their hypothesis. Populations remained stable or increased in many areas, despite extensive historical whaling and high killer whale abundance. Furthermore, observed killer whale predation has largely involved pinnipeds and small cetaceans; there is little evidence that large whales were ever a major prey item in high latitudes.

4.2.3.4 Impact of Killer Whales on Steller Sea Lions

Historical accounts of killer whale predation on marine mammals in the northern North Pacific, though somewhat limited in number, are roughly consistent with recent observations that killer whales prey on a variety of species of marine mammals, particularly pinnipeds and small cetaceans (Mizroch and Rice 2006, Wade *et al. accepted*). However, there is insufficient information on trends in predation rates, so it is not possible to make definitive statements about changes in killer whale predation rates on Steller sea lions through time.

The estimated abundance of mammal-eating killer whales throughout most of the range of the western stock of Steller sea lions (Kenai Peninsula to Tanaga Pass in the central Aleutian Islands) is 251 (95% C.I. 97-644) (Zerbini *et al.* 2006) for the years 2001-03. Mammal-eating killer whales were found to be more abundant from the Shumagin Islands to the west (226) than they were east of the Shumagins through Kenai Peninsula (27). Mammal-eating killer whales were found to be at their highest density in summer in the eastern Aleutian Islands, stretching from Umnak Island to the west to the Shumagin Islands to the east.

Williams *et al.* (2004) indicate a population of 170 mammal-eating killer whales that preyed exclusively on Steller sea lions could have caused the decline of the western stock of Steller sea lions. However, data on killer whale predation do not suggest that mammal-eating killer whales prey exclusively on Steller sea lions. In a review of observations of killer whale predation on marine mammals since the 1960s, the percent of kills that were Steller sea lions by mammal-eating killer whales were 6% in the Bering Sea and Aleutian Islands (BSAI), and 22% in the Gulf of Alaska (GOA), with most of those observations from summer (Wade *et al. accepted*). In recent studies primarily since 2001, observations by NMML/NOAA researchers in summer were 11% in the BSAI. Matkin *et al.* (*in press*) report 4% in spring/summer in the BSAI. Estimates for the BSAI therefore range from 4% to 11%. Analysis of contaminant concentrations and fatty acids confirms that, as suspected, mammal-eating killer whales have a chemical signal in the blubber that is entirely consistent with an exclusive diet on marine mammals (Herman *et al.* 2005, Krahn *et al. in review*). Analysis of stable isotope concentrations in mammal-eating killer whale skin from the BSAI results in values that are in close agreement with values predicted from observations of predation of ~4-11% Steller sea lions (Krahn *et al. in review*), suggesting the visual observations do provide an accurate assessment of killer whale predation during that time of year.

Under the assumption that the killer whale population in the BSAI meets 4-11% of its energetic needs from Steller sea lions, and using the assumed energetic demand of killer whales used in Williams *et al.* (2004), leads to an estimated kill of 242-511 Steller sea lions per year in the BSAI. This represents 0.8-1.7% of the current abundance of the western stock of Steller sea lion from the Shumagin Islands and west through the Aleutian Islands (~30,000). A similar calculation was made for the GOA. Assuming 27 mammal-eating killer whales meet 22% of their energetic demand with Steller sea lions leads to an estimate of 86 Steller sea lions killed in the GOA (east of the Shumagin Islands through Kenai Peninsula). This represents 0.6% of the Steller sea lion abundance east of the Shumagin Islands through Prince William Sound (~15,000).

Natural mortality for a stable population of Steller sea lions should roughly be about 6% per year. If it is assumed that Steller sea lions (and other pinnipeds) have always been prey of mammal-eating killer whales, then killer whale predation would be a component of that natural mortality. The current percentages of killer whale predation calculated above are lower than 6%. This indicates that this level of predation could have been a component of natural mortality, and therefore not responsible for the decline of the western stock of Steller sea lions. Additionally, if the population of killer whales is assumed to have been the same size historically as it is now, that level of predation would represent a smaller fraction of the sea lion population before its decline.

On the other hand, if the recent observed level of killer whale predation on Steller sea lions is not thought to be a component of their natural mortality (*i.e.*, killer whales only recently began preying on Steller sea lions at that level), then this level of current predation would contribute to the decline of a declining population, and retard the recovery of a growing population.

Finally, life-history changes in the western stock of Steller sea lions through time argue against the hypothesis that killer whale predation alone was responsible for the decline. Density-dependent responses seen in the western Steller sea lion population were lower growth and pregnancy rates in the 1980s than the 1970s (Calkins *et al.* 1998, Pitcher *et al.* 1998). This indicates carrying capacity for sea lions likely declined over this period. This apparently continued through the 1990s as evidenced by a possible decline in natality (Holmes and York 2003). These shifts in life history parameters during the declines argue against killer whale predation as a main cause of the decline, as, for example, there is no direct reason why increased killer whale predation would lead to a decline in natality. In addition, the eastern DPS has increased at approximately 3% per year for at least 20 years while co-existing with a similar population of transient killer whales in an environment historically exposed to commercial whaling and environmental change.

4.2.3 Inter-Specific Competition for Prey Resources

Piscivorous fish consume many of the same species and sizes of prey as Steller sea lions. The strength of these food-web interactions has likely changed during the past 30 years in response to both natural and anthropogenic factors. For instance, annual differences in the size and distribution of young-of-the-year as well as adult pollock affect annual levels of cannibalism (Livingston 1991, Wespestad et al. 2000). Differential rates of fishing within the groundfish community may have also indirectly contributed to increased in arrowtooth flounder populations, a species with considerable diet overlap with Steller sea lions (NMFS 2000, 2001). How these changes as well as substantial increases in the population of Pacific halibut since the 1980s (Hollowed et al. 2000, IPHC 2000, Wilderbuer and Sample 2000, Trites et al. 1999) affect the prey field and foraging patterns of Steller sea lions or relate to population level impacts remain to be determined.

The diets and distribution of many marine mammals and birds also overlap those of the western DPS of Steller sea lions. As consumers of common prey resources, the dynamics and concomitant prey biomass removed by these sympatric piscivore populations may therefore affect the quantity and quality of prey available to Steller sea lions. As such, recovery of Steller sea lions may be affected by changes in the abundance, distribution, and prey removal by other apex predators. Whales are considered significant consumers in many marine systems and models estimate that prey consumption (in terms of biomass) by cetaceans approaches or exceeds removals by commercial fisheries (Laws 1977, Laevastu and Larkins 1981, Bax 1991, Markussen *et al.* 1992, Kenney *et al.* 1997, Trites *et al.* 1997, Witteveen *et al.* 2006). Such high levels of consumption can have significant effects on the distribution and abundance of prey species and the structure of marine communities (Perez and McAlister 1993, Kenney *et al.* 1997). Likewise, removals and recovery of cetacean populations may affect marine ecosystems through complex trophic cascades (Laws 1985, NRC 1996, Merrick 1997, Trites *et al.* 1997, Springer *et al.* 2003, Witteveen *et al.* 2006). Shore-based and pelagic whaling in the 1900's significantly reduced the number of large whales in the North Pacific, reducing their consumption (biomass removal) of certain fish, cephalopods, and zooplankton within marine ecosystems (Rice 1978) and effectively increasing prey available to other consumers in the system (Springer *et al.* 2006). Following decades of international protection, the abundance of some whale stocks has increased, including a substantial increase in central North Pacific humpbacks between the early 1980s and early 1990s (Baker and Herman 1987, Calambokidis *et al.* 1997), and late 1990s (Calambokidis and Barlow 2004). It has been hypothesized that whale stock resurgence may have reduced prey availability and contributed to declines of piscivorous pinnipeds and birds in the Gulf of Alaska and Bering Sea ecosystems (Merrick 1995, 1997, NRC 1996, Trites *et al.* 1999).

Several large piscivorous whales are migratory and fulfill their annual consumption needs on high latitude feeding ground, including waters found within critical habitat of the western DPS of Steller sea lion. Substantial seasonal feeding aggregations of humpback (Waite *et al.* 1998, Witteveen 2003), fin, and minke whales occur within the Gulf of Alaska and Bering Sea. Their diets include large zooplankton species and a variety of schooling fish (Thompson 1947, Nemoto 1957, Moore *et al.* 2000, Tamura and Ohsumi 2000) that are also consumed by Steller sea lions (capelin, herring, sandlance, smelts, small pollock) (Pitcher 1981, Sinclair and Zeppelin 2002) or by the prey of sea lions (pollock, cod, arrowtooth flounder) (Livingston 1993). As such, piscivorous whales have the potential to compete with Steller sea lions both directly when feeding on common prey and indirectly when consuming zooplankton and forage fish upon which other sea lion prey species feed. As populations of piscivorous cetaceans recover, this potential would be expected to increase.

4.2.4 Status of Important Steller Sea Lion Prey Resources in the Action Area

4.2.4.1 Walleye Pollock

Walleye pollock, *Theragra chalcogramma*, is a marine fish species that is highly fecund, producing millions of eggs per individual spawner, and which has highly variable mortality rates in early life (Bailey and Ciannelli, in press). A consequence of this reproductive strategy (producing lots of young with high expected mortality) is fluctuating annual recruitment levels (the number of young fish entering the population each year). The instability of fluctuating year classes must be buffered by the averaging effect of many age classes in the population. Because most of the oldest fishes have been removed from the population by the fishery, the abundance of walleye pollock in the Gulf of Alaska is driven by recruitment. Although the recruitment process of walleye pollock in the Gulf of Alaska is one of the better studied systems in the world, admittedly there is still much that is not well-understood.

Pollock is an opportunistic species that is able to expand its range and adapt to different environments. On the other hand, the population is limited by finding and adapting to local conditions that favor successful spawning (maximizing reproduction) and survival (minimizing mortality) of the early life stages. Local populations of pollock respond differently to shifting environmental regimes, as warming periods have seen those stocks at the southern margins of the pollock distribution falter or fail (Bailey *et al.* 1999). In the center of its distribution of mass in the eastern Bering Sea, pollock have been (if at all) favorably impacted by periods of environmental warming. In the Gulf of Alaska the situation appears more complex, as pollock have been initially favored by a warm environmental regime (e.g., stock increase in the late 1970s and mid 1980s) but negatively impacted afterwards (Hollowed *et al.* 2001), in connection with a sharp increase of predator biomass.

Pollock spawn once per year, in an event that involves individual pairing and courtship, and that is highly concentrated in space and time. Given the fragility of eggs and larvae to environmental conditions, and their concentration in space and time, the survival of a whole year class is vulnerable to the vagaries of the ocean and weather, such as storms passing through Shelikof Strait, the major spawning site. On the other hand, pollock dynamics are buffered partly by multiple spawning stocks, spawning in different locales, and by multiple age groups in the population. Spawning in different locations moderates the effects of temporal variation in habitat suitability by taking advantage of spatial variation. While the long life span of pollock is an adaptation that tempers the high variation in year class strength, a high abundance of predators on adults, as well as commercial fishing that removes older age groups, reduces the age-span over which mean abundance is averaged (and perhaps other aspects of the contribution of older fish to the population's viability). Consequently, the population will be more dependent on fewer age groups, hence contributing to overall stock variability (Longhurst 2002).

The spawning regions of pollock are noted for mixing of coastal and nutrient-laden oceanic waters and stratification of the water column, leading to enhanced productivity; these conditions favor the survival of early life stages of pollock. In the Gulf of Alaska pollock typically spawn during the last week in March and first week in April, in the Shelikof Strait. In this area, mixing of the Alaska Coastal Current, the Alaska Stream and coastal water, along with springtime increases in sunlight and water column stratification leads to an intense spring bloom and reproduction of zooplankton. Zooplankton prey of pollock larvae are further concentrated by physical features, such as eddies and fronts (Napp *et al.* 1996), leading to favorable feeding conditions. Late larvae and juvenile pollock are advected toward favorable nursery areas, such as the waters around the Shumagin Islands.

Mortality rates of pollock eggs and young larvae are very high, ranging from 4% to 40% per day, but decline as the larvae develop. In fact, larval condition can vary from year to year and by location, and a high percentage of larvae in the ocean have been observed to be in poor feeding condition (Theilacker *et al.* 1996). Studies have shown that egg and early larval development and survival is suboptimal at temperatures below about 0^{o} and above 10^{o}-12^{o}C. Extremely high and low temperatures can be lethal to eggs and larvae, but generally for the Gulf of Alaska population, which is in the central part of its distribution, higher temperatures tend to favor better survival, perhaps through one or more indirect mechanisms (Bailey 2000). Optimal prey levels for successful feeding depend on many different conditions, including larval size, temperature, light levels, turbidity and turbulence (Porter *et al.* 2005), but generally they range between 20 and 40 prey/liter (Theilacker *et al.* 1996). At high levels of abundance, pollock foraging may exceed their food supply (Anderson *et al.* 2002) leading to slower growth and higher mortality. At later stages, predation on juveniles is an important source of loss to the population. Piscivorous fishes, including halibut, cod, arrowtooth flounder and flathead sole contribute significantly to mortality of juvenile pollock (Livingston 1993).

An evolving perspective of the recruitment of pollock is that it is a complex process, influenced by both high frequency changes in the environment of young fish stages and by bounding effects of low frequency changes in the ecosystem (Bailey *et al.* 2005). Larval mortality is highly variable and subject to many interacting high frequency factors (such as storms and prey availability), with feedback and non-linearity (Bailey *et al.* 2004). Larvae show sophisticated behaviors involving choice and decisions when confronted with multiple and perhaps conflicting stimuli (Olla et al. 1996). For example, they avoid turbulence by descending (Davis 2001), taking them out of the photic zone and into colder water where growth is less optimal and prey are less abundant (Kendall *et al.* 1994). Under normal circumstances, these conditions are associated with poor feeding and high mortality. However, prey are also driven deeper by turbulence and if there is bright daylight, these conditions are then optimal for feeding (Porter *et al.* 2005). Thus, environmental factors driving recruitment are governed by complex relationships. On the other hand, although juveniles also show complicated behaviors in response to the environment (e.g. Sogard and Olla 1996), they are less impacted by small-scale physics, and juvenile mortality seems to be more stable and predictable, occurring largely as a result of predation and density-dependent mechanisms. The role of density-dependent mechanisms also seems to be influenced by environmental factors (Ciannelli *et al.* 2004). Environmental and ecosystem structure shifts may also have indirect effects on pollock survival, such as causing changes in the operation of density-dependent mechanisms. For example, Ciannelli *et al.* (2004) found that the level of density-dependent mortality in juvenile pollock increases when water temperature and predation intensity are high. The build-up of predators in the community represents a low frequency, slowly changing pattern with lagged effects. Changes in ecosystem structure may be related to the relative stage in life history when recruitment is determined (i.e., larval versus juvenile control) (Bailey 2000). Therefore, control points may change from year to year, and depend on longer term changes in the environment and community structure, such as those occurring with environmental and biological regime shifts. Patterns in recruitment have been well-described by models incorporating stochastic mortality related to environmental conditions during the larval period and by deterministic factors and constraints during the juvenile period (Ciannelli *et al.* 2004, Ciannelli *et al.* 2005). However it should be noted that because the time series of pollock abundance is so short, our knowledge of how pollock populations respond to the environment and to self-regulation has a degree of statistical uncertainty.

4.2.4.2 Pacific Cod

Pacific cod (*Gadus macrocephalus*) are demersal gadids that commonly occur in the Gulf of Alaska, Bering Sea, and Aleutian Islands. Little is known about the recruitment process in this species, though events occurring during the egg, larval, and juvenile stages of fish life history are thought to be major regulators of recruitment to the adult populations. Interannual recruitment variability is high in this species, due in part, to the high natality of females (hundreds of thousands to millions of eggs per female), high rates of cumulative mortality among early life history stages, and considerable interannual variation in growth rates.

Pacific cod spawn primarily February – June, and eggs are demersal and weakly adhesive. Larvae hatch out at approximately 3-4 mm SL and are pelagic, occurring at approximately 50 m (Rugen and Matarese 1988). Larvae are most abundant in the pelagic environment April-June (Matarese *et al.* 2003). Laboratory studies have shown that Pacific cod larvae hatch out from eggs between 16-28 days post fertilization, with peak hatching on day 21 (A.A. Abookire unpublished data). Laboratory studies on the development of external morphology and digestive function of Pacific cod larvae indicate that an ecological turning point may to occur at approximately 9 mm TL (Yoseda *et al.* 1993). This developmental state was associated with significant changes in feeding morphology and also high mortality in that study.

Climate-induced trophic restructuring is well-documented for a variety of species and marine systems (see Duffy-Anderson *et al.* 2005), and it is likely that recruitment in Pacific cod is similarly influenced. Alterations in climate influence ecosystem biota through a variety of co-occurring and synergistic processes (climate, seasonal timings and couplings, predation, feeding, transport), but of the one major factors is likely bottom-up forcing. Factors that affect hydrography influence zooplankton availability and ultimately fish abundance, though the explicit mechanism is as yet unresolved. Pacific cod larvae are opportunistic feeders that primarily consume copepod nauplii and copepodites (Takatsu *et al.* 2002), and consequently depend on zooplankton availability for growth and survival. Since Pacific cod larvae rely on a supply of zooplankton prey for food, climate-induced variations in ocean circulation that modulate the supply of zooplankton available could significantly impact feeding, growth, and survival in this species. Oceanographic features that act to concentrate zooplankton and larvae together, such as eddies and fronts, may enhance feeding opportunities for Pacific cod larvae. Factors that break down prey-larval associations, such as storms, mixing, and significant turbulence could lead to increased mortality among larvae.

Geographical variations in larval size are also likely related to interannual variations in local meteorological oceanographic conditions. Pacific cod larvae may be vulnerable to density-dependent regulation in the late-larval stage due to prey limitation and associated slow growth. Work with Atlantic cod (*Gadus morhua*), has shown that rapid growth increases survivorship, and that selection for fast growth is enhanced in slow-growing cohorts (Meekan and Fortier 1996). Variations in larval density may also contribute to differences in year-class strength in this species (Duffy-Anderson *et al.* 2002), though the affects of this form of pre-recruitment mortality may be comparatively small relative to other forcing factors.

As early juveniles, Pacific cod move toward the bottom and become demersal. Nursery habitats for juvenile Pacific cod are the shallow Alaskan coastal waters, where Pacific cod occur in highest abundances at moderate depths (15-20 m) (Abookire *et al.* in review). Juvenile Pacific cod appear to have fairly specific habitat requirements, and they may have an affinity for structure. Juvenile cod have been shown to be associated with eelgrasses (Laur and Haldorson 1996), sea cucumber mounds (Abookire *et al.* in review), and macroalgae. Consequently, Pacific cod may be sensitive to small-scale variations in spatial heterogeneities, and density-dependent recruitment in Pacific cod between age-0 and age-1 could be influenced by the availability and/or extent of nursery habitat (Fraser *et al.* 1996).

Juvenile cod diets in the Gulf of Alaska consist of small calanoid copepods, larval barnacles and crabs, mysids, worms, and gammarid amphipods, which suggest that Pacific cod feed on benthic and epibenthic as well as pelagic prey (Abookire *et al.* in review). Juvenile cod demonstrate shifts in habitat preference with length, which may be related to changes in either foraging opportunity or predation vulnerability. Regardless, variations in growth and or survival associated with differences in habitat use could affect overall recruitment.

Trophodynamic (species interactions) shifts in the North Pacific ecosystem could also influence recruitment in Pacific cod. Bailey (2000) has shown that recruitment control of walleye pollock, another North Pacific gadid, shifted from the larval to the juvenile stage in the Gulf of Alaska, primarily due to increased predation by arrowtooth flounder on immature pollock. Pacific cod juveniles may be similarly vulnerable to the effects of increased groundfish predation, resulting in additional density-dependent regulation during the juvenile stage, which would be superimposed on that associated with habitat limitation.

The shifting distributions of adult Pacific cod throughout the year indicate seasonal migrations. Pre-spawning Pacific cod occur primarily over the inner and middle shelves of the Bering Sea (<30-100 m depths) in summer. In winter (January-March) Pacific cod appear to aggregate in major spawning areas between Unalaska and Unimak islands in the eastern Aleutian Islands and near the Shumagin Islands. Postspawning dispersal occurs in summer when Pacific cod move from deep off-shelf waters to shallower depths on the eastern Bering Sea shelf (Shimada and Kimura ,1994). Pacific cod may be vulnerable to the effects of fishing since they form large spawning aggregations and demonstrate some spawning site fidelity. Adult Pacific cod are opportunistic feeders and eat both invertebrate (shrimp, crabs, squid) and vertebrate prey (piscivory) (Yang 2003).

Overexploitation of large fish predators can cause complex changes in community dynamics by altering recruitment and survival patterns. In this case, fishing large, piscivorous species such as Pacific cod may cause a trophic release from predation, especially among the juvenile stages of small pelagic fishes (ex: juvenile gadids and forage fishes). These cascading increases in the abundances of small forage fishes such as capelin, herring, eulachon, age-0 walleye pollock, and age-0 Pacific cod, could result in increased overlap among these species and life history stages, exacerbating the potential for competition among individuals for resources such as prey and habitat. Previous work on walleye pollock in the Gulf of Alaska has shown that there is significant potential for competition between age-0 pollock and yearling capelin (Wilson *et al.* in press).

4.2.4.3 Atka Mackerel

The recruitment history of Atka mackerel is characterized by variable but fairly good recruitment throughout the time series of stock assessment estimates. The strong 1977 year class is most notable followed by the 1988, and 1999 year classes (Lowe *et al.* 2005). The most recent stock assessment estimates above average (greater than 20% of the mean) recruitment from the 1977, 1986, 1988, 1992, 1995, 1998, 1999, 2000, and 2001 year classes (Lowe *et al.* 2005). Given the history of variable, but widespread consistent recruitment for BSAI Atka mackerel, it is more likely that recruitment is largely driven by environmental factors than fishery management measures. Based on basin-wide North Pacific climate indices, there appears to have been a major regime shift in 1976/77, and a minor regime shift in 1988/89 (Boldt 2005, Hare and Mantua 2000, King 2005). There is some uncertainty if there was a regime shift in 1999 given the variability in environmental indices since 1998 (Rodionov *et al.* 2005). These hypothesized regime shifts coincide with the three strongest Atka mackerel year classes, however, it should noted that the mechanisms which produce successful recruitment are unknown.

4.2.4.4 Pacific Herring

Pacific herring (*Clupea pallasi*), is a marine fish species that with moderate fecundity producing thousands of eggs per individual spawner (Paulson and Smith, 1977). Pacific herring spawn in the spring period in near shore regions throughout the Gulf of Alaska and the Bering Sea. In the GOA major spawning locations occur near Sitka Alaska and Prince William Sound (Williams and Quinn 1998). In the Bering Sea, major spawning concentrations can be found in Bristol Bay near the village of Togiak and in Norton Sound (Funk and Rowell 1995, Williams and Quinn 1998). Comparison of recruitment time series of Pacific herring across the northwest Pacific reveals that this species exhibits episodic recruitment events that show some evidence of synchrony at a regional scale (Williams and Quinn 2000a).

Several hypotheses have been advanced to explain trends in Pacific herring. Large scale shifts in climate forcing can influence a variety of oceanographic factors including: timing of production, metabolic rate, larval transport, prey availability, and probability of encounters between predator and prey. Climate shifts have been recorded in the North Pacific in 1977 and 1989 (Hare and Mantua 2000). The most recent shift in atmospheric forcing occurred in 1998 with spatially differing impacts on ocean conditions in the Gulf of Alaska and Bering Sea (Bond and Overland 2004). Intra-species competition and predator prey interactions are may also influence recruitment patterns for Pacific herring.

Shifts in large scale atmospheric forcing appears to influence the structure of marine fish communities in the western central Gulf of Alaska ecosystem through its role in determining the timing of peak production. Species that spawn in the winter will be favored by periods of early peak production, while species that spawn in the spring and summer will be favored by periods of delayed production (Mackus *et al.* 1997, Anderson and Piatt 1999).

Environmental forcing can influence a variety of oceanographic factors governing survival during the early life history period. Tanasichuk and Ware (1987) found temperature effected fecundity and egg size. Alderdice and Hourston (1985) found temperature influenced embryonic survival rates. Williams and Quinn (2000b) found supplementing a Ricker type spawner recruit relationship with sea surface or air temperature produced an improvement to forecasts of Pacific herring recruitment. Climate shifts can influence major transport corridors for Pacific herring. Wespestad (1991) found recruitment trends of Togiak region were related to local wind conditions.

Ocean conditions that favor concentration of forage fish and their prey can enhance production. The FOCI program identified a potential mechanism linking increased precipitation to enhanced eddy formation and reduced larval mortality. Eddies are believed to provide a favorable environment for pollock larvae by increasing the probability of encounters between larvae and their prey (Megrey *et al.* 1996). An inverse or dome shaped relationship exists between the amount of wind mixing and pollock fish production. Bailey and Macklin (1994) compared hatch date distributions of larval pollock with daily wind mixing. This analysis showed that first feeding larvae exhibited higher survival during periods of low wind mixing. Research is needed to determine whether this mechanism may be important for Pacific herring.

Evidence suggests that in some years, fish predation may exhibit a measurable effect on forage species production in the Gulf Ecosystem Monitoring study region. Anderson and Piatt (1999) noted that the post regime shift increase in gadoid and pleuronectid fishes coincided with marked declines in capelin and shrimp populations. They proposed that this out phase relationship could be caused by increased predation mortality due to an increase in picivorous species. This mechanism appears to influence walleye pollock and may be important to Pacific herring. Bailey (2000) provided evidence that during the 1980s, pollock populations were largely influenced by environmental conditions, whereas, after the mid-1980s, there was a greater juvenile mortality resulting from the buildup of large fish predator populations.

Detailed studies of Prince William Sound reveal that interspecific competition for common prey resources can result in complex recruitment patterns (Norcross *et al.* 2001). In Prince William Sound, Cooney (1993) speculated that pollock predation could explain some of the observed trends in juvenile salmon and Pacific herring survival. They suggested that years of high copepod abundance were associated with high juvenile salmon survival because pollock relied on an alternative prey resource.

At finer spatial scales prey resources for forage fish may be prey limited leading to resource partitioning to minimize competition between forage fish species that occupy similar habitats. Willette *et al.* (1997) examined the diets of juvenile walleye pollock, Pacific herring, pink salmon and chum salmon in PWS. Their study revealed that two species pairs (walleye pollock and Pacific herring, and pink and chum salmon) exhibited a high degree of dietary overlap. This finding suggests that in PWS, competition for food resources may occur within these pairs when food abundance is limited. Foy and Norcross (1999) found water transported into Prince William Sound influenced the spatial and temporal distribution of prey for age-0 Pacific herring within Prince William Sound resulting in fine scale partitions in the condition of age-0 Pacific herring within the sound.

Competition for prey and oceanographic factors influencing prey availability can influence the probability of over-wintering survival for juvenile herring. Juvenile herring rely on fat resources acquired during the summer growing season during the winter (Foy and Paul 1999). Interspecies competition for common prey can produce complex recruitment patterns.

4.3 Impacts of Human Activities on Steller Sea Lions

4.3.1 Subsistence Harvests of Steller Sea Lions

Both the ESA and the MMPA contain provisions that allow coastal Alaska Natives to harvest endangered, threatened, or depleted species for subsistence purposes. Prior to 1992, no comprehensive program estimated the level of subsistence harvest of sea lions in Alaska. However, available information indicates that sea lions were being harvested at several villages on the Bering Sea, in the Aleutian Islands, and on the Gulf of Alaska (Haynes and Mishler 1991). During 1992-2004, harvest data were collected through systematic retrospective interviews with hunters in at least 60 coastal communities throughout the range of sea lions in Alaska (Wolfe *et al.* 2005). Results show the annual take (i.e., harvest plus struck and loss) decreasing substantially from about 550 sea lions in 1992 to about 200 in 1996 followed by annual takes between 165 and 215 from 1997 to 2004 (see below).

Estimated takes of western DPS Steller sea lions by Alaska Natives in five regions. Values include both retrieved harvest and reported struck and lost (Wolfe *et al.* 2005). PWS = Prince William Sound; AK = Alaska.

Year	PWS-Cook Inlet	Kodiak & AK Peninsula	Aleutian Islands	Pribilof Islands	Bristol Bay	Total
1992	40	60	135	297	9	541
1993	46	64	124	245	6	485
1994	27	67	122	193	1	410
1995	31	144	96	68	0	339
1996	17	65	58	46	0	186
1997	6	46	52	56	4	164
1998	28	27	37	78	0	170
2000	17	32	76	43	0	168
2001	16	47	98	38	0	199
2002	6	24	105	43	0	178
2003	25	41	107	32	0	205
2004	54	21	96	32	1	204
Averages						
1992-95	36	84	119	201	4	444
1996-04	21	38	79	46	1	184

In the early 1990s, juveniles were harvested at least twice as much as adults, yet that ratio declined beginning in 1996, and during 2000 to 2004 the ratio of juveniles to adults in the harvest ranged from 0.5 to 1.0. The ratio of males to females harvested in 2004 was 1.8, below the 5-year average of 4.1 during the previous five years. In 2004, 24 adult females were harvested, representing about 20% of the total harvest of known sex and age. During 1992-1995, the greatest numbers of sea lions harvested were in the Pribilof Islands, whereas during 1996-2004 the harvest was greatest in the Aleutian Islands. The surveys that produced these estimates covered all Alaskan communities that regularly hunt Steller sea lions, but a few additional animals are taken occasionally at other locations (Coffing *et al.* 1998, ADF&G unpublished data).

In 1998, the Tribal Government of St. Paul's Ecosystem Conservation Office implemented a real-time data collection program to estimate the take of sea lions, due to concerns by hunters and the local community in the uncertainty of harvest results based on retrospective surveys. Results of the real-time harvest monitoring indicated a sea lion take of about 25-35 per year from 1998-2002, followed by a reduced take of 18 sea lions in both 2003 and 2004 (Zavadil *et al.* 2005). The Tribal government also implemented a new subsistence harvest management scheme that likely may have resulted in fewer animals taken. Factors that may be responsible for this decreased take include fewer hunters, fewer animals to hunt in the communities' hunting areas, and voluntary restraint from hunting because of perceived problems with the sea lion population (Wolfe and Hutchinson-Scarbrough 1999).

Information on the harvest of Steller sea lions in Russia is fragmentary. In 1932 and 1933, newborn pups were harvested on Iony Island in the Sea of Okhotsk (1,198 and 805 respectively), and in 1935 about 30 pups were taken on the Shipunsky Cape (Kamchatka) rookery (Nikulin 1937). In 1974, an experimental harvest was conducted on Brat Chirpoev rookery in the Kuril Islands that took 296 pups (Perlov 1975). During the period when the government of the Soviet Union conducted commercial sealing (1960-1990), sea lions were not a target species, but they were taken occasionally with annual harvests ranging from 37 to 650 animals (Perlov 1996). During the 1950s to 1980s, a subsistence harvest was conducted on the

Commander Islands and Kamchatka that usually took fewer than 100 animals a year, but this harvest has stopped completely in the late 1980s (Burkanov personal communication). Some sea lions are taken in Chukotka by native hunters, but the number killed is unknown.

Current subsistence harvests represent a large proportion of the potential biological removal that was calculated for the western DPS of Steller sea lion (Angliss and Outlaw 2005). However, subsistence harvests account for only a relatively small portion of the Steller sea lions lost to the population each year and are primarily young males which reduce the impact to the recovery of the population.

4.3.2 Commercial Harvest of Steller Sea Lions

Currently, no commercial harvest for Steller sea lions exists in the United States, but sea lions were commercially harvested prior to 1973. A total of 616 adult males and 45,178 pups of both sexes were harvested in the eastern Aleutian Islands and Gulf of Alaska between 1959 and 1972 (Thorsteinson and Lensink 1962, Havens 1965, Merrick *et al.* 1987). The pup harvests, which sometimes reached 50% of the total pup production from a rookery, could have depressed recruitment in the short term and may partially explain the declines at some sites through the mid-1970s. However, these harvests do not explain why numbers declined in regions where no harvest occurred, or why in some regions declines occurred approximately 20 years after harvests ceased (Merrick *et al.* 1987). A comparative analysis of the ecology and population status of four species of pinnipeds in similar environments (Steller sea lions in the Gulf of Alaska, Cape fur seals in the Benguela Current, harp seals in the Barents Sea, and California sea lions in the California Current) indicates that directed commercial harvest was not a major factor in the Gulf of Alaska Steller sea lion decline (Shima *et al.* 2000).

Steller sea lions are hunted in Hokkaido, Japan to reduce interaction with local fisheries, with an average of 631 animals killed per year during 1958-1993 (Takahashi and Wada 1998). The animals killed had probably migrated southward from the Kuril Islands. Demographic modeling shows that kills were sufficient to deplete the Kuril population, especially in combination with incidental catches in fisheries (Takahashi and Wada 1998). More current information on the level of kill since 1993 is not available.

4.3.3 Incidental Take by Fisheries

Many Steller sea lions have been killed incidental to commercial fishing operations in the Bering Sea and North Pacific Ocean. The total estimated incidental catch of Steller sea lions during 1966-1988 in foreign and joint-venture trawl fisheries operating off Alaska was over 20,000 animals (Perez and Loughlin 1991). A particularly high level of take occurred in the 1982 Shelikof Strait walleye pollock joint venture fishery when U.S. trawlers killed an estimated 958 to 1,436 sea lions (Loughlin and Nelson 1986). The estimated take in this fishery declined to fewer than 400 animals per season in 1983 and 1984, probably due to changes in fishing techniques and in the area and times fished. Most of the animals taken were sexually mature females. Fewer than 100 per year were estimated to have been taken during 1985-1987. The level of incidental mortality has continued to decline. The minimum estimated mortality rate incidental to commercial fisheries in 2002 was 29.5 sea lions per year, based on observer data (24.1) and self-reported fisheries information (5.2) or stranded data (0.2) where observer data were not available (Angliss and Outlaw 2005).

During October-December 2002, observers recorded the incidental take of sea lions during a herring trawl fishery in the western Bering Sea. Preliminary estimates of the total number of sea lions caught were 35-60, with 32-50 killed (Burkanov and Trukhin unpublished). The genetic analysis of skin samples from sea lions caught in this trawl fishery will provide insight on which regions the sea lions may be from (i.e., Aleutian, Commander, and Kuril Islands, and Kamchatka). The majority, if not all, of these sea lions were subadult males.

Amendments to the MMPA in 1988 and 1994 required observer programs to monitor marine mammal incidental take in some domestic fisheries. Observers monitored the Prince William Sound drift gillnet fishery in 1990 and 1991 and estimated a mean annual kill of 14.5 Steller sea lions (Wynne *et al.* 1992). Hill and DeMaster (1999) provide observer-based estimates of average annual Steller sea lion incidental mortality for fisheries operating in the range of the western DPS between 1993 and 1997 as follows: 6.8 animals in the Bering Sea groundfish trawl fishery; 1.2 animals in the Gulf of Alaska groundfish trawl fishery; 0.2 animals in the Bering Sea groundfish longline fishery; and 1.0 animals in the Gulf of Alaska groundfish longline fishery. These numbers are minimum estimates of the incidental kill and serious injury in fisheries, because not all fisheries that might take sea lions are covered by observer programs.

Nikulin and Burkanov (2000) documented marine mammal bycatch in Japanese salmon driftnet fishing in the Russian exclusive economic zone of the southwestern Bering Sea. Catch of only one Steller sea lion was observed during 1992-1999, and it was released alive. Quantitative information on sea lion incidental catch in other fisheries that occur in Russian and Japanese waters is not available, but it is possible that some animals have been killed in trawl fisheries for herring and pollock.

4.3.4 Intentional and Illegal Shooting

In some areas Steller sea lions are known to have been shot deliberately by fishermen (and perhaps other people), but it is unclear how such mortality may affect the population because the overall magnitude of the take is unknown (Alverson 1992). One of the few estimates of shooting mortality was reported by Matkin and Fay (1980), who calculated that 305 Steller sea lions were shot and killed while interfering with fishing operations in the spring 1978 Copper River Delta salmon gillnet fishery. Data from a 1988-1989 study of the Copper River salmon gillnet fishery indicated that the level of directed kill of sea lions was significantly less than during 1978 (Wynne 1990). During the 1960s, sea lions were sometimes killed and used as bait by crab fishermen (Alverson 1992). Such killing may have had a significant effect in local regions and might have caused animals to move away from certain rookeries and haulout sites (Loughlin and Nelson 1986, Merrick *et al.* 1987, NRC 2003). In 1990, a regulation was implemented to prohibit fishermen from discharging firearms near Steller sea lions, but nonetheless some shooting, resulting in an unknown level of mortality, likely occurs (NMFS 2001, Loughlin and York 2000, NRC 2003).

Simulation modeling suggests that a combination of commercial harvests, subsistence harvests, and intentional and incidental take in fisheries may explain a large portion of the western Steller sea lion population decline that occurred through 1980 (Trites and Larkin 1992). However, the annual decline since 1990 has been much greater than can be accounted for by such direct causes (Loughlin and York 2000).

4.3.5 Entanglement in Marine Debris

Steller sea lions may become entangled in lost and discarded fishing gear and other marine debris, including items such as closed packing bands and net material (Calkins 1985). A study conducted in the Aleutian Islands during June-July 1985 to investigate the rate of entanglement found that a very low percentage (approximately 0.07%) of observed sea lions were entangled in net or twine; none were entangled in packing bands (Loughlin *et al.* 1986). A follow-up study was conducted during November 1986 to assess the possibility that sea lion pups were becoming entangled in debris. Researchers saw no entangled pups and only one entangled juvenile out of a total of 3,847 sea lions examined (Loughlin *et al.* 1986). However, these observational studies cannot fully evaluate the frequency of entanglement because entangled animals may die at sea and thus not be observed on land. Observations by researchers in southeast Alaska indicate higher numbers of sea lions entangled in fishing gear and other marine debris which could be limiting the populations growth rate (Pitcher *et al.* in press).

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

As the size of human communities increases, there is an accompanying increase in habitat alterations for housing, roads, commercial facilities, and other infrastructure. The impacts of these activities on landscapes and the biota they support increases as the size of the human population expands. The Alaska population has increased by almost 50 percent in the past 20 years, most of that increase has occurred in the Cities of Anchorage and Fairbanks. 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 for 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 cod 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.

4.3.7 Disturbance

The possible impacts of various types of disturbance on Steller sea lions have not been well studied, yet the response by sea lions to disturbance will likely depend on season, and their stage in the reproductive cycle (Kucey and Trites 2006). Close approach by humans, boats, or aircraft will cause hauled out sea lions to go into the water, and can cause some animals to move to other haulouts (Calkins and Pitcher 1982, Kucey 2005). The discharge of firearms at or near hauled out animals may have a particularly dramatic effect. Vessels that approach rookeries and haulouts at slow speed, in a manner that sea lions can observe the approach have less effect than fast approaches and a sudden appearance. Sea lions may become accustomed to repeated slow vessel approaches, resulting in minimal response. Although low levels of occasional disturbance may have little long-term effect, areas subjected to repeated disturbance may be permanently abandoned (Kenyon 1962, Thorsteinson and Lensink 1962). When humans set foot on a rookery or haulout, the response by sea lions is typically much greater, often resulting in stampedes that may cause trampling or abandonment of pups (Calkins and Pitcher 1982, Kucey 2005, Lewis 1987, Kucey 2005). In British Columbia, harassment and killing that occurred prior to 1970 resulted in the abandonment of one major rookery, although it is now used as a haulout (Bigg 1988).

Since Steller sea lions were afforded ESA protection in 1990, regulations have been in place to minimize disturbance of animals by humans, especially on rookeries. An unknown level of disturbance still occurs with current regulations. Repeated disturbances that result in abandonment or reduced use of rookeries by lactating females could negatively affect body condition and survival of pups through interruption of normal nursing cycles. The consequences of such disturbance to the overall population are difficult to measure. Disturbance may have contributed to or exacerbated the decline, although it is not likely to have been a major factor.

4.3.8 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.

Oil spills are expected to adversely affect Steller sea lions if they contact individual animals, haulouts, or rookeries when occupied, or large proportions of major prey populations (Minerals Management Service 1996). Potential effects could include: oil exposure, including surface contact and pelage fouling, inhalation of contaminant vapor, and ingestion of oil or oil-contaminated prey. Because the insulation of non-pup sea lions is provided by a thick fat layer rather than pelage whose insulative value could be destroyed by fouling, oil contact is not expected to cause death from hypothermia; however, sensitive tissues (e.g., eyes, nasal passages, mouth, lungs) are likely to be irritated or ulcerated by exposure to oil or hydrocarbon fumes. Oiled individuals probably will experience effects that may interfere with routine activities for a few hours to a few days; movement to clean water areas is expected to relieve most symptoms. Females returning from feeding trips may transfer oil to pups, which probably are more sensitive to oil contact.

The extent to which sea lions avoid areas that have been oiled is not known; individuals observed in Prince William Sound and the Gulf of Alaska after the Exxon Valdez oil spill did not appear to avoid oiled areas (Calkins and Becker 1990). Sea lions were sighted swimming in or near oil slicks, oil was seen near numerous haulout sites, and oil fouled the rookeries at Seal Rocks and Sugarloaf Island (Calkins *et al.* 1994). All of the sea lions collected in Prince William Sound in October 1989 had high enough levels of metabolites of aromatic hydrocarbons in the bile to confirm exposure and active metabolism at the tissue level. But as noted above, no evidence indicated damage caused to sea lions from toxic effects of the oil (Calkins *et al.* 1994).

Although Alaska is estimated to contain large petroleum resources on its outer continental shelf and in state waters, the only oil produced from Alaska's outer continental shelf to date has come from Cook Inlet south of Anchorage. In the foreseeable future, the kind of extensive oil and gas activities that characterize the outer continental shelf of the central Gulf of Mexico is not likely for the Gulf of Alaska. Little or no oil and gas exploration or production is occurring or likely to occur soon on the Russian outer continental shelf area of the Bering Sea. The National Research Council concluded, therefore, that oil and gas activities in the Bering Sea have not significantly affected the Bering Sea ecosystem (NRC 1996).

4.3.9 Impacts of Research

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 harvest and provided life history information (age, size, reproductive condition, food habits). Between 1975 and 1978, 250 sea lions were killed in nearshore waters and on rookeries and haulouts of the GOA; their stomachs were removed and examined for food content, reproductive organs were preserved for examination, blood samples were taken for disease and parasite studies, body measurements were recorded for growth studies, skulls were retained for age determination, tissue samples were preserved for elemental analysis and pelage samples were taken for molt studies. In 1985 and 1986, 178 sea lions were killed in the GOA and southeast Alaska to compare food habits, reproductive parameters, growth and condition, and diseases, with the same parameters from animals which were collected in the 1970s. The study was designed to address the problem of declining numbers of sea lions in the North Pacific and particularly in the GOA. More recently, sixteen Steller sea lions were killed for a Natural Resources Damage Assessment study following the Exxon Valdez oil spill.

For more than a decade, researchers have been conducting surveys and behavioral research on Steller sea lions. The results of their annual studies suggest that Steller sea lion populations are not adversely affected by this research, although individual animals may be adversely affected or killed. In 1998, 48,000 Steller sea lions were disturbed by these investigations, 384 pups were captured, tagged, and branded, but there were no mortalities. In 1997, 31,150 Steller sea lions were approached by these researchers, 14,550 were disturbed, 137 were captured, and 121 were tagged, but there were no known mortalities. The studies conducted in 1996 had similar effects, although one Steller sea lions died during the study (which equates to 0.002% of the animals approached or 0.007% of the animals disturbed). In 1995, 7,500 Steller sea lions were disturbed and none of them died.

Calkins and Pitcher (1982) found that disturbance from aircraft and vessel traffic has extremely variable effects on hauled-out sea lions ranging from no reaction at all to complete and immediate departure from the haulout. When sea lions are frightened off rookeries during the breeding and pupping season, pups may be trampled or, in extreme cases, abandoned. Sea lions have temporarily abandoned haulouts after repeated disturbance (Thorsteinson and Lensink 1962), but in other situations they have continued using areas after repeated and severe harassment. Johnson *et al.* (1989) evaluated the potential vulnerability of various Steller sea lion haulout sites and rookeries to noise and disturbance and also noted a variable effect on sea lions. Kenyon (1962) noted permanent abandonment of areas in the Pribilof Islands that were subjected to repeated disturbance. A major sea lion rookery at Cape Sarichef was abandoned after the construction of a light house at that site, but then has been used again as a haulout after the light house was no longer inhabited by humans. The consequences of such disturbance to the overall population are difficult to measure. Disturbance may have contributed to or exacerbated the decline, although Federal, State, and private researchers familiar with the data do not believe disturbance has been a major factor in the decline of Steller sea lions.

Disturbance by research activities includes aerial surveys, capturing of animals for branding, tagging, and sample collection, and close vessel approaches to rookeries and haulouts to observe branded animals. Sea lions are occasionally killed accidentally in the course of such scientific research activities, often due to accidental death during anesthesia or suffocation when animals are herded, and were estimated by Loughlin and York (2000) to be about three animals per year for the western DPS. However, the recent average is about 1-2 for the western DPS (NMFS unpublished data). The potential exists for additional unobserved mortality to occur following the completion of research activities, yet no estimates are available. Pups are the age-class most vulnerable to disturbance from research activities.

On May 26, 2006, a District Court judge in DC issued an opinion and a court order relative to a law suit filed against NOAA by the Humane Society of the United States. The Humane Society argued that NOAA did not follow proper procedures under the National Environmental Policy Act before issuing permits to six entities to conduct Steller sea lion research in Alaska. The court sided with the Humane Society and directed NOAA to immediately vacate all six existing permits and prepare a full Environmental Impact Statement, per NEPA requirements. A settlement agreement was reached in June 2006 which allows the following limited research to continue while NMFS completes an EIS on the research program:

No Take Activities: The following “no take” activities may be conducted by the following permit holders:

(1) Permit No. 782-1768 National Marine Mammal Laboratory, NMFS
Visual observation of sea lions from hidden observation posts on Ugamak and Marmot Islands, outside of the view of sea lions. No sea lion disturbance is anticipated.

(2) Permit No. 358-1769 Alaska Department of Fish and Game
Visual observation of sea lions from hidden observation posts on Lowrie Island, outside of the view of sea lions. No sea lion disturbance is anticipated.

(3) Permit No. 881-1668 Alaska Sea Life Center
Operation of a remote-controlled camera (already in place) on Chiswell Island, and receiving a video feed to observe sea lions hauling out within range of the cameras. This activity does not require approaching the rookery, or disturbance in any manner. No sea lion disturbance is anticipated.

(4) Permit No. 434-1669 Oregon Department of Fish and Wildlife
Operation of a remote-controlled camera (already in place) at Rogue Reef (OR) and St. George Reef (CA) and receiving a video feed to observe sea lions hauling out within range of the cameras. This activity does not require approaching the rookery, or disturbance in any manner. No sea lion disturbance is anticipated.

Low Take Non-Invasive Activities: The following “low take” activities may be conducted by the following permit holders:

(1) Permit No. 782-1768 National Marine Mammal Laboratory, NMFS

Low-level disturbances of sea lions during counts and mark resighting cruises conducted from small boats moving in front of haulouts and rookeries. These surveys will occur for approximately two (2) weeks during each of two time periods, May 1-31, 2007 and August 1-31, 2007. Defendants believe that during such surveys, the likely behavioral change is that some sea lions may alter their behavior from a resting position to an alert posture and that a few animals may enter the water, but believe this reaction is not common.

Low-level incidental disturbance associated with aerial surveys to assess population trends. These aerial surveys are for localized, regional surveys around Kodiak, Alaska. These surveys are to be conducted in addition to the non-invasive “non-pup” aerial survey by the National Marine Mammal Laboratory as permitted by the court in its June 13, 2006 order. This survey will occur for a two week period between June 15, 2006 and July 15t, 2006, September – December 2006, and March 2007. Defendants believe that the actual number of seals showing any reaction to an aircraft passing overhead is likely to be small. For those sea lions that do show some reaction, the typical response is to change from a resting to an alert posture and that a few animals may enter the water, but Defendants believe that this response is not common.

(2) Permit No. 358-1769 Alaska Department of Fish and Game

Low-level disturbances of sea lions during counts and mark resighting cruises conducted from small boats moving in front of haulouts and rookeries. The cruises will occur over a two week period during the following months in 2006-2007: January– February, April, and June-July. Defendants believe that during such surveys the only behavioral change likely is that some sea lions may alter their behavior from a resting position to an alert posture.

(3) Permit No. 881-1668 Alaska Sea Life Center

Routine maintenance of a remote-controlled camera system (already in place) at Chiswell Island, Alaska conducted several times per year. There is no set maintenance schedule and it is done on an as-needed basis. However, maintenance will not occur during the peak pupping period from May 15-July 10. Maintenance activities at other times at the camera site may cause minimal disturbance of sea lions along the periphery of the rookery. This activity does not require directly approaching the rookery, but personnel approaching the nearby camera site may be seen by sea lions, which could result in low level disturbance including animals altering behavior from a resting posture to an alert posture. The activity will not occur during the pupping season.

(4) Permit No. 715-1784 North Pacific Universities Marine Mammal Research Consortium

Low-level disturbances of sea lions during counts and mark resighting cruises conducted from small boats moving in front of haulouts and rookeries. The boat surveys are frequent, approximately one per month year round in southeast Alaska. Defendants believe that, during such surveys, the only behavioral change likely is that some sea lions may alter their position from a resting posture to an alert posture and that a few animals may enter the water, but Defendants believe that this response is not common.

Low-level incidental disturbance associated with aerial surveys to assess population trends. The aerial surveys are coordinated with the boat surveys and occur approximately once per month year round in Southeast Alaska. Defendants believe that the actual number of seals showing any reaction to an aircraft passing overhead is likely to be small. Defendants believe that, for those sea lions that do show some reaction, the typical response is to change from a resting to an alert posture.

Visual observation of sea lions from observation posts on Brothers Island in southeast Alaska. During these activities there is a possibility that a small number of sea lions may be incidentally disturbed while the observers are making their way to and from their observation posts. This activity does not require directly approaching this haulout site. According to Defendants, Brothers Island is not a rookery, so no pupping occurs at this location. Personnel approaching the observation posts may be seen by sea lions, which could result in low level disturbance such as changing from a resting posture to an alert posture.

Routine maintenance of a remote-controlled camera system (already in place) at Brothers Island, Alaska several times per year. There is no set maintenance schedule. However, when necessary, routine maintenance usually occurs during boat surveys. This would result in up to one maintenance activity per month. However, Brothers Island is not a rookery; therefore, no pups or mother-pup pairs will be disturbed. Maintenance may cause minimal disturbance of sea lions along the periphery of the rookery. This activity does not require directly approaching the rookery, but personnel approaching the nearby camera site may be seen by sea lions, which could result in low level disturbance. Defendants believe that some sea lions may alter their position from a resting posture to an alert posture and that a few animals may enter the water, but believe this response is not common.

(5) Permit No. 434-1669 Oregon Department of Fish and Wildlife

Routine maintenance of a remote-controlled camera system (already in place) at Rogue Reef, Oregon and St. George Reef, California. Maintenance activities at the camera site may cause minimal disturbance of sea lions along the periphery of the rookery. This activity does not require directly approaching the rookery, but personnel approaching the nearby camera site may be seen by sea lions, which could result in low level disturbance. The activity will not occur during the pupping season.

(6) Permit No. 1010-1641 Aleutians East Borough

Low-level incidental disturbance during quarterly aerial surveys of Steller sea lion abundance and trend surveys conducted in March, June, September and December. Defendants believe that the actual number of sea lions showing any reaction to an aircraft passing overhead is likely to be small. For those sea lions that do show some reaction, the typical response is to change from a resting to an alert posture.

Low Take Handling and Release of Captured Animals: The low take handling and release of previously captured animals may be conducted by the following permit holder:

(1) Permit No. 881-1668 Alaska Sea Life Center

Release of sea lions that the Alaska SeaLife Center is now holding in captivity. Prior to the permits being vacated, the ASLC had captured four (4) sea lions to conduct health assessments that now need to be released.

The protocol for release of sea lions now held by the ASLC will include the following: collection of blood for CBC, blood chemistry, viral serology; skin and mucosal swabs for pathogen screening; and morphometrics and ultrasound readings for body condition. Pathogen screening requires two weeks, during which time the animals will not be handled or sampled.

During the release (approximate time -- end of June 2006) the animals will be sampled for blood (for final CBC and chemistries), morphometrics and ultrasound readings. Anesthesia and physical restraint will be required for the safety of the animals and personnel.

The protocol for release of animals currently held by ASLC will not include additional standard exit procedures, including deuterium oxide dilution, blubber biopsy, branding, flipper tagging, and satellite tagging.

4.3.10 Summary of Known Direct Take of Steller Sea Lions

The information below represents our best estimate of the sum of direct human related mortality factors as developed by the SSLRT (NMFS 2006). Incidental catch estimates for the trawl fisheries based on observer data, were calculated by Perez and Loughlin (1990). Available quantitative information bearing on harvests, shooting, and incidental catch was compiled and analyzed by Trites and Larkin (1992). A draft analysis by a subgroup of the SSLRT extended and extrapolated the Trites and Larkin estimates.

This resulted in the values below, where the cell entries are the accumulated number of deaths attributed to each cause over the interval. The historic non-subsistence direct harvest was confined to pups, and took place during a discrete subinterval, 1963-1972, of the period to which it is assigned.

	Time Period				
Mortality Source	**1958-1977**	**1977-1985**	**1985-1989**	**1989-2000**	**2000-2004**
Non-subsistence harvest	45,178	0	0	0	0
Subsistence harvest	9,995	2,900	850	3,300	750
Shooting	12,716	8,277	1,870	2,200	1,000
Incidental catch and entanglement	28,191	14,461	2,255	330	150
Total	**96,080**	**25,638**	**4,975**	**5,830**	**1,900**

4.3.11 Early Environmental Observations

Although there were no scientific surveys or collections from 100 years ago that are directly comparable with those of the last 25 to 30 years, the observations and conclusions of some of the early naturalists in Alaska are worth reviewing (Nelson 1887, Jordon *et al.* 1896, 1898, Alexander 1898a, b, Jordon and Evermann 1902). A number of early observations of the North Pacific ecosystem have been previously cited in this opinion, especially those relating to Steller sea lion food habits (Table 3.20a). Other reviews provide quotes from various early sources as well (Causey *et al.* 2005, NRC 2003). In this section we provide an overview of some of the commonly cited observations. These observations should be read with caution as they represent anecdotal information (and unpublished works) and generally were not part of a rigorous scientific study. They do provide a sense of the variability in the ecosystem and should remind us that the environment is not static.

Nelson (1887) reported that sea lions were scarce in the Aleutian Islands in the 1880s, but were abundant in the Pribilof Islands (about 35,000 animals), and during the early 1800s had once numbered several hundred thousand animals on St. George Island alone (but were extirpated upon direction of the Russians). Dixon (1986) investigated middens on Kodiak Islands and found Steller sea lions to be the most common fauna identified. Causey *et al.* (2005) concluded, based on zooarchaeology of early human sites in the Aleutian Islands from *c.* 3500 yr ago, that seabirds have fluctuated with temperature and precipitation. Populations of marine mammals may have also fluctuated (in abundance or availability to Aleuts) based in part on climate and hunting by Aleuts (Dixon 1986, Maschner unpublished manuscript[4]). In reports from expeditions to the Pribilof and Aleutian islands, researchers found Alaskan pollock in the Bering Sea and neighboring waters south to Sitka and the Kurils to be "excessively abundant, swimming near the surface and furnishing the great part of the food of the fur seal" (Jordon and Evermann 1902).

Turner (1886) indicated that Pacific cod and Atka mackerel were apparently rarely encountered at Attu Island prior to 1873, but were abundant there in 1878–81. At Attu Island, capelin were said to be very abundant every third year, as may have been the case at Atka Island. At Atka Island, capelin were also abundant when Turner visited (1878–81), and "dead fish [capelin, post-spawning] were so thick on the beach that it was impossible to walk without stepping on hundreds of them" (Turner 1886, p. 102).

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[4] From Maschner, H.D.G, K. Reedy-Maschner, A.M. Tews, and M. Livingston. Unpublished manuscript. Anthropological investigations on the decline of the Steller sea lion in the western Gulf of Alaska and southern Bering Sea.

Jordan and Evermann (1902) stated that "Alaskan pollock found in the Bering Sea and neighboring waters south to Sitka and the Kurils. It is excessively abundant throughout the Bering Sea, swimming near the surface and furnishing the great part of the food of the fur seal. It reaches a length of 3 feet and is doubtless a good food-fish." and that "Likewise, cod is very abundant in the Bering Sea", and Atka mackerel is described as being abundant in the Aleutian Islands as it is today. Arrowtooth flounder, Greenland turbot, and Pacific halibut were all common." Jordan *et al.* (1896, 1898) in their fur seal accounts state that "In Bering Sea, in August and September, the Alaskan pollock seems to form by far the most important part of the seal's diet" and that "the cod, halibut, and Atka-fish are very abundant."

Alexander (1898a,b) stated that "Cod were abundant…. Their abundance may have been the cause of the seals being plentiful in this region." and that "For several days, seals had been observed chasing some kind of fish….2 seals were speared. The fish proved to be Alaskan pollock. Both seals were large males." Kenyon and Wilke (1952) found "Evidence from the food remains on the Pribilof rookeries is that fur seals depend to a large degree on the…family Gadidae during their stay in the Bering Sea."
While Fiscus, Baines and Wilke (1962) found "Theragra, Mallotus and squid have consistently been the principal food of seals in the Bering Sea" since observations began in the 19th century (N=thousands).

4.4 Impacts of Commercial Fisheries Within the Action Area

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

Commercial fisheries in the action area have gone through many cycles of development and collapse since they began in the 1800s and the focus of the fisheries has shifted many times since its beginning. A complete historical review of commercial fisheries is provided in NMFS (2000) and incorporated here by reference. 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 2000.

These fisheries affected the environment in the BSAI and GOA as described in previous biological opinions (NMFS 2000, 2001, 2003). 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 and a review of ecosystem level impacts beyond the direct effects of removing sea lion prey. Because this action is on-going and it is impossible to disentangle the environmental effects of the current action from the effects of the action on Steller sea lions, the discussion of specific fishery effects on Steller sea lions and their prey (e.g., competition for prey) will be discussed in detail in Chapter 5 (Effects of the Action). Section 4.7 below will synthesize the status of the baseline and species and outline the approach for assessing the impacts of the proposed action in relation to this baseline.

4.4.1 Fishery Measures Taken to Conserve Steller Sea Lions

Steller sea lions prey upon some fish species that are also harvested by commercial, subsistence, and recreational fisheries (e.g. pollock, Pacific cod, Atka mackerel, salmon, and herring). Fishery removals have the potential to reduce the availability of these species to sea lions at a variety of spatial and temporal scales (NMFS 2000, 2001). Reduced prey availability can represent an acute or chronic threat to sea lion populations (Trites and Donnelly 2003). Acute prey shortages may lead to starvation while chronic (or sub-lethal) prey shortages have been shown in other mammals to reduce reproductive fitness, increase offspring mortality, and increase the susceptibility to disease and predation.

Immediately after listing in the early to mid-1990s, NMFS implemented a number of conservation measures intended to ensure that commercial harvests of pollock, Pacific cod, and Atka mackerel would not limit the recovery of Steller sea lions (Ferrero *et al.* 1994, Fritz *et al.* 1995). In addition to those direct actions, many other fishery management measures recommended by the NPFMC and implemented by NMFS may have indirectly contributed to Steller sea lion conservation efforts (see Section 4.5.7 below for a detailed list of actions).

In the late 1990s and early 2000s, NMFS reviewed federally managed groundfish fisheries in a series of consultations under section 7 of the ESA. Two of those consultations resulted in a determination that the commercial fisheries were likely to jeopardize the continued existence of the western DPS of Steller sea lion and adversely modify its critical habitat. Therefore, as required under the ESA, additional conservation measures were implemented to avoid jeopardy and adverse modification (NMFS 1998a, NMFS 2000). The expectation was that these measures would promote the recovery of Steller sea lions in areas where potential competition from commercial fisheries may have contributed to the population decline.

The implementation of conservation measures, in both the early 1990s and the late 1990s early 2000s, is correlated with a reduction in the rate of decline of the western DPS of sea lions. However, the information necessary to determine if the conservation measures actually contributed to the reduced rate of decline is not currently available.

A suite of fishery conservation measures was implemented in 2002 after being reviewed under an ESA section 7 consultation (NMFS 2001). These measures are described in detail in the 2001 Biological Opinion (NMFS 2001) and its Supplement (NMFS 2003). The measures were intended to reduce fishing in near-shore critical habitat, reduce seasonal competition for prey during critical winter months, and disperse fisheries spatially and temporally to avoid local depletions of prey.

The 2002 measures provided increased protection for near-shore critical habitat areas based on an analysis that closely examined satellite telemetry data and on information on foraging behavior, diet, nutritional stress, and population distribution. The analysis placed increased importance on near-shore critical habitat, specifically identifying those areas within 0-10 nm of listed haulouts and rookeries as more important for foraging sea lions than waters from 10-20 nm offshore.

NMFS (2003), re-evaluated each of the conservation measures after they had been implemented in 2002 and concluded that despite various levels of effectiveness in achieving specific goals, the conservation measures were, in aggregate, successful in avoiding jeopardy and adverse modification of critical habitat. A summary table of the effectiveness of each of the actions can be found in Table IV-1 of NMFS (2003). NMFS (2003) provides an in-depth review of each of the conservation measures, a review of the satellite telemetry data (available at the time), and an analysis of the important foraging areas for sea lions based on those data. Further, a summary of the federal fishery management measures that may have affected Steller sea lions is provided in NPFMC (2005a, 2005b) and described in this opinion in Chapter 2.

4.4.2 Recent Fisheries for Pollock, Pacific cod, and Atka mackerel

A description of catch rates and catch amounts of pollock, Pacific cod, and Atka mackerel is provided in Figures 4.21, 4.22, and 4.23. A thorough review of the recent fishery for these species was provided in NMFS (2003) and is incorporated here. NMFS (2003) provides estimates of catch by fishery, gear, area, and estimates of harvest rates. Also provided in Table IV-1 is a summary of the efficacy of the conservation measures (compared to their intended effect).

4.4.3 Evidence for Long Term Fishery Effects on the Environment

In Section 4.1 we investigated the north Pacific ecosystem, natural environmental change, and climate shifts, and explored some of the potential impacts of fisheries on those changes (Section 4.1). We also looked for climate shift signals in sea lion prey recruitment and abundance. In this section we explore recent modeling results which utilize more complex systems to assess ecosystem impacts of fishing.

4.4.3.1 Fishery Effects on the GOA Ecosystem

Bailey (2000) suggested potential connections between climate shifts, food web effects, and pollock recruitment in the GOA, but did not address potential fishing effects. Understanding Gulf of Alaska pollock production has been difficult for stock assessment teams since pollock became an important resource to domestic fisheries during the 1980s. Despite regulation of fishing mortality since that time, production (mainly pollock recruitment) has been unpredictable, and therefore has received considerable research attention in the attempt to correct this lack of predictive capability. Scientists searching for answers have often chosen either fishing or the “natural” explanations, but integration is rare. One potential physically mediated mechanism for changes in GOA pollock population dynamics has been suggested by Bailey (2000). Notably, the biomass trajectory of GOA pollock does not correspond directly to the regime shift of 1976-77; rather biomass peaks in 1981-82 and then declines to present levels roughly equivalent with the early 1970’s. This contrasts with the trajectories of several other exploited populations, notably flatfish such as arrowtooth flounder and Pacific halibut, which show a steady increase from the late 1970’s through the present, suggesting a connection, though not a mechanism, for climate regime control (Clark *et al.* 1999). Bailey (2000) suggests that pollock population dynamics are nevertheless related to the 1976-77 regime shift in an indirect way. He proposes that in the 1970’s, pollock recruitment was largely driven by larval mortality and that the regime shift increased plankton production in Shelikof Strait and throughout the GOA (there is no reference given for this critical phenomenon), leading to better larval survival and constantly improving pollock recruitment increasing population biomass. Then, after a 5-10 year lag the “ecosystem matured and the abundance of large predators built up,” thus increasing predation on the juvenile phase in the life history and countering the effects of (presumably still) increased larval survival, reducing recruitment and ultimately pollock population biomass.

One way to assess the relative effects of fishing and environmental effects including predation is with static and dynamic food web models including as many relevant ecosystem groups as possible. Gaichas (2006) used a dynamic ecosystem model to evaluate different hypotheses regarding the relative effects of fishing history, climate change, and predator prey interactions in determining biomass trajectories for important species in the Gulf of Alaska. The GOA dynamic ecosystem model is based on a food web model. The GOA food web model includes area- and time-specific production and consumption parameters based on research surveys and single species stock assessments that characterized the state of the system in the early 1990s. It also includes explicit juvenile groups for major groundfish and pinnipeds, and substantial taxonomic detail in benthos, pelagics, birds, and marine mammals. The GOA model includes 129 living groups (4 producer and 125 consumer), 5 detritus groups, and 15 fisheries. Fishery catches were reconstructed from NMFS Observer catch composition sampling data for groundfish fisheries, ADF&G catch statistics for salmon, herring, and crab fisheries, and International Pacific Halibut Commission (IPHC) research surveys and literature values for the halibut fishery. Details of model construction and parameterization for the GOA are documented in Gaichas (2006).

In the dynamic ecosystem model, twelve historical time series represented the dynamics of species groups ranging from Steller sea lions through commercial groundfish to pandalid shrimp. This background information was used to develop an experimental design which compares biomass and catch trajectories predicted from the ecosystem model with the twelve species time series from the Gulf of Alaska for six hypotheses of ecosystem control (Gaichas 2006).

In general, none of the results support the idea that the historical effects of fishing are reversible (Gaichas 2006; NMFS 2006b). Removing fishing mortality from populations initialized in the early 1990s and running the model without fishing for over 100 years did not produce populations "recovered" to pre-fishing biomass. It was necessary to both estimate specific predator-prey relationships and provide some form of increased historical production, in addition to removing fishing mortality, for populations to reach historical levels.

In all modeled hypotheses, fits for several groups were consistently poor. The high historical biomass of Steller sea lions is not produced by any hypothesis. However, some potentially important relationships between juvenile Steller sea lions and pollock were suggested by one of the better-fitting models which incorporated both fishing and our best information on environmental effects on herring, POP, and pollock production (recruitment). The consistent lack of fit to the historical portion of the Steller sea lion time series in all models has been observed in other studies, but results from the present study still provide insight into ecosystem relationships and potential fishery interactions for this protected species. The Steller sea lion time series is likely to represent sea lion biomass dynamics well, because the time series themselves are estimated from field sampling at the appropriate Gulfwide scale.

It is important to note that the biomass time series for juvenile Steller sea lions mirrors that for pollock, and is best explained in the model forced with pollock recruitment for the later portion of the time series from 1980-2002. The changes in juvenile biomass do not translate into changes in the adult population, however, most likely because the biomass of adults is so much larger that it absorbs these short term fluctuations. The early part of the series where biomass of juvenile and adult Steller sea lions was high is not explained by any model, suggesting that no mechanisms producing a high historical biomass of sea lions were implemented under any tested forcing hypothesis. This is consistent with the findings of another modeling study specifically designed to address the Steller sea lion decline (NRC 2003). In that study, the decline of Steller sea lions in Alaska could only be explained by including increased adult mortality, apparently from undocumented culling of these predators by participants in the fishery. The only other hypotheses supporting a realistic Steller sea lion decline involved increased mortality of small pelagic fish due to disease outbreaks, or decreased vulnerability of Steller sea lion prey as a result of the 1977 regime shift, for which no mechanism was identified (NRC 2003). The ecosim model used in the NRC hypothesis testing suffered from an unfortunate lack of precision in the inclusion of time series from both the Bering Sea and the Gulf of Alaska; for example, pollock biomass and recruitment time series from the Bering Sea were mixed with small pelagic and invertebrate time series derived from Anderson and Piatt (1999) which apply only to the GOA (and then only to the nearshore GOA as shown above). Given that Bering sea pollock biomass is an order of magnitude higher than GOA pollock biomass, and that Bering sea pollock biomass trends have been stable to increasing over the same period that GOA pollock sharply declined (Ianelli *et al.* 2005, Dorn *et al.* 2005), it seems possible that any relationship between pollock and Steller sea lions in the GOA might have been overlooked in the NRC analysis. The NRC report (2003) rightly concludes that the historical data which might support one of these population decline hypotheses over another was never collected, so the "true" explanation may never be revealed. While the present study was not designed to address Steller sea lion declines specifically, the inclusion of appropriate time series and parameters for the GOA does reveal a potential linkage between pollock recruitment and juvenile sea lions. The strength of this linkage may be important for fishery and protected species management, and because it is not dependent on unobserved historical events, research efforts may evaluate it further.

The results of Gaichas (2006) demonstrate that both environmental variation and historical fishing effects (and predator prey interactions) are necessary to explain historical Gulf of Alaska ecosystem dynamics, and even then some dynamics remain unexplained. Ecosystem modeling suggests that no single hypothesis explains all biomass time series, suggesting that in the GOA, there is no single main driver of the ecosystem. Both "top-down" control by fishing and "bottom-up" environmental effects either for individual species or for the entire system are necessary to explain ecosystem dynamics. Furthermore, different groups are best explained by different control hypotheses, which in turn imply very different predator-prey relationships within the ecosystem. Gaichas (2006) concluded that fishing, environmental change, and keystone species drive regime dynamics, and must be considered together. Further, while fishing clearly has effects in the GOA, fishing effects do not damp out all other ecosystem processes. It is difficult at this point to determine whether a fished ecosystem without clear fishing dominance to be ecologically healthier relative to those with a single dominant fishing driver. Clearly fishery management is necessary in a system with multiple drivers—and may be crucial to preventing fishing from becoming the dominant driver (NMFS 2006b).

4.4.3.2 Potential Food-Web Effects of Fishing

This section is divided into two parts; the first is an assessment of current relationships between Gulf of Alaska groundfish predators (including Steller sea lions) and pollock; and the second part presents the results of ecosystem modeling of the direct and indirect effects of removing fishing pressure.

In this analysis we model a fishery in which the harvest strategy is similar to the Council's "F40" harvest strategy, where the maximum permissible Allowable Biological Catch (ABC) is based on an exploitation rate for commercial groundfish which is intended to reduce the equilibrium spawning stock biomass to 40% of its presumed unfished biomass (Goodman *et al.* 2002). While several of the commercially important groundfish stocks are fished with this harvest rate, not all stocks are fished at this harvest rate for a variety of reasons related to data quality, assessment, and multispecies bycatch management. Furthermore, some stocks (halibut, herring, and salmon) are not managed by the Council and may have a different harvest rate. Therefore, we elected to use exploitation rates observed in 2005 fisheries even if some of these harvest rates would not result in the removal of 40-60% of a stock's biomass relative to unfished biomass at equilibrium, rather than attempting to estimate and simulate an F40 harvest rate for every fished species.

> **Competitive interactions between Steller sea lions and groundfish predators in the Gulf of Alaska (based on Dorn *et al.* 2005 and NMFS 2006b).**
>
> In the Gulf of Alaska, the top five predators on pollock greater than 20 cm by relative importance are arrowtooth flounder, Pacific halibut, Pacific cod, Steller sea lions, and the directed pollock fishery (Figure 4.24). For pollock less than 20 cm, arrowtooth flounder represent close to 50% of total mortality. All major predators show some diet specialization, and none depend on pollock for more than 50% of their total consumption. Pacific halibut is most dependent on pollock (48%), followed by sea lions (39%), then arrowtooth flounder (24% for juvenile and adult pollock combined), and lastly Pacific cod (18%). It is important to note that although arrowtooth flounder is the largest single source of mortality for both juvenile and adult pollock, arrowtooth depend less on pollock in their diets then do the other predators.
>
> The size preference of predators for walleye pollock varied by predator species. Pacific cod and Pacific halibut fed primarily on pollock greater than 30 cm fork length; this size range is similar to that published by Sinclair and Zeppelin (2002) for Steller Sea Lions. Arrowtooth flounder, on the other hand, primarily feed on fish between 10 to 30 cm long. Unlike the Bering Sea,

cannibalism is a relatively minor source of mortality for pollock in the Gulf of Alaska. It is notable that the three species that focus on adult pollock as prey (cod, halibut, and sea lions) all show biomass declines since the late 1980s as adult pollock biomass has declined, while arrowtooth flounder, feeding on the smaller pollock, have increased (Figure 4.25).

To better judge natural mortality, consumption was calculated for two size groups of pollock, divided at 30 cm fork length. This size break, which differs from the break in other ECOPATH analyses, is based on finding minima between modes of pollock in predator diets. This break is different from the transition matrices used in the stock assessment; perhaps due to differences in size selection between predators and surveys. For this analysis, it is assumed that pollock less than 30 cm are ages 0 to 2 while pollock greater than or equal to 30 cm are age 3+ fish.

Consumption of age 0 to 2 pollock, per unit predator biomass (using survey biomass), varied considerably through survey years, although within a year all predators had similar consumption levels. Correlation coefficients of consumption rates were 0.98 between arrowtooth and halibut, and 0.90 for both of these species with pollock. Correlation coefficients of these three species with cod were ~0.55 for arrowtooth and halibut and ~0.20 with pollock. The majority of this predation by weight occurred on age 2 pollock.

Plotted against age 2 pollock numbers calculated from the stock assessment, consumption/biomass and total consumption by predators shows a distinct pattern. In “low” recruitment years consumption is consistently low, while in high recruitment years consumption is high, but does not increase linearly, rather consumptions seems to level out at high numbers of juvenile pollock, resembling a classic “Type II” functional response. This suggests the existence bottom-up control of juvenile consumption, in which strong year classes of pollock “overwhelm” feeding rates of predators, resulting in potentially lower juvenile mortality in good recruitment years which may amplify the recruitment. However, this result should be examined iteratively within the stock assessment, as the back-calculated numbers at age 2 assume a constant natural mortality rate. Assuming a lower mortality rate due to predator satiation would lead to lower estimates of age 2 numbers, which would make the response appear more linear.

Consumption of pollock greater than or equal to 30 cm shows a different pattern over time. A decline of consumption per unit biomass is evident for halibut and cod. Arrowtooth shows a non-significant decline; it is possible that the noise in the arrowtooth trend, mirroring the consumption of less than 30 cm fish, is due to the choice of 30 cm as an age cutoff. As a function of age 3+ assessment biomass, consumption per unit biomass and total consumption remained constant as the stock declined, and then fell off rapidly at low biomass levels in recent years. Again, this result should be approached iteratively, but it suggests increasing predation mortality on age 3+ pollock between 1990 to 2005, possibly requiring increased foraging effort from predators.

There has been a marked decline in Pacific halibut weight at age since the 1970s that Clark *et al.* (1999) attributed to the 1977 regime shift without being able to determine the specific biological mechanisms that produced the change. Possibilities suggested by Clark *et al.* (1999) include the physiological effect of an increase in temperature, intra- and interspecific competition for prey, or a change in prey quality. The two species most dependent on pollock in the early 1990s (Pacific halibut and Steller sea lion) have both shown an exceptional biological response during the post-1977 period consistent with a reduction in carrying capacity (growth for Pacific halibut, survival for Steller sea lions). In contrast, the dominant predator on pollock in the Gulf of Alaska (arrowtooth flounder) has increased steadily in abundance over the same period and shows no evidence of decline in size at age. Given that arrowtooth flounder has a range of potential prey types to select from during periods of low pollock abundance, we do not expect that arrowtooth would decline simply due to declines in pollock.

Taken together, these results suggest that recruitment remains bottom-up controlled, even under the current estimates of high predation mortality, and may lead to strong year classes. However, top-down control seems to have increased on age 3+ pollock in recent years, perhaps as predators have attempted to maintain constant pollock consumption during a period of declining abundance. Thus, increasing competition for larger prey is consistent with the parallel declines of halibut, cod, and Steller sea lions. It is possible that natural mortality on adult pollock will remain high in the ecosystem in spite of decreasing pollock abundance.

The results presented above are taken from Gulfwide weighted averages of consumption; Steller sea lions and the fishing fleet are central place foragers, making foraging trips from specific locations (ports in the case of the fishing fleet, and rookeries or haulouts for Steller sea lions). Foraging bouts (or trawl sets) begin at the surface, and foragers attack their prey from the top down. For such species, directed and local changes in fishing may have a disproportionate effect compared to these results (Dorn *et al.* 2005, NMFS 2006b).

In contrast, predation by groundfish is not as constrained geographically, and captures are likely to occur when the predator swims upwards from the bottom. Changes in the vertical distribution of pollock may tend to favor one mode of foraging over another. For example, if pollock move deeper in the water column due to surface warming, foraging groundfish might obtain an advantage over surface foragers. Alternatively, pollock may respond adaptively to predation risks from groundfish or surface foragers by changing its position in the water column.

Potential effects of stopping all fishing using the ECOPATH model

To examine the relative role of pollock natural versus fishing mortality within the GOA ecosystem, a set of simulations were run using the ECOPATH model (Aydin *et al.* in review). Two approaches were taken to the modeling. First, sensitivity analyses were performed on the model to determine the relative importance of direct and indirect effects within the model. Secondly, projections were made under several ecological and fishing scenarios to attempt to examine the effects of fisheries removals.

Following the method outlined in Aydin *et al.* (2003), the sensitivity analysis indicated that the largest effects of declining adult pollock survival would be declines in halibut and Steller sea lion biomass. Declines in juvenile survival would have a range of population effects, including populations of halibut and Steller sea lion, but also releasing a range of competitors for zooplankton including rockfish and shrimp. The pollock trawl itself has a lesser effect throughout the ecosystem (fishing mortality is small in proportion to predation mortality for pollock); the strongest modeled effects are not on competitors for prey but on incidentally caught species, with the strongest effects being on sharks.

To address this question for the Gulf of Alaska ecosystem, NMFS performed a simulation analysis using the Gulf of Alaska dynamic ecosystem model parameterized with information from the early 1990's (Gaichas 2006, Aydin *et al.* in review). To determine what potential food web or cumulative effects of fishing might impact sea lion prey or the ecosystem as a whole, we compared predicted biomass trajectories for key species between two fishing scenarios: a "status quo" scenario where 2005 exploitation rates in all fisheries were continued for 100 years, and a "no fishing" scenario where all fishing was stopped for 100 years. The simulation includes an assessment of uncertainty, and considers alternative future production regimes for both pollock and primary production. The difference between the results from the "no fishing" scenario and the "status quo" scenario under each potential future production regime is intended to provide insight into broad potential food web or cumulative effects of fishing in the Gulf of Alaska ecosystem. In particular, we focus on results for pollock and Steller sea lions, as well as halibut, cod, and arrowtooth flounder. The groundfish species presented have been identified as potentially important structural components of the GOA ecosystem (Gaichas 2006). However, results are available for all groups in the ecosystem.

The GOA dynamic ecosystem model is fully described in Gaichas (2006) and Aydin *et al.* (in review). The initial food web model was built with the ECOPATH algorithms (Christensen *et al.* 2005). For the key groundfish species under analysis here, fully age structured population dynamics were implemented based on the life history "stanza" implementation of Ecosim (Walters and Martell 2004), with modified maturity accounting used to better match Gulf of Alaska groundfish. For most other species, the biomass dynamics equations described in Walters *et al.* (1997) were used to make forward projections. For this analysis, we included all fisheries operating in the Gulf of Alaska, including groundfish fleets, the halibut fishery, the herring and salmon fisheries, and the subsistence fishery which takes a small number of Steller sea lions each year. For more details on methods see NMFS (2006b).

NMFS attempted to discern the potential food web or cumulative effects of fishing the ecosystem as a whole by stopping fishing, allowing the ecosystem model to re-equilibrate with no fishing, and comparing equilibrium no fishing biomass levels with biomass at status quo fishing in ecosystem model simulations. Overall, the clear effects of fishing on the ecosystem are apparent only for top predators which are directly exploited, either as target species or as bycatch. It is less clear how fishing affects species with high predation mortality, and unfished species via prey interactions.

Under the no fishing scenario, while pollock increase between 5-10% for the first few years of the simulation (2006-2009), this is followed by a decrease back to the level of the status quo scenario; ceasing fishing within the ecosystem model has little or no effect on pollock standing stock in 50% of the modeled ecosystems (NMFS 2006b). This is due to the increase in predators as fishing ceases, the predators of pollock are able to absorb increases in biomass through increased predation. It is important to note that, as these confidence regions represent a range of whole ecosystems, there are ecosystems between the 50% and 95% intervals in which ceasing fishing causes pollock to increase (and decrease) substantially. This highlights the fact that, for some species, the single species F40 reference point does not mean that the cessation of fishing will result in a 40-60% increase in the standing stock of biomass; it is possible that this will simply redirect prey from fisheries to other predators.

There were two cases in which ceasing fishing has a predictable effect similar to single-species projections. Ceasing fishing on Pacific halibut and Pacific cod results in a 40-60% increase in those species. In both cases, as these are top predators within the ecosystem, there is little or no buildup of predators above them. For Steller sea lions, the model predicts that the cessation of fishing would cause Steller sea lions to increase in biomass (50% confidence intervals is between 2-10% increase). It is important to note that this effect, similar to that for pollock, is also dampened over time.

The effect of ceasing fishing (on all species) on arrowtooth flounder results in a definite downward for arrowtooth. This counterintuitive result is a reflection of indirect effects. Arrowtooth are lightly fished compared to their competitors such as cod and halibut; stopping fishing for all species greatly shifts the competitive advantage to those other species, thereby out-competing arrowtooth for prey.

The examination of the trophic relations reveals a great deal of uncertainty, as shown by the uncertainty of the projections (NMFS 2006b). However, some of the counterintuitive results can be seen against the background of overall uncertainty; namely, the limited increase of pollock under no fishing scenarios, reflects that many of the stock assessment reference points (e.g. F40) are reflections of historical conditions and not necessarily predictive of future ecosystem states.

An additional, important note from these results is that, on the scale of an entire large marine ecosystem, fish predators, with faster life-histories and greater area coverage, have a greater capacity to respond to prey releases than do central place foragers such as Steller sea lions. The results shown here represent fishing policies applied on the ecosystem scale; it is quite possible that spatially and temporally targeted fishing reductions (e.g. near haulouts) would direct more of the prey released towards Steller sea lions (NMFS 2006b).

Potential effects of stopping only pollock fishing using the ECOPATH model

The reaction of the pollock stock to a reduction or stoppage in fishing depends, in part, on how important predation is relative to fishing in causing pollock mortality at present (Figure 4.26). Using different modeling assumptions suggests a range of possible changes in pollock biomass if pollock fishing is reduced or stopped relative to continuing with status quo fishing for other species over the same projection period. Single species bars (blue) report differences between year 2018 projections for the no fishing (scenario 5) and author's recommended F (scenario 1 or 2) from 2005 stock assessments for each species, except for arrowtooth flounder which reported only a five year projection to 2010. Predation bars report differences between ecosystem model runs from the mid-1990s to the end of a 20 year period for two scenarios: no pollock fishery but other fisheries continue ("no pollock F", pink bars), and no fisheries for any species including herring, salmon, and all groundfish ("no F", burgundy bars).

The difference between the single species outcome for pollock and the ecosystem model outcomes has to do with the relative importance of fishing and predation mortality assumed in each model, and whether the fishery for pollock stops or all fishing stops. In the single species stock assessment model for pollock, natural mortality is assumed to be higher than fishing mortality (M = 0.3, F = 0.19 in 2005; Dorn *et al.* 2005). Therefore, in the single species assessment model, fishing mortality represents nearly 39% of total mortality for pollock. When this source of mortality is removed in the model, the pollock stock is predicted to increase by over 100% by 2018 relative to applying the author's recommended F over that same time period (which varies between 0.19 and 0.23, Dorn *et al.* 2005). In this model, it is assumed that fishing on pollock stops, which strictly may be interpreted as an end to all fishing which might catch pollock unintentionally. More commonly, the assumption is that the target fishery for pollock would stop, which in this case accounts for over 99% of all fishing mortality on pollock (2005 NMFS AKRO Catch Accounting System data, Terry Hiatt AFSC personal communication). Therefore, clarifying whether pollock fishing is reduced or stopped by stopping the pollock fishery or all fisheries is irrelevant in the single species case. We note that for most other groundfish, achieving F=0 implies shutting down more than just the fishery targeting that fish.

The outcome of stopping only the targeted pollock fishery in the ecosystem model results in a considerably lower predicted increase in pollock biomass than the single species assessment model predicts. After accounting for diets and consumption of predators in the ecosystem, we can confirm that the assumption that natural mortality exceeds fishing mortality is correct; however, the ratio of fishing to natural mortality is estimated to be quite different in the ecosystem model. The vast majority of adult pollock mortality is caused by predation; further, the vast majority of the predation mortality is caused by three groundfish predators: arrowtooth flounder (33% of total mortality), halibut (23%), and cod (16%; Figure 4.27). The pollock trawl fishery causes only 6.6% of adult pollock mortality, which is similar in magnitude to that caused by sablefish, Steller sea lions (adults and juveniles combined), and by pollock cannibalism. When the fishery on pollock is removed in the ecosystem model, just under 7% of mortality is removed, rather than nearly 39% as in the single species model. Therefore, the ecosystem model predicts that the pollock stock would increase by about 10% if the pollock fishery were to stop (but all other fisheries continued).

When all fishing is stopped in the entire ecosystem (burgundy bars in Figure 4.26), pollock biomass is actually predicted to decrease relative to status quo fishing. This apparently counterintuitive pattern is explained by the indirect effects of fishing on the system: a complete lack of fishing in the ecosystem increases predator biomass and therefore the predation mortality experienced by pollock. Because pollock are apparently predicted to experience more of an increase in predation mortality than the decrease in fishing mortality when all fishing is stopped, overall pollock mortality increases and their biomass decreases in a Gulfwide no fishing scenario.

Initial modeling results give similar results for the Bering Sea for pollock; both age-structured multispecies models (MSFOR) and ecosystem dynamics models (ECOSIM) give similar results, suggesting that pollock would only increase 10 to 20% with cessation of fishing, while single-species models produce increases of up to 60%. Part of this difference may be due to recruitment methodology; the single-species stock assessment model draws projected recruitment from density-independent past recruitment rather than assuming a stock-recruitment relationship.

4.4.4 Alaska State Managed Fisheries

Detailed information on fisheries in inside waters is contained in section 4.10 of the Groundfish SEIS, as well as in Kruse *et al.* 2000 and Woodby and Hulbert 2006. This section includes a brief review of those fisheries which may affect Steller sea lions, including:

- A description of the fishery management strategy including any special measures pertaining to sea lions,
- Recent changes in the spatial and temporal distribution of the fisheries, and
- A description of direct and in-direct sea lion interactions.

To this date there have been no studies specifically designed to address the effects of these nearshore fisheries on sea lions, so the information presented here is descriptive in nature. Significant changes in state waters fisheries since the 2001 opinion include an all-time high salmon harvest, the re-opening of several crab fisheries in the GOA, and a new Pacific cod fishery in the Aleutian Islands. This section describes recent changes in state waters including removal of greater volumes of sea lion prey biomass as well as other fish and invertebrate species from nearshore areas. Because the nearshore areas may be more important for sea lions than previously thought in NMFS (2000, 2001), and because some state fisheries are concentrated in time and space critical to sea lions (Woodby and Hulbert 2006), this suggests that state waters fisheries may have greater effects on sea lions than NMFS previously concluded (NMFS 2000, 2001).

ADF&G manages fishing activity occurring inside waters from shore to three miles seaward, herein referred to as state waters. Additionally, ADF&G oversees BSAI crab, salmon, lingcod, and some rockfish fisheries in Federal waters (EEZ – outside of three miles from shore). 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. The state retains regulatory jurisdiction over all fisheries within state waters.

State fisheries are managed by a highly localized system of regional offices throughout the state by species and area. Each region is responsible for issuing Guideline Harvest Limits (GHL), and providing in-season management of smaller-scale, localized fisheries. This is in contrast to the Federal fisheries which are composed of very large management units with relatively large harvest limits. Whereas the Federal fisheries use summer and winter surveys combined with stock assessment models to assess biomass and catch limits, the state employs a variety of methods of determining catch and biomass including stock recruitment models, aerial surveys, escapement goals, and historical fishery harvest performance. 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. Woodby and Hulbert (2006) expanded and updated this report to include changes between the 2000 report and the latest fisheries data available before the preparation of this document (2006). They also added information on the Pacific cod, pollock, and Atka mackerel parallel fisheries occurring inside state waters.

Seasonal and temporal distributions of state waters fisheries vary widely by species, area, and gear type, and are discussed in more detail in subsequent sections. These distributions are depicted in detail in Kruse et al 2000 for the year 1999, and in Woodby and Hulbert (2006) for the year 2005. Another descriptive reference is *Commercial Fisheries off Alaska* (Woody et al, 2005). The reader should consult these three references for a complete description of the fisheries. Only summary information is included here.

4.4.4.1 Potential State Fishery Interactions with Steller Sea Lions and Critical Habitat

Direct interactions between state managed fisheries and Steller sea lions involve both lethal and non-lethal impacts. Lethal impacts include sea lions inadvertently killed in fishing gear such as trawls, seines, and gill nets. Non-lethal 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 the incidental take of about 23 Steller sea lions per year (Angliss and Outlaw 2005). 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. On one hand, it might be low due to the lack of observer coverage in these fisheries, yet on the other hand this estimate is potentially biased high due to the very high estimate for a Prince William Sound gillnet fishery (Angliss and Outlaw 2005). There are no available estimates of the frequency or severity of non-lethal takes. Illegal shooting of sea lions by fishermen likely still occurs, but the number of animals affected is difficult to evaluate given the lack of observer coverage on these vessels. Loughlin and York (2001) estimated the mortality level from shooting at 50 sea lions per year, or more.

Potential indirect effects of state managed fisheries include the competition for prey resources and the modification of sea lion critical habitat. State fisheries remove important sea lion prey species, many fisheries are concentrated in space (usually bays or river outlets) and in time (usually spawning aggregations and salmon congregating near rivers for their return to spawning grounds in spring and summer).

The geographic range of state managed fisheries in state waters coincides almost entirely with the area designated as Steller sea lion critical habitat (Figure 2.14). To reduce interactions between sea lions and state managed fisheries, in 1999 ADF&G established no 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 3 nm 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. In 2004, ADF&G mirrored a federal change to open up several sea lion haulouts in the GOA. In addition, the BOF currently is currently entertaining proposals to permit fishing inside sea lion haulouts at its October 2006 meeting.

In an analysis of Steller sea lion diet, Sinclair and Zeppelin (2002) found that 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 (Table 3.21). 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 suggest that Steller sea lions, and especially pups and juveniles, spend the majority of their time in areas within 10 nm of shore (see Section 3.1.7). Because state fisheries are concentrated in time and space in these near shore waters, there is potential for negative effects on sea lion prey (critical habitat) and sea lion condition. Each state waters fishery is unique in its number of participating vessels, gear used, seasonality, duration, and/or target fish species. The next four sections describe state waters groundfish fisheries, herring fisheries, salmon fisheries, and invertebrate fisheries and their potential effects on sea lions.

4.4.4.2 State Groundfish Fisheries

State managed groundfish fisheries are relatively small in tonnage compared to the federally managed groundfish fisheries, 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. Parallel fisheries for Pacific cod, pollock, and Atka mackerel are also prosecuted in inside waters prior to the state-managed fisheries seasons, in many of the same locations. Total harvest volume in these fisheries is usually much higher.

In addition to Pacific cod and pollock, the state has established separate GHLs and seasons for the following fisheries in the western GOA: sablefish, lingcod, black rockfish *(Sebastes melanops)*, and blue rockfish *(S. mystinus)*. The state-managed fisheries for sablefish and Pacific cod occur within state waters, whereas the state has full management authority for lingcod and black and blue rockfish fisheries throughout the EEZ. In the Central GOA, state-managed fisheries in state waters also include sablefish and all rockfish species in state waters of PWS and lower Cook Inlet (LCI).

The Alaska Board of Fisheries (BOF) 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. Substantial areas of state waters are closed to non-pelagic trawling (Figure 4.28). 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 BOF to protect seafloor habitats, shellfish such as depressed crab populations, and non-target demersal fishes.

Under the ESA, groundfish fisheries are prohibited within 3 nm around major Steller sea lion rookeries (no-entry zones around major rookeries for all vessels; 50 CFR 223.202). The no-entry zones apply to state permitted fishing vessels as well as federal permitted fishing vessels. The rookery closures are intended primarily to avoid disturbance rookeries during the breeding season and to maintain a no-disturbance zone year-round to protect these very important breeding sites. The loss of a breeding site to human impacts could have a substantial impact on the population.

Although the 3 nm closures were designed specifically to protect sea lion rookeries, the closures have indirect effects of protecting bottom habitat which provides protection to non-target species including octopus, sculpins, flatfish, greenlings, and other forage fishes. 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.

Walleye pollock

Pollock is harvested in inside waters both in a state-managed fishery in PWS, and in parallel fisheries throughout state waters. The state managed PWS pollock fishery has been declining over the past 6 years. In 2005, most of the harvest occurred in early March inside sea lion critical habitat. The parallel fishery is much larger in volume than the state-managed fishery, and has increased since 2000.

The PWS fishery is based on a constant harvest rate strategy. Because reliable estimates of biomass and natural mortality are available, the PWS pollock stock falls into Tier 5 of the federal stock assessment strategy (see section 2.4.2). The GHL is calculated as the product of the biomass estimate, instantaneous natural mortality rate (0.3) and a “safety factor” of 0.75. Biomass is estimated by bottom trawl surveys in summer and hydroacoustic surveys of spawning aggregations in winter. In 1999 the BOF directed the ADF&G to file an emergency regulation establishing a PWS pollock trawl fishery management plan to reduce potential impacts on the endangered population of Steller sea lions. The plan divides the Inside District of (PWS) into three management sections 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 reduce competition for fish between the pollock fishery and sea lions. This measure was in lieu of closing two Steller sea lion haulouts that were specified to be closed under the 1998 Biological Opinion (NMFS 1998). Although pollock in the GOA are considered to be one stock, the state surveys pollock in PWS separately from NMFS surveys in the GOA. However, NMFS takes the PWS fishery into consideration when setting the GOA TAC.

The effects of the state managed pollock fishery on Steller sea lions is mitigated to some degree by existing restrictions on the fishery. The Prince William Sound outside district (including Wooded Island, Seal Rocks, Cape Hinchinbrook, and Hook Point) is closed to fishing (Figure 4.29). 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 PWS 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.

The parallel pollock fishery inside state waters in 2005 occured in Kodiak, Chignik, South Alaska Pennsula, and the Aleutian Islands. The Kodiak fishery peaked in February/March and then again in September/October and occurred throughout all Kodiak statistical areas. The Chignik fishery had landings in January and September and was concentrated south of Chignik at Seal Cape. In the South Alaska Peninsula, most landings occurred in January and October in the Shumagins and Pavlof Bay. The Aleutian Islands fishery landings were highest in July and August, and most harvest was taken at Unalaska Island. These fishery seasons have specific start dates according to the federal pollock fisheries. Most of the A season pollock TAC is taken in January, and then harvest peaks again in early fall when the new season allocation is obtainable. Most of this catch occurs inside sea lion critical habitat in the Kodiak, South Alaska Peninsula, and Aleutian Islands areas. The parallel harvest inside state waters has been between 20 and 40 times the volume of the state-managed PWS fishery in the past 6 years.

Pacific cod

In 1996, the BOF adopted Pacific cod FMPs for fisheries in PWS, Lower Cook Inlet, Chignik, Kodiak, and the South Alaska Peninsula. All five FMPs have some common elements that include: only pot or jig gear is permitted, pot vessels are limited to no more than 60 pots, jig vessels are limited to no more than five jigging machines, and exclusive area registration requirements. Vessels participating in the South Alaska Peninsula and Chignik areas are limited to no more than 58 feet in length. Catches are allocated to users as: 85% pot and 15% jig in South Alaska Peninsula and Chignik areas, 60% pot and 40% jig in PWS, and 50:50 in Kodiak and Cook Inlet areas. If target gear allocation percentages are not met by late in the season, then the unattained GHL becomes available to all gear types. State GHLs are set as a percentage of the federal TAC. State GHLs for PWS are set at 25% of the federal TAC for the eastern GOA. Similarly, up to 25% of the central GOA TAC is allocated among Chignik (up to 8.75%), Kodiak (up to 12.5%) and Cook Inlet (up to 3.75%). Finally, the state GHL for the South Alaska Peninsula fishery is set at 25% of the western GOA TAC. The fishery generally occurs in the spring following the Federal fishery, opening by regulation between 1 and 7 days after the federal fishery closes.

Pacific cod harvested in state waters in 2005 came from sea lion critical habitat in the South Alaska Peninsula (most harvest occurring in March), Kodiak (February through April), and Chignik (March through May) areas primarily, with smaller harvests in PWS and Cook Inlet. The temporal distribution of catch around Kodiak was more concentrated in 2005 from February through April as compared to 1999 when there was a more substantial fall component to the harvest.

In addition to the state managed fishery, the parallel Pacific cod fishery also occurs inside state waters and mostly inside sea lion critical habitat. In PWS, the 2005 parallel fishery was much more widely distributed than the state-managed fishery and most harvest was taken in April and August. A greater volume of Pacific cod was taken in the parallel fishery in Cook inlet in February and March and extends all along the outer coast from Resurrection Bay to the tip of the peninsula. The Kodiak parallel fishery was about equal in volume and spatial distribution to the state-managed fishery, but was mostly taken in January and late fall. A similar pattern emerges in the South Alaska Peninsula fisheries with most parallel harvest taken in January and February. The Chignik fisheries break this pattern in that the parallel fishery is very small in comparison to the state-managed fishery. There was no state-managed fishery for Pacific cod in the Aleutian Islands in 2005. The parallel fishery was spread along the chain and harvested most catch from February to April.

On March 15, 2006, the BOF approved the opening of a new state waters Pacific cod fishery in the Aleutian Islands west of 170W for pot, jig, longline, and non-pelagic trawl gears. This state-managed fishery opens after the parallel fishery closes. The 2005 GHL was 5807 mt, or 3% of the BSAI ABC. The fishery is temporally regulated so that no more than 70% of the GHL can be harvested before June 10, 2006, however, most of this was taken in March. The remainder of the GHL can be harvested starting June 10. Twenty-six vessel registered for the fishery, including 3 trawlers less than 60 feet, 17 larger trawlers, one large pot vessel, 5 large freezer longliners, 2 floating processors and 2 shore-based processors participated. Observer coverage and VMS are not required in this state-waters fishery, but 6 vessels chose to carry a federal observer, and 23 planned to activate VMS during the fishery.

Atka Mackerel

There is no state-managed fishery for Atka mackerel other than the parallel fishery that occurs inside state waters. The parallel Atka mackerel fishery is harvested with bottom trawl gear and has ranged between 12 and 88 mt from 2000 to 2005 (Woodby and Hulbert 2006). Because most state waters are closed to bottom trawling and Atka mackerel generally do not occur in the GOA, this fishery is largely confined to a few small locations in the Aleutian Islands, including Unalaska Island, Atka island, and the Islands of Four Mountains. These areas are inside sea lion critical habitat. Most landings occurred in June and August in 2005.

Other Groundfish

Sablefish, rockfish, and lingcod are not important in the diet of Steller sea lions, but fisheries for these species could cause indirect impacts to sea lion foraging behavior through disturbance. There are no specific measures to protect sea lions included in the state management plans for these species. Sablefish landings occurred inside sea lion critical habitat in PWS, lower Cook Inlet, and the western Aleutian islands in 2005. Landings occurred in March through May and August in PWS, in July in Cook inlet, and primarily May through August in the western Aleutian Islands. Most of the lingcod harvest in 2005 was taken in the Kodiak area, although catch occurred inside sea lion critical habitat in Kodiak, Cook Inlet, and PWS from July through October. Similarly, most rockfish harvest occurred around Kodiak Island, but harvest occurred inside sea lion critical habitat in PWS, Cook inlet, Kodiak, Chignik, South Alaska Peninsula, and the Aleutian Islands primarily from March through August.

Harvest of Steller Sea Lion Prey Species

The amount of groundfish prey species (pollock, Pacific cod, and Atka mackerel) harvested in the parallel fisheries is presented in Table 4.7. Although the amount of fish harvested in the 3 nm area around haulouts appears low, the amount of area composed inside 3 nm of haulouts in the GOA is roughly 0.5% of the total area. Catch percentages of up to 7.4% of total (pot, Pacific cod) represent a catch rate that is two orders of magnitude higher 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, very limited information is available on these fishing activities as compared to larger boats operating in federally managed waters that have observer coverage.

4.4.4.3 State Herring Fisheries

At present, state herring fisheries that occur within sea lion critical habitat include fisheries in Prince William Sound, Cook Inlet, Kodiak, Alaska Peninsula, Bristol Bay, Kuskokwim, Norton Sound, Southeast, and Port Clarence. Approximately 25 distinct fisheries for Pacific herring occur in these regions. Harvest methods are by gillnet, purse seine, and handpicking of roe from kelp. Herring are primarily caught for their roe during the sac roe harvest in the spring when they move closer to shore (and therefore sea lion critical habitat) to spawn. On occasion the entire allowable harvest has been taken in less than one hour, although most sac roe fisheries occur during a series of short openings of a few hours each, spanning approximately one week. Fishing is not allowed between these short openings to allow processors time to process the catch, and for managers to locate additional herring of marketable quality.

Prior to 1999, the average annual harvest of herring for sac roe was about 48,000 mt. During the past 5 years, harvest of herring for sac roe has been stable at around 22,000 mt. due to low abundance in some areas. The major populations of herring in Alaska are at moderate levels and in relatively stable condition, with the exceptions of Prince William Sound and Cook Inlet. Since 1999, the PWS fishery has been closed due to low abundance, and in 2006 the Exxon Valdez Oil Spill Trustee Council initiated planning for a long-term herring restoration program. The lower Cook Inlet fishery has been closed since 1998 due to low abundance. Herring harvest near Kodiak has increased during the last 6 years and is distributed throughout sea lion critical habitat. The fishery occurs in a concentrated time period from late April to early May.

Spawn-on-kelp fisheries harvest intertidal and subtidal macroalgae which contain freshly deposited herring eggs. Smaller amounts of herring are harvested from late July through February in herring food/bait fisheries. Herring spawn timing is temperature dependent, so that herring spawning and roe harvest timing occurs progressively later from southeast Alaska, where spawning begins in March, through the northern Bering Sea, where spawning ends in June. Herring food and bait landings in 2005 in the Alaska peninsula area were concentrated in the Akutan district inside sea lion critical habitat and occurred in late July. Smaller food and bait landings occurred in Kodiak in January, October, and December of 2005.

Harvest policies used for herring in Alaska set the maximum exploitation rate at 20% of the exploitable or mature biomass. The 20% exploitation rate is considered by ADF&G to be lower than commonly used biological reference points for species with similar life history characteristics. In some areas, such as Southeast Alaska, a formal policy exists for reducing the exploitation rate as the biomass drops to low levels. In other areas, the exploitation rate is similarly reduced, without a formal policy. In addition to exploitation rate constraints, minimum threshold biomass levels are set for most Alaskan herring fisheries. If the spawning biomass is estimated to be below the threshold level, no commercial fishing is allowed. Threshold levels are generally set at 25% of the long-term average of unfished biomass (Funk and Rowell 1995).

Most herring fisheries in Alaska are regulated by management units or regulatory stocks (i.e., geographically distinct spawning aggregations defined by regulation). Those aggregations may occupy areas as small as several miles of beach or as large as all of Prince William Sound. Herring sac roe and spawn-on-kelp fisheries are always prosecuted on individual regulatory stocks. Management of food and bait herring fisheries can be more complicated because they are conducted in the late summer, fall, and winter when herring from several regulatory stocks may be mixed together on feeding grounds distant from the spawning areas. Where possible, the BOF avoids establishing bait fisheries that harvest herring from more than one spawning population.

Interactions Between Herring Fisheries and Steller Sea Lions

Herring fisheries may affect sea lions or their critical habitat when vessel activity interferes with sea lion foraging, reduces prey availability, or alters long term herring biomass. 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; Angliss and Outlaw 2005). Steller sea lions are attracted to areas where herring spawn to feed on the dense aggregations of herring present during the short spawning period. Observations of Steller sea lions in Prince William Sound indicate that sea lions may target herring despite the presence of much greater abundance of pollock (Thomas and Thorne 2001). These results suggest that under some conditions (e.g., when highly aggregated in shallow water), herring (or other high lipid fish) may be an important prey resource for sea lions (Sigler *et al.* 2004, Womble and Sigler 2006).

Because of the variability in the timing of herring spawn, fishery managers have learned to depend on the presence of Steller sea lions to determine when 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. 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 may avoid these fishing areas due to the intense vessel activity, nets, and other hazards (e.g. shooting or other harassment). Sea lions that do choose to forage in these ares may have higher stress levels involved with avoiding vessels, gear, and dealing with noise, yet may appear to be foraging effectively but at an increased metabolic cost.

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 2002), 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 4.30. 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.

Sea lions 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.

4.4.4.4 State Salmon Fisheries

The state salmon fishery includes five species: chinook, sockeye, coho, pink, and chum. These fisheries are divided into southeast, Prince William Sound, Cook Inlet, Bristol Bay, Kodiak, Chignik, Alaska Peninsula, Kuskokwim, Yukon, Norton Sound, and Kotzebue management areas. The PWS, Kodiak, Chignik, and Alaska Peninsula areas report substantial harvest inside sea lion critical habitat in 2005 (Woodby and Hulbert). Salmon are taken by purse seines, gill nets, trolling, and beach seining via an extensive small boat fleet. The catch in 2000 was about 135 million fish, but Alaska's salmon landings reached an all-time high in 2005 of 221.9 million fish primarily due to high pink salmon catches, healthy salmon stocks and improving world-wide markets for wild fish. Economically, the salmon fishery is worth more than all other state fisheries combined.

Landings have increased for all salmon species except chum, and are trending towards a more temporally concentrated distribution earlier in the summer. Kodiak purse seine landings were twice as high in July and August of 2005 as compared to 1999, with more catch inside sea lion critical habitat. Chignik purse seine landings were concentrated earlier in June and July. Similarly, the South Alaska Peninsula (SAP) drift gillnet landings were more temporally concentrated in June as opposed to lasting into September as in 1999. SAP purse seine catches also peaked earlier in the summer.

The fisheries are managed for minimum escapement goals, where regional ADFG biologists have determined what level of escapement seems to produce the maximum yield per year. These methods have not been standardized, and range from aerial flights to determine if the streams are "full" to fish weirs and remote sonar counters. The timing of the fisheries corresponds with the various spawning time for each run, which is highly variable and which is managed on a stream by stream basis.

State managed salmon fisheries have direct impacts on Steller sea lions through the interaction of gear. 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. Sinclair and Zeppelin (2002) found that Pacific salmon were the third most dominant fish in the diet of Steller sea lions, based on scats observed from 1990 to 1998 on summer and winter island sites across the range of the western stock of sea lions. Sinclair and Zeppelin (2002) 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.

The cumulative effect of early summer fisheries described above could affect sea lions during an important weaning period for juveniles and leading up to the birth of pups. 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. The salmon escapement goals limit the commercial harvest to the surplus above the amount 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.

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.

4.4.4.5 State Invertebrate Fisheries

ADF&G manages fisheries for several species of crab, shrimp, scallops, and sea cucumbers inside sea lion critical habitat. Invertebrates are not important in the diet of Steller sea lions, but the fisheries could cause indirect impacts to sea lion by influencing sea lion foraging behavior due to disturbance. No specific measures to protect sea lions are included in the state management plans for these species.

Since 1999, tanner crabs stocks have recovered enough to re-open fisheries in Kodiak, Chignik, South Alaska peninsula, eastern Aleutian Islands, and the eastern Bering sea management areas. Thus, new effort and therefore increased vessel traffic is now occurring in the south Alaska peninsula, Kodiak, and Chignik areas of sea lion critical habitat primarily in January.

In 2005, Dungeness crabs were harvested inside sea lion critical habitat around the east side of Kodiak and the South Alaska Peninsula. Harvests are highest in late summer peaking in July, August, and September. Crab rationalization in 2005 for king and tanner crab stocks in the BSAI provides for a prolonged harvest season, given that fishermen can fish their quota when they desire. The 2005 to 2006 harvest of golden king crab in the Aleutian Islands within critical habitat started in the eastern Aleutian Islands in August, peaking in September and October, and then shifted to the western Aleutians where harvest remained low through March.

Other invertebrates harvested in state managed fisheries inside sea lion critical habitat include shrimp, scallops, and sea cucumbers. These species, like the crab species discussed above, are not important components of the sea lion diet, but fisheries for these species could cause indirect impacts to sea lion foraging behavior through disturbance caused by vessel traffic. Small volume shrimp trawl fisheries were prosecuted in 2005 in PWS and Kodiak inside critical habitat from April through September.

In May of 2000, 6 of 9 federal license holders formed the North Pacific Scallop Cooperative, and effectively reduced the number of participating vessels and prolonged the season. In 2005, scallop harvest occurred in critical habitat around Kodiak starting in July, but continuing into December.

4.4.4.6 Summary of State Fisheries

State managed fisheries represent a substantial influence on the near-shore marine ecosystem in Alaska. Both parallel and state managed groundfish fisheries occur almost entirely within sea lion critical habitat (inside 3 nm). Because management of these fisheries is done on a regional basis, it is difficult to describe the overall impact of these fisheries on Steller sea lions or their critical habitat, although efforts such as Kruse *et al.* (2000) and Woodby and Hulbert (2006) are quite helpful. Most activity that occurs within state waters, including harvest and vessel traffic, occurs within sea lion critical habitat.

The parallel fisheries for pollock, Pacific cod, and Atka mackerel are by far the largest fisheries within state waters by weight. The pollock harvest is an order of magnitude larger than the state managed fishery. Parallel Pacific cod landings are greater than state managed landings everywhere except the Chignik area. Atka mackerel is currently not harvested in a state managed fishery.

Fisheries for Pacific cod, pollock, Atka mackerel, salmon, and herring occur throughout the year. According to Woodby and Hulbert (2006), Pacific cod is harvested in nearshore waters from January through May, pollock is harvested in January and early fall, and Atka mackerel is fished in the summer. Salmon harvest was at an all-time high in 2005, and was highest in June, July and August. The herring sac-roe fisheries occur in April and May, while food and bait fisheries occur periodically throughout the year.

Fisheries for species other than pollock, Pacific cod, and Atka mackerel could potentially affect Steller sea lions due to vessel noise, disturbance, pollution, and ecosystem level effects. Fisheries for other groundfish, including sablefish, lingcod, and rockfish, occur primarily in the summer inside critical habitat. Additionally, fisheries for several invertebrate species also occur inside state waters. Crab, shrimp, scallop, and sea cucumber fisheries all occur inside critical habitat. Tanner crab fisheries have reopened and occur in January, while Dungeness crab are harvested in late summer, and Aleutian Islands golden king crab are taken in the winter. Scallops were taken July through December of 2005, and small volumes of shrimp were taken in trawl fisheries from April through September. Kodiak Island in particular has a high level of fishing activity for groundfish and invertebrates year-round (Woodby and Hulbert 2006) which could result in changes to the sea lion prey field year-round.

4.4.5 Direct Effects of Commercial Fisheries on Steller Sea Lions

Commercial fisheries can directly affect Steller sea lions in the BSAI, and GOA by capturing , injuring, or killing them in fishing gear or in collisions with fishing vessels, and if fishermen kill them intentionally. These impacts were described in detail above in Sections 4.3.3 (incidental take in commercial fisheries), 4.3.4 (intentional and illegal killing), and in 4.3.7 (disturbance). In general, the current level of direct impact to Steller sea lions is relatively small (see summary in Section 4.3.10). However, it is likely that historical direct impacts influenced the rapid decline rate observed in the 1980s, but by the mid-1990s was no longer an important factor in the decline and lack of recovery.

4.4.6 Indirect Effects of Commercial Fisheries on Steller Sea Lions

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; the ultimate impact to sea lions would be either acute or chronic nutritional stress.

The survival of large predatory mammals such as Steller sea lions is dependent on the availability of abundant, high quality prey (Stephens and Krebs 1986, Williams 2005a,b; see Section 4.6 below). Due to the high energetic demands of Steller sea lions relative to terrestrial mammals and the large number of sea lions seasonally concentrated on rookeries, this species may be especially vulnerable to reduced prey biomass and quality (Winship and Trites 2003, Williams 2005a). As a result, natural and anthropogenic factors that substantially influence prey availability, particularly during critical life history stages (e.g., pregnant females with a nursing pup, or recently weaned juveniles), have the potential to affect Steller sea lion vital rates and impede their survival and recovery.

A reduction in prey resources may result in a reduction in population growth rate, and a lower carrying capacity. Specifically, reduced prey availability can lead to physiological responses by sea lions that directly (e.g., reduced natality) or indirectly (e.g., increased mortality from predators due to increased foraging) reduces their population growth. A sustained reduction of prey resources across a broad geographic region (i.e., ecosystem) would thus reduce the carrying capacity of sea lions. These impacts have generally been referred to as nutritional stress (see Section 3.1.15).

4.4.6.1 Overview of Potential Fisheries Effects

Management measures to address potential fishery effects on Steller sea lions were first promulgated in 1991 to 1993, and then extensively modified between 1998 and 2002 (Fritz *et al.* 1995, NMFS 2003). The measures included: spatial and temporal allocations of harvest quotas to reduce the likelihood of localized depletions of groundfish prey, fishery exclusion zones to limit spatial overlap between fisheries and sea lions within critical habitat, and modified harvest control rules to reduce the likelihood of overall prey abundance being reduced to less than 20% of pristine levels. NMFS (2001, 2003) concluded that the suite of management measures proposed avoided jeopardy and adverse modification of critical habitat. However, since 2003, a substantial quantity of literature on Steller sea lion biology, habitat, and fisheries has become available (Loughlin and Tagart 2006). The purpose of this section is to review the general indirect impacts of fisheries to the baseline for Steller sea lions and their critical habitat. A more thorough review of specific effects will be discussed in Chapter 5 (Effects of the Action).

Steller sea lions eat a wide variety of marine fish and cephalopods, some of which are densely schooled in spawning, migratory, or feeding aggregations (Sinclair and Zeppelin 2002; Table 3.21). The abundances of many of the primary prey species of Steller sea lions have undergone changes during the past 30 years (NRC 1996, 2003, NPFMC 2005a, b). Thus, during the period of decline of Steller sea lion populations in the western DPS, many primary prey species increased in abundance, while others decreased or remained relatively stable (e.g., arrowtooth flounder increased while GOA pollock decreased). Several factors have been implicated in these changes in prey biomass for Steller sea lions: 1) natural or environmental variability, 2) anthropogenic (fisheries) affects, and 3) ecosystem disruption resulting in inter-specific competition (Anderson and Piatt 1999, Trites *et al.* 1999, Benson and Trites 2002). These factors may act individually or collectively to affect the availability of prey for Steller sea lions.

Fishing can affect the availability of prey on localized and ecosystem-wide scales (Trites *et al.* 2006e), which is of concern for the stability and recovery of Steller sea lion populations (Lowry *et al.* 1982). Fisheries in Alaska are some of the largest in the world. In 2005, over 2 million metric tons of groundfish were caught in the BSAI and GOA (Tables 2.5 and 2.6), which is equivalent to a harvest rate of approximately 10% (Table 3.7 and Figure 4.21). Fishing has the potential to affect Steller sea lion recovery in several ways, including overall ecosystem-wide reductions in prey biomass, local and temporal depletions of prey, and reduced quality (size, age and caloric value) of individual prey by selective removal of larger, older individuals (Goodman *et al.* 2002, Trites *et al.* 2006e).

Many fisheries in the North Pacific are managed using a maximum sustainable yield (MSY) single-species strategy. MSY is based on the assumption that production of fish recruits, on average, is in excess of the level needed for replacement and that fisheries can remove the surplus of adults without jeopardizing future stock recruitment. Fishing mortality rates (F) set using single-species, MSY methodologies are designed to maximize yield (weight of catch) before it is lost to natural mortality (M) and minimize the likelihood of overfishing the target stock. Fishing at $F_{40\%}$ will, over the long run, reduce the average spawning stock size to 40% and total biomass to approximately 50% of their theoretical pristine levels (using single-species assessments).

While single species catch quotas are set for relatively large management areas (e.g., the Gulf of Alaska), individual vessels that fish for these species work in discrete areas. The potential for fisheries to reduce local abundances of fish was shown for Atka mackerel (Lowe and Fritz 1997) and Pacific cod fisheries (Fritz and Brown 2005) where local, short-term harvest rates were much greater than the annual target harvest rates on the stocks as a whole, and for pollock (NMFS 2006b) where fisheries were shown to result in a significant reduction in biomass. Many of the areas fished by the Atka mackerel fishery in the Aleutian Islands and all of the Pacific cod fishery data analyzed by Fritz and Brown (2005) were collected within designated sea lion critical habitat. Statistical and correlative analyses of fishery effort/catch with trends in local sea lion populations have yielded equivocal results, some indicating a positive and some a negative relationship between catch and sea lion population trends (Loughlin and Merrick 1989, Ferrero and Fritz 1994, Hennen 2006, Wolf and Mangel 2005, Dillingham *et al.* 2006, NMFS 2006b). The utility of these analyses is diminished by issues of temporal and spatial scale mismatch between the treatment (magnitude of fish catch around a rookery) and response (population trend at that rookery), since animals breeding at a particular rookery range much farther during the year than the area encompassed by the catch data. Hennen (2006), found significant positive relationships between several metrics of fishing and the steep rates of population decline in the 1980s. This relationship vanished in the 1990s, leading to the conclusion by Hennen (2006) that measures taken in the early 1990s (e.g., trawl exclusion zones, spatial-temporal management, shooting ban, reduction in incidental catch) may have been effective in slowing the decline. Given the relatively long generation time for Steller sea lions, we would expect there to be a time lag in response to improved conditions.

Fisheries generally target larger, older individuals. As a result, a fished population will be composed of smaller, younger individuals, and have a smaller average size and age than an unfished population of the same species (NMFS 2000, Walsh *et al.* 2005, Trites *et al.* 2006e, NMFS 2006b; see Figures 4.31 and 4.32). These fishery-related changes may have two consequences for foraging sea lions. First, the distribution of fish within the water column and geographically, which often correlates with age (Ianelli *et al.* 2005), will be altered in a way that potentially affects availability to foraging sea lions. Second, a reduction in the average size of individual fish will reduce the per capita energy content and may necessitate increased foraging effort by sea lions to obtain the equivalent amount of energy in a larger number of small fish (Calkins and Goodwin 1988, NMFS 2000, NMFS 2006b).

The objective of fisheries management measures implemented in 2002 (NMFS 2001, 2003) was to mitigate potential adverse effects of fisheries on Steller sea lions and their critical habitat. These measures were intended to address both ecosystem-level effects (e.g., biomass reduction) as well as the temporal and spatial effects of fishing by raising minimum fish stock size thresholds ($B_{20\%}$), reducing fishing in near-shore portions of critical habitat, reducing seasonal competition for prey, and reducing the likelihood of fishery-related localized prey depletions. The spatial-temporal fishery management measures were based largely on an analysis of the at-sea distribution of sea lions recorded by satellite linked time-depth recorders. The analysis led to the development of a “zonal approach” to management for the 2002 measures (NMFS 2001, 2003), in which near-shore portions of critical habitat were considered more important to foraging sea lions than offshore areas. However, as previously acknowledged by NMFS, most of the data used in the telemetry analysis was collected from juvenile sea lions less than 2 years of age, many of which were likely not completely weaned. As a consequence, the foraging habitat of adult animals, particularly females, is underrepresented in the telemetry data that was considered in the development of management measures in 2002 (NMFS 2003).

Impacts of fisheries on Steller sea lion foraging success will depend on spatial, temporal, and targeted species overlap for which few data is currently available (Baraff and Loughlin 2000). The potential for competition between fisheries and Steller sea lions, as indicated by energetic models, differs for each prey species considered. For instance, the estimated consumption of gadids based on the energetic demands and diets of wild sea lions was 179,000 ± 36,700 t in all regions of Alaska in 1998. This represented approximately 12% of the total commercial catch (Winship and Trites 2003). In the same study, it was estimated that Steller sea lions consumed a total of 104,000 ± 20,600 t of Atka mackerel in 1998, but this was equivalent to 181% of the fishery catches off Alaska. At this level, Steller sea lion predation would have also accounted for a large proportion of the total natural Atka mackerel mortality. NMFS (2001) also looked at consumption rates, and found similar results, such that the Aleutian Islands contain only about 24% of the needed biomass to sustain Steller sea lions, and that the GOA contained only 37% (see Section 3.1.9). Further, harvest in local areas was also reviewed (NMFS 2003; their Table III-7), with generally low harvest rates inside 0-10 nm of critical habitat (harvest rate of 2.3% for pollock, Pacific cod, and Atka mackerel).

The amount of prey available for sea lions is rarely known with confidence in the areas (and seasons) 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 (i.e., Aleutian Islands pollock, see Section 4.1.4.3).

4.4.6.2 Competition: Prey Species

Fisheries may compete with sea lions if they remove the same species of fish. Our knowledge of Steller sea lion prey use is largely through the collection and analysis of scat samples and historically through stomach contents (Sinclair and Zeppelin 2002; Table 3.20). In NMFS (2000, 2003), 14 species (or species groups) were of concern in the BSAI and 15 species in the GOA (see Table III-1 in NMFS 2003) to potentially be affected by the federal groundfish fisheries. Sinclair and Zeppelin (2002) assess the importance of various species by area and season. Steller sea lions rely on a variety of prey resources with pollock, Pacific cod, Atka mackerel, salmon, herring, sand lance, and arrowtooth flounder representing the most common species. Sea lions are opportunistic predators which rely on seasonal aggregations of prey resources in predictable locations and quantities.

Sea lion diet likely reflects the availability of prey and their ability to take advantage of it. Although we are limited in the locations and times that we have sampled sea lion diets (stomachs or scats), diet likely reflects local availability and vice versa. The Aleutian Islands represent a good example of this foraging pattern. In the Central and Western Aleutian Islands, the average frequency of occurrence of pollock in winter was only 12% while Atka mackerel appears to have been the primary food source for sea lions (found in 55% of scats in winter and 96% in summer; Table 3.21). Sinclair and Zeppelin (2002) point out that although some of the food items had a low frequency of occurrence (FO) when averaged across all samples, some had higher occurrences when looked at during specific seasons or at specific sites (Sinclair and Zeppelin 2002, their Appendix 1). Specifically, areas within the eastern Aleutian Islands seem to be more dependent upon pollock with a FO of 53% in winter. In NMFS (2006c [formal section 7 consultation on AI EFP]; their Table 9), the FO is provided for various cites near Adak in the central Aleutian Islands (from Sinclair and Zeppelin 2002; their Appendix 1). Pollock ranked among the top three prey species at both Kasatochi Island (summer) and at Ulak Island (summer), both of which are rookeries in the Central Aleutian Islands. Table 10 (of NMFS 2006c) describes the prey items found in scats at Adak, Amlia, and Kasatochi in 1999 and 2000, and Table 11 (of NMFS 2006c) describes scats at a variety of sites in the central Aleutian Islands since 2001. In general, Atka mackerel was the dominant prey item found, especially during the summer. Pollock was more important in the diet during the winter but was also found at some sites during the summer (NMFS 2006c; Tables 10 and 11, Figure 9). In the most recent samples collected during the winter in 2002, pollock was between 8% and 46% FO at Seguam and Silak. In these samples pollock was much more important in the diet than the average values reported above and likely represent the local availability of prey as well as the variability in sampling times. Season appears to be an important consideration as pollock was most often in the diet of Steller sea lions during the winter.

NMFS (2006c) concluded:

> *In summary, pollock is an important prey item for Steller sea lions in the Aleutian Islands, especially in the eastern portion of the area and in other locations where pollock may be available in relatively small aggregations, especially in winter. Based on the differences in the occurrence of pollock in scat samples, pollock may be more important to Steller sea lions using the Atka Island/North Cape haulout than for animals using haulouts near Kanaga Sound. The variability of pollock in the diet of sea lions is likely to be linked to the availability of the prey and is likely to reflect similar patterns as the fishery. Harvest of pollock in the Aleutian Islands has*

> *been patchily distributed with some locally high harvest amounts due to dense aggregations of pollock nearshore during spawning. Due to the remoteness of the Aleutian Islands, scat is not frequently collected at many sites which further confounds our ability to draw a clear picture of prey utilization in these areas. From the best information available, pollock is likely to be an important component of Steller sea lion diet in the winter but not during the summer (Tables 10 and 11; Sinclair and Zeppelin 2002). Also from the 2001 Opinion, we know that the ratio of prey biomass available to the biomass consumed by sea lions is the lowest in the Aleutian Islands, and may be lower than what is optimal for their survival (NMFS 2003, their Table III-8). This indicates that sea lions in the Aleutian Islands may be more susceptible to perturbations in the prey field than other areas such as the eastern Bering Sea.*

Thus, we cannot equate average FO over large areas as a good representation of important prey species at individual haulout sites and the potential for competition with fisheries on that scale. What is likely to be most important is the local availability of prey, likely consumption by local sea lions, and the potential for localized depletion (NRC 2006).

4.4.6.3 Competition: Size and Depth of Prey

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 or other predators. The degree of overlap in the sizes of groundfish taken by Steller sea lions and by the various groundfish fisheries is considerable for pollock, Pacific cod, and Atka mackerel (see Section 3.1.8.2). 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 (Tollit *et al.* 2004b, Zeppelin *et al.* 2004). Second, much of the information presented in the scientific literature on sizes of prey taken by sea lions or fisheries has been based on the relationship between otoliths (or other hard part) size and the total length of prey. Inferences on the relative importance of prey to sea lions using the occurrence in scat data is misleading, as dietary value is determined by biomass consumed and the energy content of that fish (at the time it was taken). That is, sea lions may gain a great deal more nutrition (energy) from consumption of a single large prey item (in a particular season) than from the consumption of multiple small prey items and, therefore, number or occurrence, is not necessarily the best indicator of dietary value and may underestimate the importance of larger, or more energy rich prey.

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.

4.4.6.4 Competition: Seasonal Timing and Sea Lion Age Class

Changes in behavior, foraging patterns, distribution, and metabolic or physiological requirements during the Steller sea lion annual cycle (Figure 3.22) are all pertinent to consideration of the potential impact of prey removal by commercial fisheries. Steller sea lions, at least adult females and juveniles, are unlike other marine mammals that store large amounts of energy (fat) to allow extended periods of fasting. Sea lions need more or less continuous access to food resources throughout the year. Nevertheless, the sensitivity of sea lions to competition from fisheries may be higher 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 increased by harsh environmental conditions.

Behavioral observations indicate that lactating females spend more time at sea during winter than in the summer. Attendance cycles (consisting of one trip to sea and one visit on land) averaged about 3 days in winter and 2 days in summer (Trites and Porter 2002, Milette and Trites 2003). Time spent on shore between trips to sea averaged about 24 hours in both seasons. The winter attendance cycle of dependent pups and yearlings averaged just over 2 days, suggesting that sea lions do not accompany their mothers on foraging trips. Foraging trips by mothers of yearlings were longer on average than those by mothers of pups.

Weaned pups may be independent of their mothers, but may not have developed adequate foraging skills. They must learn those skills, and their ability to do so determines, at least in part, whether they will survive to reproductive maturity. This transition to nutritional independence is likely confounded by a number of seasonal factors. Seasonal changes may severely confound foraging conditions and requirements; winter months bring harsher environmental conditions (lower temperatures, rougher sea surface states) and may be accompanied by changing prey concentrations and distributions (Merrick and Loughlin, 1997). Weaned pups' lack of experience may result in greater energetic costs associated with searching for prey. Their smaller size and undeveloped foraging skills may limit the prey available to them, while at the same time, their small size results in relatively greater metabolic and growth requirements.

Other times of the year are also important for Steller sea lions. For example, the observed increases in consumption by captive animals in the fall months indicate that preparation for winter is important. Spring is also important as pregnant females will be attempting to maximize their physical condition to increase the likelihood of a large, healthy pup (which may be an important determinant of the subsequent growth and survival of that pup). Similarly, those females that have been nursing a pup for the previous year and are about to give birth may wean the first pup completely, leaving that pup to survive solely on the basis of its own foraging skills. Thus, food availability is surely important year-round, although it may be particularly important for juvenile animals and pregnant-lactating females during the winter.
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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), and with season being a better predictor of body condition than the quality of prey consumed (Calkins *et al.* 2005). Further, prey diversity may be lower in the winter (Sinclair and Zeppelin 2002, Trites *et al.* 2006d). 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 idea that the fall and winter period is a time of high metabolic demand, and supports the importance of prey availability 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 pregnant-lactating females in the winter and for juveniles during the summer and fall.

4.4.6.5 Competition: Location and Depletions of Prey

Information about the potential impacts of trawl fisheries (and other gear types) on sea lion prey is mixed (NMFS 2006b). Since the last formal consultation on the fisheries (NMFS, 2003), NMFS has conducted experiments to determine whether trawl fisheries do in fact alter the prey field. For pollock fisheries, of the two years that the experiment was successfully completed, one year resulted in a change to the prey field and one year did not. Mixed results were also found for the Atka mackerel fishery in the Aleutian Islands (testing of closure areas), while no indication of localized depletion was found for the Pacific cod fishery in the Eastern Bering Sea experiment. However, conclusions based on the Pacific cod study conflict with an analysis of the Pacific cod fishery using winter survey data from 2001 (Fritz and Brown, 2005).

4.4.6.6 Competition: Gear Types

Numerous gear types have been used for fishing 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 (hook-&-line), and large catcher processors. Descriptions of these fisheries are outlined in detail in the Groundfish SEIS.

In an analysis similar to NMFS (2001; their section 5.3.1.6 and Figures 5.1 and 5.2), observer data was used to describe concentration in time and space for BSAI trawl, pot, and hook-&-line fisheries (Figure 4.33). In this analysis, the timing of catch was linked to the 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 to have the highest proportion of their catch in cells with high catch rates. Pot gear had less of a proportion in those high catch rate cells, whereas hook-&-line gear had the highest proportions of catch in the lowest catch rate bins (Figure 4.33). These data suggest that the hook-&-line fishery is more dispersed than the trawl fishery, and may be less likely to cause localized depletions of prey. However, the critical link between fisheries removals (time, rate, location, etc.) and the effects on sea lions is poorly understood and we cannot determine the relationship between these catch rates and the impacts on prey except that higher catch rates would be more likely to result in localized depletions (or prey field effects) as described by NMFS (2006b). Some published papers (Lokkeborg *et al.* 1989, Lokkeborg 1998, and Lokkeborg and Ferno 1999) have looked at the effects of gear such as hook-&-line on the distribution and abundance of fish species. Hook-&-line fisheries appear to be more dispersed in both time and space - one of the fishery components which would reduce the likelihood of resulting in adverse modification of critical habitat (NMFS 2001, 2003). The likelihood of jig gear resulting in localized depletions is 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.

4.4.6.7 Interactive Competition: Disturbance of the Prey Field

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 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, pollock, Pacific cod, and Atka mackerel are very important in the diets of Steller sea lions, although they prey on a variety of other species. 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 (NMFS 2006b).

A predator faced with competitive pressure would normally shift its diet (if possible). 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.

4.5 Summary of Conservation Measures for Steller Sea Lions

This section describes the conservation measures that have been undertaken to reduce impacts to Steller sea lions. Most of the actions have been focused on the western DPS while some have broader implications. The incidental take of Steller sea lions in fishing gear and the shooting of sea lions by fisherman and others were factors in the decline during the 1970s and 1980s. However, by the early 1990s, laws implemented under the Marine Mammal Protection Act (MMPA), ESA, and MSFCMA had reduced these levels to negligible amounts. From the mid-1990s to the present, conservation efforts have focused largely on federal fishery restrictions, disturbance issues, and subsistence harvests. Although actions to reduce intentional take have been effective, it is unknown whether fishery conservation measures have been effective in reducing threats to Steller sea lions. Nevertheless, moderating declines and recent population increases following these measures has resulted in debates about cause and effect. Unlike the direct take of a species, indirect take through competitive interactions is difficult to either prove or disprove with currently available data. The increasing sea lion population trend is correlated with fishery conservation measures taken since the 1990s, but it is unknown whether the relationship is causal (Hennen 2006).

4.5.1 Reduction of Intentional and Illegal Killing

Prior to 1972, approximately 45,000 Steller sea lions were intentionally killed in Alaska during state-sanctioned commercial harvest and predator control programs (Merrick et al. 1987). A large but unknown number of Steller sea lions are believed to have been shot throughout the state between 1972 and 1990 (Trites and Larkin 1992).

These sources of direct intentional killing of Steller sea lions were banned following passage of MMPA in 1972. A provision under section 118 of the MMPA, however, allowed fishermen to lethally deter Steller sea lions from interfering with commercial fishing operations. The provision allowing lethal deterrence was eliminated in 1990 when sea lions were listed as threatened under the ESA. Following this protection, both NOAA and fishing industry representatives supported a “Don’t Shoot Sea Lions” campaign and two cases of illegal shootings were successfully prosecuted in 1998. Increased public scrutiny and the threat of fishery closures curbed illegal killings, and the current level of illegal shooting is believed to be minimal (Angliss and Outlaw 2002).

Because it is illegal, intentional killing of Steller sea lions is rarely observed, and no formal reports of lethal deterrence in commercial fisheries have been recorded by fishermen or observers since the practice was banned. The two convictions cited above however resulted from confidential voluntary reports from commercial fishermen who witnessed and reported the violations to NMFS Enforcement agents.

Systematic surveys of shorelines have successfully located carcasses of gunshot Steller sea lions (Wynne 1990). In areas where subsistence hunting occurs, it is impossible to determine whether the gunshot sea lions were shot illegally or legally, in a subsistence harvest, and subsequently lost.

4.5.2 Reduction of Incidental Takes in Commercial Fisheries

Steller sea lions have been incidentally caught in a variety of commercial fishing gear including gillnets (Wynne 1990), trawls (Loughlin and DeLong 1983), and longlines (Angliss and Outlaw 2005). Steller sea lions may also ingest baited hooks set for salmon by commercial or recreational trollers (Angliss and Outlaw 2005). The frequency of lethal entanglements varies annually, by gear type and method, but the minimum estimate between 1996 and 2000 averaged 29.5 animals a year (Angliss and Outlaw 2005) and was 30.5 and 3.6 in 2005 for the western and eastern DPSs respectively (Angliss and Outlaw 2005).

The MMPA authorized the incidental take (serious injury and death) of marine mammals in the course of commercial fishing operations while striving to reduce that mortality to an insignificant level. The MMPA was amended in 1988 to better monitor the cumulative effects of fishery-specific incidental takes. As a result, each US fishery is designated as being in one of three categories based on its frequency of marine mammal interaction; this "List of Fisheries" is reviewed annually. Vessel owners in Category I or II fisheries (frequent or occasional interactions) are required to register with the NMFS Marine Mammal Authorization Program and to record all lethal marine mammal interactions in a logbook (originally) or self-reports (currently). The 1988 amendments also required the Secretary to implement emergency regulations to prevent further taking of Steller sea lions if more than 1,350 were taken during a calendar year.

In addition, NMFS may place observers on Category I and II vessels to 1) obtain reliable estimates of incidental serious injury and mortality of marine mammals; 2) determine the reliability of reports submitted by vessel owners and operators; 3) identify changes in fishing methods or technology that may decrease incidental serious injury or mortality if necessary; 4) collect biological samples that may otherwise be unobtainable for scientific studies; and 5) record data on bycatch and discard levels of all species.

The 1994 amendments to the MMPA presented a new means of identifying and weighing the cumulative anthropogenic threats to each marine mammal stock and a process for reducing fishery-specific impacts. For each stock, a Potential Biological Removal (PBR) level is calculated that represents the annual human-induced mortality the stock can sustain, based on conservative estimates of minimum population level and net productivity and then reduced by a scaled recovery factor (Angliss and Outlaw 2005). Total annual human-related mortality is then compared to PBR to determine "Strategic Stocks" and identify those fisheries for which incidental take must be reduced. If incidental mortality of a stock in commercial fisheries exceeds PBR, NMFS is required to convene a Take Reduction Team and develop a Take Reduction Plan to reduce the level of incidental fishing-related mortality. Although the western stock of Steller sea lions is considered "strategic," the current level of incidental take is lower than the PBR; no Take Reduction Team has been convened for either stock.

Observer programs already collecting catch data under provisions of the MSFCMA in Category I fisheries were assigned the additional task of reporting incidental marine mammal take in those fisheries. Under this program, incidental take of Steller sea lions is monitored by NMFS observers on 33-76% of groundfish trawl vessels fishing in AK, WA, OR, and CA (Angliss and Outlaw 2005).

For Category I and II state fisheries, NMFS developed a Marine Mammal Observer Program under the MMPA mandates. The Alaska Marine Mammal Observer Program has monitored the incidental take of Steller sea lions and other marine mammals and birds in state-managed set and drift gillnet fisheries for salmon occurring in Prince William Sound, S. Alaska Peninsula, Cook Inlet, and Kodiak. Observers continue to document the incidental take of Steller sea lions from the eastern DPS occurring in the CA/OR thresher shark and swordfish drift gillnet and Northern WA set gillnet fishery. Updated information on incidental fishing-related mortality is incorporated into annual NMFS reviews of the status of marine mammal stocks, including Steller sea lions .

4.5.3 Subsistence Takes

Alaska Natives were exempted from the 1972 MMPA and ESA ban on taking marine mammals. This exemption allowed Alaska Natives to continue taking marine mammals for subsistence or handicraft purposes. The mean annual harvest of Steller sea lions (including struck and lost – those animals killed but not recovered) by Alaska Natives for 2000 - 2004 was estimated by the subsistence division of the Alaska Dept. of Fish & Game to be 190.4 (Angliss and Outlaw 2005).

In 1994, section 119 of the MMPA was amended to allow for the co management of marine mammal stocks used for subsistence purposes by Alaska Natives. Co-management provides a mechanism for NMFS to work with Alaskan Native Organizations (ANO) to manage use of marine mammal species listed under the ESA and to participate in research efforts. For example, the Tribal Government of St. Paul and the Aleut Community of St. George located in the Pribilof Islands, have each signed co-management agreements with NMFS for Steller sea lions. NMFS expects to enter into additional co-management agreements for sea lion conservation with other ANOs in the future.

The Tribal Governments of St. Paul and of St. George each monitor sea lion subsistence harvest as a function of the co-management agreement in place, and provide harvest information to NMFS. The Tribal Government of St. Paul has implemented a real-time harvest monitoring method to increase the accuracy in reporting. This method is also being adopted on St. George in 2005. Annual estimation of harvest, including those struck-and-lost, for other ANOs, is not available

4.5.4 Reduction in Research-related mortality

Intentional lethal sampling of Steller sea lions was a primary means of collecting reproductive, morphometric, dietary, and histologic samples for scientific research in the 1960s and 1970s. This sampling method was strictly regulated after passage of the MMPA and was discontinued once the species was listed as Threatened under the ESA.

Activities authorized under the MMPA and ESA are highly regulated and closely monitored and may include the incidental taking or harassment of Steller sea lions in the course of bonafide research. These research activities, including counting, capturing, and handling animals, may result in inadvertent or indirect Steller sea lion mortality.

Efforts are underway to reduce the amount of disturbance on rookeries caused by the presence of researchers for the purpose of counting. Aerial surveys may serve as an alternative to some of the work currently necessitating human presence.

The NMFS Permit office reviews permit applications, which are also reviewed by the Marine Mammal Commission and made available for public review through notice in the federal Register. Researchers are required to submit annual plans and reports of research activities and real-time reports of research-related mortality. Cumulative impacts of multiple projects are monitored by a Regional Coordinator, and all research may be curtailed if incidental mortalities reach a pre-determined cap.

4.5.5 Pollution, Contaminants, and Entanglement in Marine Debris

Steller sea lions are exposed to local and system-wide contaminants and pollutants as they traverse the North Pacific basin. Effects on other pinnipeds have included acute mortality, reduced pregnancy rates, immuno-suppression, and reduced survival of first born pups (see Section III), but there have been no published reports of contaminants or pollutants representing a mortality source for Steller sea lions.

Steller sea lions have been observed with packing bands, discarded netting, and other debris around their necks. Such debris can be lethal if the debris is not degradable. Annex V of the MARPOL Treaty bans the dumping of plastic trash in the ocean or navigable waters of the U.S. (outside 3 nm from shore). Information and education combined with voluntary community-based efforts have resulted in the retrieval, recovery, and disposal of discarded nets and gear in several fishing areas (e.g. Oregon, St. Paul Island, Puget Sound).

Researchers record the frequency and type of debris observed on Steller sea lions during resight surveys and, infrequently, the relative amount and type of debris seen on haulouts and rookeries they visit.

4.5.6 Reduction in Disturbance on Terrestrial Sites and Critical Habitat

Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators. Terrestrial habitat has been protected throughout the range by a variety of agencies, and by the fact that sea lions generally inhabit remote, unpopulated areas. Many haulouts and rookeries used by the western DPS are afforded protection from disturbance because they are located on land whose access is regulated by the Alaska Maritime National Wildlife Refuge and other agencies.

No transit zones for vessels within 3 nm of listed rookeries were implemented under the ESA during the initial listing of the species as threatened under the ESA in 1990. These 3 nm buffer zones around all Steller sea lion rookeries west of 150°W were designed to prevent shooting of sea lions at rookeries. Today, these measures are important in protecting sensitive rookeries in the western DPS from disturbance from vessel traffic. In addition, NMFS has provided “Guidelines for Approaching Marine Mammals” that discourage approaching any closer than 100 yards to sea lion haulouts.

Since the listing of Steller sea lions in 1990, NMFS has commented on hundreds of federal actions through the informal consultation process. NMFS commonly consults informally with the US Forest Service on logging projects, with the EPA on discharge permits, and with the Minerals Management Service on oil and gas lease sites. NMFS comments on actions that may take place in sensitive Steller sea lion critical habitat and suggests means to avoid the most sensitive areas or minimize the likelihood of having adverse impacts.

In 2002, NMFS implemented the North Pacific Fishery Management Council (NPFMC) recommendation to require a Vessel Monitoring System (VMS) on federally licensed groundfish vessels involved in pollock, cod and Atka mackerel fisheries. The VMS tracks fishing vessels, providing real-time information on vessel location and violation of no-transit and no-trawl areas.

4.5.7 Fishery Measures

The following is a compilation of the conservation measures implemented by NMFS since the development of the BSAI and GOA FMPs. Further description of conservation actions are provided in Section 4.4.1 and in Section 2.5.2. Biological opinions are described in Section 1.2.

1. In 1989, the Environmental Defense Fund and 17 other environmental organizations petitioned NMFS for an emergency rule listing all populations of Steller sea lions in Alaska as endangered and to initiate a rulemaking to make that emergency listing permanent.
2. On April 5, 1990, NMFS issued an emergency interim rule (55 FR 12645) to list the Steller sea lion as a threatened species under the ESA and established protective regulations as emergency interim measures to begin the recovery process. The rule established the following:
    - Monitoring of incidental take and monthly estimates of the level of incidental kill of Steller sea lions in observed fisheries.

- Aggressive enforcement of protective regulations, especially as they relate to intentional, lethal takes of Steller sea lions.
- Establishment of a Recovery Team to provide recommendations on further conservation measures.
- Prohibition of shooting at or within 100 yds of Steller sea lions (this did not apply to Alaska native subsistence hunting).
- Establishment of 3 nm "no-approach" buffer zones around the principle Steller sea lion rookeries in the GOA and Aleutian Islands.
- Reduction of incidental kill quota from 1,350 to no more than 675 Steller sea lions.

3. On November 26, 1990, NMFS issued the final rule to list the Steller sea lion as threatened under the ESA (55 FR 49204).
4. On January 7, 1991, NMFS issued a final rule to implement regulations to amend the BSAI and GOA FMPs that limited pollock roe-stripping and seasonally allocated the pollock TAC in the BSAI and GOA (56 FR 492). For BSAI fisheries, the pollock TAC was divided between an A (roe) season and a B season (summer-fall). In the GOA fisheries, the pollock TAC for the Central and Western (C/W) Regulatory areas was divided into 4 equal seasons. NMFS noted in the proposed rule (55 FR 37907, September 14, 1990) that "shifting fishing effort to later in the year may reduce competition for pollock between the fishery and Steller sea lions whose populations have been declining in recent years."
5. On June 19, 1991, NMFS issued an emergency interim rule to ensure that pollock fishing did not jeopardize the continued existence or recovery of the threatened Steller sea lion (56 FR 28112). The rule contained the following measures to protect Steller sea lions:

    - Allocated the pollock TAC for the combined W/C Regulatory areas equally between two subareas located east and west of 154°W,
    - Limited the amount of unharvested pollock TAC that may be rolled over to subsequent quarters in a fishing year, and
    - Prohibited fishing with trawl gear in the EEZ within 10 nm of 14 Steller sea lion rookeries.

6. On January 23, 1992, NMFS issued a final rule to implement amendments 20/25 to the BSAI and GOA FMPs (57 FR 2683). This replaced prior emergency rules, and extended some of the protections. The amendments contained the following protections:

    - Prohibited trawling year-round within 10 nm of 37 Steller sea lion rookeries in the GOA and BSAI,
    - Expanded the no-trawl zone to 20 nm for 5 of these rookeries from January 1 through April 15 each year,
    - Established 3 GOA pollock management districts, and
    - Imposed a limit on the amount of an excess pollock seasonal harvest that may be taken in a quarter in each district.

7. On January 7, 1993 NMFS released the final Steller sea lion Recovery Plan. Section 4(f) of the ESA requires that NMFS develop and implement plans for the conservation and survival of endangered and threatened species. NMFS appointed a Steller Sea Lion Recovery Team to draft the Recovery Plan in 1990. The draft Recovery Plan was released for public review and comment on March 15, 1991. NMFS responded to comments received and provided notice on January 7, 1993 that the final Recovery Plan was available (58 FR 3008).
8. On March 12, 1993, NMFS issued a final rule to implement a seasonally expanded no-trawl zone around the Ugamak Island Steller sea lion rookery in the eastern Aleutian Islands during the pollock roe fishery season in the BSAI (58 FR 13561). The expanded buffer zone around Ugamak Island was expected to better encompass Steller sea lion winter habitats and juvenile foraging areas in this portion of the southeastern Bering Sea shelf during the BSAI winter pollock fishery.
9. On July 13, 1993, NMFS issued a final rule to implement regulations (BSAI FMP amendment 28) that subdivided the Aleutian Islands subdistrict into three subareas (Areas 541, 542, 543) (58 FR 37660). This action was taken because of concerns that concentrated fishery removals, particularly Atka mackerel, in the eastern Aleutian Islands could cause localized depletions. While dispersal of the Atka mackerel TAC was initiated to conserve fishery resources, it was also consistent with the conservation objectives for Steller sea lions.
10. On August 27, 1993, pursuant to the ESA (§1533(a)(3)(A)), NMFS designated critical habitat for Steller sea lions (58 FR 45269).
11. On November 1, 1993, NMFS initiated a status review of Steller sea lions to determine whether a change in classification to endangered was warranted (58 FR 58318). NMFS solicited comments and biological information concerning the status of Steller sea lions to be used in its review.
12. On November 29-30, 1994, NMFS convened the Steller Sea Lion Recovery Team specifically to consider the appropriate ESA listing status for Steller sea lions and to evaluate the adequacy of ongoing research and management programs. The Recovery Team recommended that NMFS list the Steller sea lion as two separate population segments, split to the east and west of 144°W. The Recovery Team recommended that the western population segment be listed as endangered and the eastern population segment be listed as threatened.
13. On February 22, 1995, NMFS forward its recommendation to NMFS Headquarters to split the Steller sea lion population east and west of 144°W, and to list the western population as endangered. In October 1995, NMFS issued a proposed rule to list the western population of the Steller sea lion as endangered.
14. On May 5, 1997, NMFS reclassified Steller sea lions as two distinct population segments under the ESA (62 FR 24345). The population segment west of 144°W (near Cape Suckling, AK) was reclassified as endangered, while the population east of 144°W was maintained as threatened.
15. On March 17, 1998, NMFS issued regulations to create a separate forage fish category (Amendments 36/39 to the BSAI and GOA FMPs; 63 FR 13009). Directed fishing for forage fish was prohibited at all times in Federal waters of the BSAI and GOA. The intended effect of this action was to prevent the development of a commercial directed fishery for forage fish, a critical food source for many marine mammal, seabird, and fish species.
16. On June 11, 1998, NMFS issued a final rule to reallocate pollock TAC in the W/C Regulatory areas of the GOA by moving 10% of the TAC from the 3rd fishing season, which started on September 1, to the 2nd fishing season, which started on June 1 (63 FR 31939). This seasonal TAC shift was a precautionary measure intended to reduce the potential impacts on Steller sea lions.

17. On January 22, 1999, NMFS issued a final rule to spatially and temporally distribute the Atka mackerel TAC in the Aleutian Islands subarea. This was a precautionary approach to reduce the probability of localized depletions of Atka mackerel inside Steller sea lion critical habitat. The amendment implemented both spatial and temporal redistribution of the Atka mackerel TAC.
18. On January 22, 1999, NMFS published an emergency interim rule (64 FR 3437) implementing the reasonable and prudent alternatives (RPAs) from the December 3, 1998 Biological Opinion which concluded that the pollock fisheries as proposed were likely to jeopardize the continued existence of the endangered western population of Steller sea lions and adversely modify its critical habitat. The rule created (1) Temporal dispersion of fishing effort, (2) spatial dispersion of fishing effort, and (3) pollock trawl exclusion zones around Steller sea lion rookeries and haulouts. On July 21, 1999, NMFS extended the emergency rule through December 31, 1999 (64 FR 39087), with revisions to include specifications for the B and C pollock seasons in the Bering Sea.
19. In October 1999, NMFS conducted additional analyses of the RPAs and developed revised final RPAs (RFRPAs) to be incorporated into the December 3, 1998 Opinion as compelled by a Court Order. The RFRPAs provided a detailed set of alternative management measures that would avoid the likelihood that the pollock fisheries would jeopardize the continued existence of the western population of Steller sea lions or adversely modify its critical habitat. Season dates, pollock catch percentages within critical habitat, and no pollock trawling areas were modified from the original RPAs.
20. On January 25, 2000, NMFS published an emergency interim rule (65 FR 3892) implementing the RFRPAs from the December 3, 1998, Biological Opinion as modified in October 1999. On June 12, 2000, NMFS extended the emergency interim rule through December 31, 2000 (65 FR 36795).
21. On August 9, 2000, NMFS closed all Steller sea lion critical habitat to all groundfish trawling to comply with a U.S. District Court Order (65 FR 49766, August 15, 2000).
22. On November 30, 2000, NMFS issued a biological opinion on the FMPs (comprehensive BiOp), which determined that the pollock, Pacific cod, and Atka mackerel fisheries were likely to jeopardize the continued existence of the western DPS of Steller sea lions and to adversely modify its critical habitat. It contained a reasonable and prudent alternative (RPA) that included large fishery closure areas, harvest limits and seasonal distribution of harvest for the pollock, Pacific cod, and Atka mackerel fisheries. Before the RPA could be implemented, the President signed Public Law 106–554 on December 21, 2000, which contained a 1–year timetable to phase in the RPA. This year provided the Council with time to develop alternative conservation measures that would avoid jeopardy and adverse modification of critical habitat for Steller sea lions.
23. On January 1, 2001, in accordance with Public Law 106–554, the 2001 BSAI and GOA groundfish fisheries were initially managed in accordance with the fishery management plans and Federal regulations in effect for such fisheries prior to July 15, 2000 (i.e., prior to the trawling ban in critical habitat, thus lifting the prohibition).
24. On January 22, 2001 NMFS published an emergency interim rule (66 FR 7276) under the Magnuson-Stevens Act which replaced the initial fishery management regime of 2001 as provided in Public Law 106–554, section 209(c)(4), effective on January 18, 2001 (and corrected and amended March 20, 2001 (66 FR 15656), March 29, 2001 (66 FR 17083 and 17087), July 2, 2001 (66 FR 34852), July 17, 2001 (66 FR 37167) August 22, 2001 (66 FR 44073), and September 20, 2001 (66 FR 48371)). The emergency interim rules contained a suite of management measures that phased in certain provisions of the RPA from the 2000 Biological

Opinion. The July 17, 2001 emergency interim rule implemented the Steller sea lion protection measures that were developed by the Council's RPA Committee and forwarded to NMFS for review and implementation.

25. In July 2001, the parties to the litigation concerning the biological opinions and the RFRPA (1998 Biological Opinion and subsequent October 1999 revision) filed a joint status report and agreed to stay further litigation until completion of the 2001 BiOp in October 2001. A subsequent joint status report dated November 1, 2001, agreed to continue the temporary stay of litigation until January 18, 2002, when a follow-up status report would be filed with the Court.
26. In October 2001, NMFS issued a biological opinion in (2001 BiOp), which determined that the Steller sea lion protection measures developed by the RPA Committee and the Council were unlikely to jeopardize the continued existence of the western DPS of Steller sea lions or adversely modify its critical habitat. These measures were implemented by emergency interim rule (67 FR 956, January 8, 2002, amended and corrected 67 FR 21600, May 1, 2002, and extended 67 FR 34860, May 16, 2002 and corrected July 10, July 19, and October 18, 2002 (67 FR 45671, 47472, and 64315, respectively).
27. On January 2, 2003 NMFS issued a final rule (68 FR 204), which implemented the Steller sea lion protection measures reviewed in the 2001 BiOp (and corrected May 8, 2003 (68 FR 24615)).
28. To ensure consistency with State closures (Alaska State waters) for Steller sea lion protection measures in the Pacific cod pot fishery, NMFS removed restrictions on using pot gear for directed fishing for Pacific cod by vessels named on a Federal groundfish fishing permit in waters within 3 nm of Cape Barnabas and Caton Island (May 28, 2003, 68 FR 31629).
29. On December 20, 2004, NMFS issued a final rule (69 FR 75865) which implemented changes to the Steller sea lion protection measures in the GOA for the pollock and Pacific cod fisheries. The final rule adjusted Pacific cod and pollock fishing closure areas near four Steller sea lion haulouts and modified the seasonal management of pollock harvest in the GOA. The intent of the revisions was to maintain protection for Steller sea lions and their critical habitat while easing the economic burden on GOA fishing communities.

4.6 Response of Other Pinnipeds to Environmental Change, Prey Depletion, or Direct Takes

The growth of marine mammal populations, as for all vertebrates, is fundamentally governed as a bottom-up process by prey availability, but other processes such as intraspecific social dynamics, environmental disturbances, or top-down control through predation can supersede or interact with that bottom-up control and result in complex population responses (Boyd and Murray 2001, Sinclair and Krebs 2002, Frid *et al.* 2006). However, a substantial amount of literature associates physiological, behavioral, or population level responses of pinnipeds with reductions in prey availability in both inferential and direct studies. In nearly all of these studies, individual or population responses were associated with reductions in prey availability due to stochastic environmental conditions or intraspecific competition, though prey abundance can also be reduced by interspecific competition, long-term climatic influences, or commercial fisheries. Management concerns of competition for prey with commercial fisheries have recently been expressed for California sea lions (*Zalophus californianus*) breeding in the Central Gulf of California (Szteren *et al.* 2006) and Australian sea lions (*Neophoca cinerea*, Campbell *et al.* 2006, Fowler *et al.* 2006).

For a comparison of responses to reduced prey availability that might be observed in Steller sea lion populations, it is appropriate to limit review to studies of other otariid (sea lion and fur seal) populations. All otariids utilize a forage-cycle maternal strategy (Schulz and Bowen 2004) that relies upon energy obtained during lactation to provision pups, an income breeding strategy that contrasts with the capital breeding strategy of phocids (Boyd 2000). This strategy is energetically costly (Costa 1993), but provides for maximization of energy transfer to pups when local prey availability is high (Pitcher *et al.* 1998). Conversely, responses to decreased prey availability are poor maternal and/or pup condition. The type and magnitude of response depends on the timing, duration and magnitude of prey depletion in relation to the period of gestation and lactation. Longer-term life-history consequences appear to develop over sustained periods of low food availability.

Undernutrition of reproductive females at the time of implantation results in unsuccessful or delayed implantation (observed in Antarctic fur seals *Arctocephalus gazella*, Lunn and Boyd 1993a,b; Boyd 2000). Because energy requirements increase throughout gestation the effects of undernutrition during that period can greatly affect subsequent birth rates. Poor maternal condition during gestation is associated with decreased birth rates due to increased abortions in several species (South American sea lion (*Otaria flavescens*), Soto *et al.* 2004); Antarctic fur seal, Duck 1990, Lunn and Boyd 1993b; South African fur seal (*Arctocephalus pusillus*), Guinet *et al.* 1998; and South American fur seal (*Arctocephalus australis*), Lima and Paez 1995). Low food availability in late pregnancy is also associated with smaller subsequent birth masses (Antarctic fur seals, Boyd and McCann 1989; Lunn and Boyd 1993b; Lunn *et al.* 1994).

Depending upon the species, pups are either wholly dependent upon maternal provisioning until weaned (fur seals), or may supplement energy needs with independent foraging during mid to late lactation (some sea lions). Thus local prey abundance and distribution strongly influences maternal foraging trip duration and attendance patterns (Boness and Bowen 1996) and has consequences for the ability of lactating females to provision pups. As a consequence of decreased prey availability, maternal foraging trips may increase in duration, become more variable, or otherwise show changes in diving behavior indicative of increased foraging effort (California sea lion, Costa *et al.* 1991; Juan Fernandez fur seal, Francis *et al.* 1998; Antarctic fur seal, Boyd *et al.* 1994, McCafferty *et al.* 1998, Lea *et al.* 2006; South American sea lion, Soto *et al.* 2006). Extended foraging trips have an associated decrease in time spent onshore for pup attendance (South American sea lion, Soto *et al.* 2006; California sea lion, Heath *et al.* 1991), increasing the duration of pup fasting periods.

Changes in maternal attendance and provisioning efficiency subsequently have effects on pup growth rates and weaning mass, which decrease in response to declining prey availability (South African fur seal, Guinet *et al.* 1998; Subantarctic fur seal, Chambellant *et al.* 2003; Antarctic fur seal, Boyd and Murray 2001, Boyd *et al.* 1994; California sea lion, Boness *et al.* 1991; New Zealand fur seal (*Arctocephalus forsteri*), Bradshaw *et al.* 2000). Increased pup mortality is also associated with decreased prey availability (Antarctic fur seal, Boyd *et al.* 1994; Lunn *et al.* 1994) and is particularly acute during extremely low food availability years associated with strong El Niño conditions (South American sea lion, Soto *et al.* 2004, 2006; Galapagos fur seal, Trillmich and Limberger 1985; Galapagos sea lion, Trillmich and Limberger 1985), during which there is also increased mortality of the youngest age classes (South American sea lions, Soto *et al.* 2004; Galapagos fur seal, Trillmich and Limberger 1985).

Reductions in prey availability during a breeding season may have consequences that extend into subsequent years. There may by a trade-off between pregnancy and lactation (South African fur seal, Guinet *et al.* 1998), and reduced prey availability during a breeding season delayed birth dates in the subsequent year (South American sea lion, Soto *et al.* 2004; Antarctic fur seal, Lunn and Boyd 1993a). There is also evidence that care of a yearling during an extended lactation period reduces natality or survival of subsequent pups (Galapagos fur seal, Trillmich 1986; Australian sea lion, Higgins and Gass 1993).

Otariids clearly can be affected by reductions in prey availability throughout the breeding cycle, and acute prey depletion circumstances (as occurs during some El Niño events among temperate and sub-tropical dwelling species) can have catastrophic impacts extending beyond the season of depletion. However, otariid life-history strategies have evolved in association with intra- and inter-annual variations in prey availability. When low food availability becomes chronic however, the combined impacts clearly regulate populations. For example, in association with long-term decreased prey availability likely associated with density dependency, Subantarctic fur seals exhibited slower maturation rates, lower age-specific reproductive rates, and lower older-age class female survival, resulting in an overall limitation of the number of weaned pups produced per a female lifetime (Dabin *et al.* 2004).

4.7 Synthesis of Effects to Steller Sea Lions and Their Environment

Differences in the timing and magnitude of the regional population trajectories in the 1970s, 1980s, and 1990s (Figure 4.34) suggest that the overall western DPS decline was not caused by a single factor, but rather by the cumulative effect of multiple factors that had different relative spatial and temporal magnitudes. Indeed, the marked change in the rate of the decline since 1990 suggests that the factors that contributed to the more rapid prior declines may not be the most significant factors operating today (Bowen *et al.* 2001); in addition, there may have been density-dependent responses at lower population levels.

We have only a limited or qualitative understanding of how multiple factors interact to create an overall cumulative effect on sea lion populations. In addition, data are insufficient to show what the natural dynamics of Steller sea lion populations have been. Such dynamics would be driven primarily by changes in the North Pacific ecosystem that affect carrying capacity (e.g., prey abundance), but would also be affected by changes in rates of predation and disease. Increased knowledge of both natural ecosystem dynamics and how human activities influence those dynamics is required before their respective impacts on sea lions can be delineated with certainty (NRC 1996, NMFS, 2001, NRC 2003). Yet, a number of theories attempting to explain the decline in sea lions and apparent changes in the structure of North Pacific ecosystems since the 1970s have been developed, and these involve direct (e.g., top-down) and indirect (e.g., bottom-up) or a combination of both types of forces (NRC 1996, Anderson and Piatt 1999, Merrick 1997, Orensanz *et al.* 1998, Estes *et al.* 1998, Francis *et al.* 1998, Trites *et al.* 1999, NMFS 1998a, NMFS 2000, Jackson *et al.* 2001, Hunt *et al.* 2002, NRC 2003, Springer *et al.* 2003). Depending on the emphasis placed within each individual theory, trophic cascades and systemic modifications were triggered alone or in various combinations by whaling, fishing, predation, or atmospheric and oceanographic changes.

The following is a synthesis of the direct and indirect impacts of various stressors to Steller sea lions and their habitat.

4.7.1 Synthesis of Direct Impacts

As listed above, several factors act as direct or top-down sources of sea lion mortality; i.e., commercial harvest, intentional shooting, entanglements or incidental catch by fishing gear, disturbance, and predation. Direct sources of mortality were significant contributors to the sea lion population declines observed prior to the 1990s, when there were relatively large reductions in juvenile survival rates, and smaller reductions for adults (Pasqual and Adkison 1994, York 1994, Holmes and York 2003, Fay 2004). Since 1990, rates of mortality from harvests, shooting, entanglement, and incidental catch have been substantially reduced and likely has contributed to a rebound in both juvenile and adult survival rates (Holmes and York 2003, Fay 2004, Holmes *et al.* in review). Subsistence harvests of Steller sea lions continue but have declined substantially.

As previously described, predation by killer whales has the potential to be a significant additional top-down source of mortality (Williams *et al.* 2004, NRC 2003). Springer *et al.* (2003) proposed a hypothesis in which killer whales shifted their diet from large whales (following extensive commercial whaling in the 1950s and 1960s) to pinnipeds, resulting in sequential collapses of northern fur seals, harbor seals, and Steller sea lions, and culminating in the collapse of sea otter populations (see also Estes *et al.* 1998). This hypothesis, however, has been called into question because of inconsistencies with data on large whale catches, killer whale diets, and the spatial-temporal patterns of pinniped declines (Barrett-Lennard *et al.* 1995, Trites *et al.* 2006c, DeMaster *et al.* 2006, Wade *et al.* in press). Further review (see Section 4.2.3), suggest that killer whale predation is within the range of natural mortality of Steller sea lions and that current estimates of killer whale predation should not be a major influence on Steller sea lion growth rates. Analyses presented by Holmes and York (2003) is contradictory to top-down stressors, especially in the region of Kodiak Island where killer whales are known to specialize on sea lions, yet adult and juvenile survival are high. Although the NRC (2003) concluded that killer whale predation and top-down impacts were the likely driver for the decline of Steller sea lions, current information contradicts that hypothesis, and suggests that bottom-up factors may currently be more important. That is not to say that killer whale predation or shooting was not important in the past. Historical data does not allow us to better evaluate the potential impacts of these various factors (NRC 2003, NMFS 2006a), thus we must focus on current stressors. The Goodman PVA (in NMFS 2006a) may provide a tool to further evaluate the historical impact of these top-down stressors, but this approach will likely take years to develop and refine, and will only provide a sensitivity analysis.

4.7.2 Synthesis of Indirect Impacts

Evidence that indirect or bottom-up factors may have contributed to the decline observed from the mid-1970s through the late 1990s include reductions in size at age (Calkins and Goodwin 1988, Calkins *et al.* 1998), possible depressed late-term pregnancy rates (Pitcher *et al.* 1998), significantly reduced pregnancy rates for lactating females (Pitcher *et al.* 1998), and a decline in per capita natality of female sea lions at some rookeries (Holmes and York 2003, Fay 2004, Winship and Trites 2006, Holmes *et al.* in review). These responses by sea lions are opposite to those predicted by direct, top-down, factors (Bowen *et al.* 2001, NRC 2003), as body condition, growth rates, and natality should increase or remain the same when population abundance is reduced. These bottom-up factor(s) appeared to be affecting sea lions as early as the 1960s and 1970s (see Section 3.1.15.1), at about the same time that large numbers of sea lions were also killed directly (especially in the late 1970s and 1980s). The combination of reduced population abundance and poor body condition indices is consistent with a substantial reduction in carrying capacity (Gerrodette and DeMaster 1990, Calkins *et al.* 1998).

The changes in vital rates (see above) may have been a function of nutritional stress resulting from a combination of reduced prey availability and quality (Trites *et al.* 2006a). Two stressors were likely to have affected the prey field for Steller sea lions: (1) climate induced changes in the species composition, distribution or nutritional quality of sea lion prey (see review by Trites and Donnelly 2003 and Trites *et al.* 2006a), and (2) fishery-induced changes in localized or overall prey abundance and quality (Braham *et al.* 1980, NMFS 1998a, 2000). Both climate change and fisheries induced changes in prey communities likely have affected the condition of Steller sea lions over the last 40 years, but the relative importance of each is a matter of considerable debate.

The carrying capacity of the North Pacific for Steller sea lions likely fluctuates in response to changes in the environment (Hare *et al.* 1999, Overland *et al.* 1999, Stabeno *et al.* 2001, Benson and Trites 2002, Hunt *et al.* 2002, Shima *et al.* 2002, Trites and Donnelly 2003, Trites *et al.* 2006a), yet what may have been unusual about the decline in sea lions observed through 2000 is the introduction of large-scale commercial fisheries on sea lion prey. While large-scale groundfish fisheries began in the 1960s, their potential for competitive overlap with Steller sea lions (e.g., catches within what would be designated as critical habitat) increased markedly in the 1980s (NMFS 1998, 2000, 2001). Overall and localized fisheries removals of prey could have exacerbated natural changes in carrying capacity, possibly in non-linear and unpredictable ways (Goodman *et al.* 2002). Reductions in carrying capacity may have contributed to declines in natality that are believed to have occurred at some rookeries through at least 2002 (Holmes and York 2003, Fay 2004, Winship and Trites 2006, Holmes *et. al.* in review) despite climate shifts to potentially more favorable environmental conditions that may have occurred in 1989 and 1998 (Hare and Mantua 2000, Bond *et al.* 2003).

Although the "junk food" hypothesis (Rosen and Trites 2000a, Trites and Donnelly 2003), has been rejected (Rosen and Trites 2004, Calkins *et al.* 2005), changes in the overall energy density of the prey field due to both climate shifts and long term fisheries impacts, may have reduced the efficiency of sea lions and affected their ability obtain adequate energy to maintain body condition and full reproductive potential (see Section 4.6). In our review of climate and regime shifts, gadids were not necessarily affected across the range of Steller sea lions by the 1977 shift. Although it appears that EBS pollock did benefit from this change, GOA pollock and Atka mackerel likely were unaffected or affected in different ways that are still not clear. Also, the Steller sea lion population may have been increasing during the 1940s and 1950s during a time period that was rich in gadids, but may have been affected by nutritional stress as early as the 1960s and 1970s, before the 1977 regime shift. Results by Hennen (2006) correlate sea lion declines with fisheries around rookeries in the 1980s, and find no correlation between fisheries and sea lion dynamics in the 1990s after conservation measures were enacted around rookeries and shooting was prohibited[5] (Hennen 2006, Dillingham *et al.* 2006).

4.7.3 Synthesis and Summary of the Baseline

Both direct and indirect stressors can affect Steller sea lion population growth and vital rates. In addition, both types of stressors can operate simultaneously and at various levels. Steller sea lions have been affected by climate and regime shifts, diseases, parasites, and predation for their entire existence, and humans have hunted them for food and for other uses for thousands of years (Walker *et al.* 1999, Dixon 1986). The impact of each of these factors has likely varied over time in response to marine ecosystem dynamics and predator abundance (e.g., killer whales and humans), as well as in response to the size of the sea lion population itself. Steller sea lions persisted in the North Pacific despite the adverse impact of these stressors, and they did so without an apparent loss of genetic diversity which would indicate that the population had gone through a "genetic bottleneck" (NMFS unpublished data). Therefore, for tens of thousands of years prior to the 1970s, Steller sea lions had adapted to and accommodated fluctuations in their carrying capacity due to natural variability, disease and parasitism, killer whale predation, human-related kills, and apparently maintained, on average, a relatively large population size (i.e., above the point that would have resulted in an obvious genetic bottleneck). This is not to say that the population did not go through historical changes in population size or distribution as reported by Nelson (1887) or similar changes for seabirds (Causey *et al.* 2005), but that it appears unlikely that rapid and large population increases and decreases were common for sea lions. The western portion of the range of sea lions was probably at a relatively large population size at the beginning of the sharp declines in the 1980s, and may have been increasing prior to that decline.

In the last several decades, several stressors have developed as a result of human influence such as contaminants, incidental take, shooting, fisheries, and potentially global climate change[6] (NRC 2003, NMFS 2006). The absolute impact of each stressor on survival and reproduction during the sea lion

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[5] Numerous sea lion conservation measures were implemented throughout the 1990s, see Sections 4.4.1 and 4.5 for a thorough historical review.

[6] Global climate change is a highly debated theory, both on the mechanisms and results. See NMFS (2006a) for a short discussion of the topic. In this opinion we recognize the possibility of global climate change and the potential influence on sea lions and changing habitat and range. The southern contraction of the range of the eastern DPS may be in response to warming (see NMFS 2006a for this discussion).

population decline are unknown. Yet, based on several PVAs, there is a significant probability that either a portion of the range of the western DPS of Steller sea lion may be extirpated (Winship and Trites 2006) or that the entire western DPS will go extinct in the next 100 years (York *et al.* 1996, Gerber and VanBlaricom 2001, Goodman in NMFS 2006a). The eastern DPS is likely to continue to increase and appears to be large, healthy, and based on Goodman (PVA in NMFS 2006a) is not in danger of extinction or likely to become endangered.

It is likely that both direct and indirect stressors affected sea lions at different times, and to varying degrees, to cause the sea lion population declines (NRC 2003; Table 4.8, Figure 4.34). Increases in both direct and indirect threats were necessary to account for the rapid rates of population decline in the 1980s that were accompanied by declines in juvenile survivorship, body size, and birth rate. Specifically, direct mortality from humans (e.g., legal and illegal shooting, incidental take, subsistence hunting) and killer whales were augmented by declines in carrying capacity associated with regime shifts, increased inter-specific competition, and fishing. A reduction in the rate of population decline in the 1990s suggests that the effect of one or more stressors also declined, possibly through density dependence or changes in human behavior. This coincides with the listing of Steller sea lions under the ESA and the imposition of a ban on shooting at or near Steller sea lions, fishing closures near rookeries, as well as a potential change in oceanographic conditions. Thus, there may have been a reduction in direct mortality from humans, a hypothesis supported by time series of juvenile and adult survivorship, as well as a shift to potentially more favorable environmental conditions. In addition, rates of predation may also have decreased through density dependence. The lower rate of population decline since about 1990 and the associated improvement in survivorship, but continued decline in the birth rate, suggests the sustained effect of indirect stressors and a reduction in the magnitude of direct threats.

Thus, the current potential indirect impacts of fisheries on sea lions (i.e. prey) include:

- Reduction in the availability of prey within near-shore critical habitat (0-10 nm), and to a lesser extent (10-20 nm),
- Changes in the age structure of important prey in a resulting reduction in foraging efficiency and change in distribution of the prey based on age differences and habitat preference,
- Long term reductions in biomass that alter the availability of near-shore prey abundance, and
- Year-round potential to impact sea lion foraging efficiency.

Chapter 5 will evaluate the potential impacts of the FMPs and the actions they authorize on the prey field for Steller sea lions, and determine whether continuation of the fisheries, and those long-term impacts which have already affected the environment (described in this section) would result in jeopardy and adverse modification. Chapter 5 will evaluate (a) the exposure of sea lions to fisheries, (b) response of individual sea lions to that exposure, (c) response of sea lion populations, (d) response of the western and eastern DPSs to fisheries, and (e) the response of critical habitat.

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 opinion, which presents the most recent accounting of the various sources of Steller sea lion mortality, including anthropogenic sources and predation, as well as indirect and non-lethal effects of various sources of disturbance. The sources of mortality identified in section 4 are likely to remain for the foreseeable future. The table in section 4.3.10 above shows the most recent estimate of mortality from human activities since 1958; as shown in this table, the most recent accounting estimates a total of 1,900 sea lions killed from human activities over the past five years, a substantial decline from the previous decade’s level of takes from subsistence harvests, shootings, and incidental catch and entanglement. Assuming that these levels of anthropogenic mortality continue into the foreseeable future, cumulative effects will derive from the combination of these takes and any additional mortality caused by the proposed action.

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 Steller 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 a large proportion of the potential biological removal calculated for the western DPS of Steller sea lions (Angliss and Outlaw 2005). Harvest data taken in systematic retrospective interviews with hunters in at least 60 coastal Alaskan communities show that total annual takes decreased substantially from 541 in 1992 to a low of 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, although subsistence takes in the Prince William Sound-Cook Inlet area increased in 2004 to 50 animals, more than double the area’s subsistence harvests from 2003.

The overall impact of 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 4.4.4 of this 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 impacts. 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, pollock, Pacific salmon, Pacific cod, and Pacific herring. State-managed groundfish fisheries 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.

The state-managed herring and salmon fisheries are short in duration and relatively small in scale. The record of incidental Steller sea lion mortality shows very low rates for fixed gear (including pot, jig, and longline) fisheries as compared to trawl fisheries. The pollock fishery in Prince William Sound, a very limited and infrequent sablefish trawl fishery in Prince William Sound, and the new Pacific cod fishery in the Aleutian Islands are the only state-managed groundfish fisheries where trawls are permitted west of 144º W longitude.

There are no observer requirements for state-managed groundfish fisheries and as a consequence no observer data are collected for these fisheries. The inside district of Prince William Sound has been divided into three management sections to disperse pollock harvest and reduce the likelihood of fishery interactions with sea lions. The Pacific cod fishery in the Aleutians is temporally dispersed to some degree in that the first portion of the fishery beginning in March is limited to 70% of the harvest, with 30% reserved for the June opening.

The size of the state-managed groundfish fishery is small compared to the Federal groundfish fishery and thus could have proportionately less impact on sea lions with respect to competition for prey and long-term ecosystem effects. However, the state-managed fisheries occur in nearshore waters (within 3 nm). Recent research suggests that these nearshore waters may be critical for adult females that remain within 20 nm of shore during the breeding season, as well as other seasons if they are nursing a pup. Moreover, 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, relying more heavily on nearshore prey.

There continues to be extensive overlap between the locations of state-managed groundfish fisheries and areas designated to be Steller sea lion critical habitat. The overlap has recently been extended into the central Aleutian Islands with the advent of the state-managed Pacific cod fishery west of 170° W longitude. It is unclear whether the state will develop other new fisheries such as the recent Pacific cod fishery near Adak. In January 2005, the Alaska Board of Fisheries generated proposals to permit fishing inside Steller sea lion haulouts in the state-managed pollock fisheries in the Aleutian Islands (Adak), Western Gulf, and Cook Inlet areas. At the October meeting, the board voted down the Western Gulf proposal, but postponed taking final action on the proposal for the Aleutians Islands/Adak and the Central Gulf to October 2006. These proposals could increase the overlap between state-managed groundfish fisheries and areas critical to sea lions.

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 (Angliss and Outlaw 2005) or more, if the Board of Fisheries permits additional fishing inside sea lion haulouts. 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, the causes of the current decline and the extent that the contributing factors play in the decline are debatable.

NMFS expects the existing state-managed fisheries and their direct and indirect effects on Steller sea lions to continue into the foreseeable future.

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 rurual communities in Alaska, and subsistence uses are central to the customs and traditions of many Alaska Native groups, including the Aleut, Athabaskan, Alutiiq, Haida, Inupiat, Tlingit, Tsimshian, and Yup'ik. NMFS expects that traditional uses of natural resources will continue. About 20% of Alaska's population participates in subsistence harvests (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

The State of Alaska Division of Oil and Gas conducts lease sales for exploration of oil and gas reserves in the state and researches and analyzes social, economic, environmental, geological and geophysical information about sale areas. The division then develops a preliminary best interest finding that describes the sale areas and discusses the potential effects that may occur as a result of oil and gas exploration, development, production and transportation. It also contains mitigation measures to be imposed on plans of operation as permit terms designed to reduce or eliminate negative effects.

In January 2006, the Division of Oil and Gas published its Five-Year Oil and Gas Leasing Program report for proposed lease sales through 2010. A total of 26 lease sales for exploration of oil and gas are scheduled over the next five years – 11 on the North Slope, five in Cook Inlet, six in the Beaufort Sea, and four on the Alaska Peninsula. The four proposed Alaska Peninsula Areawide Oil and Gas Lease Sales encompass a gross area of approximately 5 million acres (3.5 million acres onshore and 1.5 million offshore, within state waters), but lie in the Port Moller region along the northern shore of the peninsula, outside the action area of this Biological Opinion.

The five proposed Cook Inlet area sales include unleased, state-owned uplands located in the Matanuska and Susitna Valleys, the Anchorage Bowl, the western and southern Kenai Peninsula from Pt. Possession to Anchor Pt., as well as on the western shore of Cook Inlet from the Beluga River to Harriet Pt. These sales will also include the tide and submerged lands in the upper Cook Inlet from Kink and Turnagain Arms south to Anchor Pt. and Tuxedni Bay. A number of state and federal wildlife refuges, critical habitat areas, recreation areas, and parks exist within or near the proposed sale area. These areas encompass important fish and wildlife habitat.

No decision has been made on whether these sales will be held. Approximately nine months prior to each proposed lease sale the Division of Oil and Gas will issue a request for new information that has become available since the original finding was issued in January 1999. Should the division determine that, based on new information, a supplement to the finding is justified, the supplement, along with the division's decision, will be issued at least 90 days before each sale (Alaska Department of Natural Resources 2006).

6.7 Vessel and Aircraft Activity

As discussed in section 4 of this 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 foreseeable future at levels comparable to the present, although population growth will likely also increase the amount and frequency of such disturbance.

6.8 Population Growth

In general, as human communities increase in size and number, habitat alterations and environmental impacts also increase. Native plants and animals become displaced by the construction of housing, roads, commercial facilities, and other infrastructure such as facilities for waste disposal.

Although Alaska has the lowest population density of all of the states in the United States, the state'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, on the Island of Kodiak, in Bethel, and in the Valdez - Cordova region, but few of these towns and villages would be considered urbanized. Section 4 of this Biological Opinion discusses populations trends.

The population of Alaska will most likely continue to expand at a high rate, especially in urban areas. As noted above, the increasing population will likely result in increases in vessel activity, subsistence uses of natural resources, sport fishing, and even the development of commercial fisheries. Rural populations may increase or decrease precisely on their ability to exploit resources such as fisheries and to secure necessities to live in these remote areas. To bolster rural communities that have experienced population declines, such as in the Aleutians, 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 dependence of specific coastal communities on fisheries.

Such developments may put severe pressure on fishery managers to enact more regulations that provide for near-shore fisheries, which will in turn lead to conflicts with measures to limit adverse impacts to critical habitat for sea lions.

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Table 1.1. Consultation history on Bering Sea and Aleutian Island Groundfish Fishery Management Plan and Gulf of Alaska Groundfish Fishery Management Plans as they pertain to Steller sea lions and other ESA-listed species.

Region	Year	Date	Consultation	ACTION	CONCLUSION
BSAI					
	1979	14-Dec	Formal	BSAI FMP	No jeopardy (only whales listed under ESA at this time)
	1989	5-Jul	Formal	Issue of MMPA exemptions	No jeopardy
	1990	30-Oct	Formal	Bering Sea snail fishery	No jeopardy
	1990	24-Oct	Formal	BSAI crab FMP	No jeopardy
	1991	22-Oct	Informal	Amendments 17/22 & 20/25	No adverse affects not already considered, reinitiation not necessary
	1991	19-Apr	Formal	BSAI FMP	No jeopardy
	1992	9-Oct	Informal	Amendments 20/25	No adverse affects not already considered, reinitiation not necessary
	1992	11-Jun	Informal	IFQ fishery	Not likely to adversely affect listed species
	1992	4-Mar	Formal	Amendment 18 inshore/offshore	No jeopardy
	1992	21-Jan	Formal	1992 TAC	No jeopardy
	1993	28-Apr	Formal	Delay of pollock "B" season	No jeopardy
	1993	20-Jan	Informal	1993 TAC	No adverse affects not already considered, reinitiation not necessary
	1994	2-Feb	Informal	1994 TAC	No adverse affects not already considered, reinitiation not necessary
	1995	26-Sep	Informal	Effect of I/O (38/40) on SSL	No adverse affects not already considered, reinitiation not necessary
	1995	25-Aug	Informal	Amendments 38/40, other species	No adverse affects not already considered, reinitiation not necessary
	1995	3-Feb	Informal	1995 TAC	No adverse affects not already considered, reinitiation not necessary
	1996	26-Jan	Formal	1996 TAC and BSAI FMP	No jeopardy
	1997	17-Jan	Informal	1997 TAC	No adverse affects not already considered, reinitiation not necessary
	1998	26-Feb	Informal	1998 TAC	Reinitiation not triggered
	1998	19-Oct	Formal	1998 pollock and Atka mackerel	Jeopardy and adverse modifcication; Steller sea lions and pollock fishery
	1999	23-Dec	Formal	2000 TAC	No jeopardy
	2000	30-Nov	Formal	BSAI FMP	Jeopardy and adverse modifcication; SSLs and pollock, cod, mackerel
	2001	19-Oct	Formal	BSAI pollock, P. cod, A. mackerel	No jeopardy
	2003	19-Jun	Supplement	BSAI pollock, P. cod, A. mackerel	No jeopardy
	2004	16-Jul	Informal	AI pollock	Not likely to adversely affect listed species; no action taken
	2005	23-Nov	Informal	EBS pollock start date	Likely to adversely affect listed species; no action taken by Council
	2006	19-Mar	Formal	AI pollock EFP	No jeopardy

Table 1.1. Continued.

Region	Year	Date	Consultation	ACTION	CONCLUSION
GOA					
	1991	23-Dec	Informal	1992 TAC	No adverse affects not already considered, reinitiation not necessary
	1991	12-Nov	Informal	Amendment 23	No adverse affects not already considered, reinitiation not necessary
	1991	22-Oct	Informal	Amendments 17/22 & 20/25	No adverse affects not already considered, reinitiation not necessary
	1991	20-Sep	Formal	4th quarter pollock fishery	No jeopardy
	1991	5-Jun	Formal	1991 pollock TAC	No jeopardy
	1991	19-Apr	Formal	GOA FMP	No jeopardy
	1992	11-Jun	Informal	IFQ fishery	No adverse affects likely, therefore further consultation not required
	1992	4-Mar	Informal	Season 2nd quarter delay	Not likely to adversely affect listed species
	1993	6-Jul	Informal	Amendment 31	No adverse affects not already considered, reinitiation not necessary
	1993	16-Feb	Informal	Season 2nd quarter delay	No adverse affects not already considered, reinitiation not necessary
	1993	27-Jan	Informal	1993 TAC	No adverse affects not already considered, reinitiation not necessary
	1993	6-Jan	Informal	EFP	Not likely to adversely affect listed species
	1994	31-Jan	Informal	1994 TAC	No adverse affects not already considered, reinitiation not necessary
	1995	26-Sep	Informal	Effect of I/O (38/40) on SSL	No adverse affects not already considered, reinitiation not necessary
	1995	25-Aug	Informal	Amendments 38/40, other species	No adverse affects not already considered, reinitiation not necessary
	1995	3-Feb	Informal	1995 TAC	No adverse affects not already considered, reinitiation not necessary
	1996	26-Jan	Formal	1996 TAC and GOA FMP	No jeopardy
	1997	10-Sep	Informal	Amendment 46	Action will not adversely affect listed species
	1997	17-Jan	Informal	1997 TACs	No adverse affects not already considered, reinitiation not necessary
	1998	2-Mar	Formal	1998 TAC	No jeopardy
	1998	19-Oct	Formal	1998 pollock and Atka mackerel	Jeopardy and adverse modifcication; Steller sea lions and pollock fishery
	1999	23-Dec	Formal	2000 TAC	No jeopardy
	2000	30-Nov	Formal	GOA FMP	Jeopardy and adverse modifcication; SSLs and pollock, cod, mackerel
	2001	19-Oct	Formal	GOA pollock, P. cod	No jeopardy
	2003	19-Jun	Supplement	GOA pollock, P. cod	No jeopardy
	2004	13-Jan	Informal	GOA pollock, P. cod, A. mackerel	Partial not likely to adversely affect listed species; action modified to NLAA

Table 2.1a Summary of management measures for the BSAI groundfish fishery.

Management Area	U.S. Exclusive Economic Zone (EEZ) of the eastern Bering Sea and that portion of the North Pacific Ocean adjacent to the Aleutian Islands which is west of 170° W. up to the U.S.-Russian Convention Line of 1867. **Subareas:** The area is divided into two subareas, the Bering Sea and the Aleutian Islands.
Stocks	All stocks of finfish and marine invertebrates in the management area except salmonids, shrimps, scallops, snails, king crab, Tanner crab, Dungeness crab, corals, surf clams, horsehair crab, lyre crab, Pacific halibut, and Pacific herring. Those stocks and stock complexes that are commercially important and for which an annual TAC is established include: walleye pollock, Pacific cod, sablefish, yellowfin sole, Greenland turbot, arrowtooth flounder, rock sole, flathead sole, Alaska plaice, “other flatfish”, Pacific ocean perch, northern rockfish, shortraker and rougheye rockfish, “other rockfish”, Atka mackerel, and squid.
Maximum Sustainable Yield (MSY)	The historical estimate of MSY for the BSAI groundfish complex is in the range of 1.7 to 2.4 million mt.
Optimum Yield (OY)	The OY of the BSAI groundfish complex (consisting of stocks listed in the ‘target species’ and ‘other species’ categories, as listed in Table 3-1) is 85% of the historical estimate of MSY, or 1.4 to 2.0 million mt, plus the incidental harvest of nonspecified species.
Procedure to set Total Allowable Catch (TAC)	Based on the annual Stock Assessment and Fishery Evaluation (SAFE) report, the Council will recommend to the Secretary of Commerce TACs and apportionments thereof for each target species and the “other species” category. The Secretary will implement annual TACs which may cover up to 2 fishing years, following public comment and Council recommendations at the December Council meeting. **Reserve**: 15% of the TAC for each target species (except pollock and fixed-gear sablefish) and the “other species” category is set aside to form the reserve, used for correcting operational problems of the fleets, adjusting species TACs for conservation, or apportionments. The reserve is not designated by species or species groups.
Apportionment of TAC	**Pollock**: the amount of pollock that may be taken with non-pelagic trawls may be limited; pollock TAC shall be divided into roe-bearing (“A” season) and non roe-bearing (“B” season) allowances. **Sablefish**: vessels using fixed gear may harvest no more than 50% of the TAC in the Bering Sea and 75% of the TAC in the Aleutian Islands; vessels using trawl gear may harvest no more than 50% of the TAC in the Bering Sea and 25% of the TAC in the Aleutian Islands. **Pacific cod**: TAC shall be allocated 2% to vessels using jig gear, 47% to vessels using trawl gear, and 51% to vessels using hook-and-line or pot gear. The trawl gear allocation is allocated 50% to catcher/processor vessels and 50% to catcher vessels. The allocation to hook-and-line and pot gear is apportioned 80% to hook-and-line catcher/processor vessels, 0.3% to hook-and-line catcher vessels, 3.3% to pot catcher/processor vessels, 15% to pot catcher vessels, and 1.4% to catcher vessels less than 60' LOA. Allocations may be seasonally apportioned. **Atka mackerel**: up to 2% of the eastern Aleutian Islands and Bering Sea TACs will be allocated to vessels using jig gear. **Shortraker and rougheye rockfish**: after subtraction of reserves, the Aleutian Islands TAC will be allocated 70% to vessels using trawl gear and 30% to vessels using non-trawl gear.
Attainment of TAC	The attainment of a TAC for a species will result in the closure of the target fishery for that species. Further retention of that species will be prohibited.
Permit	All vessels participating in the BSAI groundfish fisheries, other than fixed gear sablefish, require a Federal groundfish license, except for: vessels fishing in State of Alaska waters; vessels less than 32' LOA; and jig gear vessels less than 60' LOA that meet specific effort restrictions. Licenses are endorsed with area, gear, and vessel type and length designations. Fixed gear vessels engaged in directed fishing for Pacific cod must qualify for a Pacific cod endorsement. Fishing permits may be authorized, for limited experimental purposes, for the target or incidental harvest of groundfish that would otherwise be prohibited.
Authorized Gear	Gear types authorized by the FMP are trawls, hook-and-line, pots, jigs, and other gear as defined in regulations. **Pollock**: The use of non-pelagic trawl gear in the directed fishery for pollock is prohibited.

Time and Area Restrictions	**All trawl**: Fishing with trawl vessels is not permitted year-round in the Crab and Halibut Protection Zone and the Pribilof Islands Habitat Conservation Area. The Nearshore Bristol Bay Trawl Closure area is also closed year-round except for a subarea that remains open between April 1 and June 15 each year. The Chum Salmon Savings Area is closed to trawling from August 1 through August 31. **Non-pelagic trawl**: The Red King Crab Savings Area is closed to non-pelagic trawling year-round, except for a subarea that may be opened at the discretion of the Council and NMFS when a guideline harvest level for Bristol Bay red king crab has been established. **Directed pollock fishery**: Catcher/processor vessels identified in the American Fisheries Act are prohibited from engaging in directed fishing for pollock in the Catcher Vessel Operational Area during the non-roe ("B") season unless they are participating in a community development quota fishery. **Marine mammal measures**: Regulations implementing the FMP may include conservation measures that temporally and spatially limit fishing effort around areas important to marine mammals. **Gear test area exemption**: Specific gear test areas for use when the fishing grounds are closed to that gear type are established in regulations that implement the FMP.
Prohibited Species	Pacific halibut, Pacific herring, Pacific salmon and steelhead, king crab, and Tanner crab are prohibited species and must be returned to the sea with a minimum of injury except when their retention is authorized by other applicable law. Groundfish species and species under this FMP for which TAC has been achieved shall be treated in the same manner as prohibited species.
Prohibited Species Catch (PSC) Limits	When a target fishery attains a PSC limit apportionment or seasonal allocation, the bycatch zone or management area to which the PSC limit applies will be closed to that target fishery for the remainder of the year or season. **Red king crab**: Based on the size of the spawning biomass of red king crab, the PSC limit in Zone 1 for trawl fisheries is either 23,000, 97,000 or 197,000 red king crab; attainment closes Zone 1. ***C. bairdi* crab**: Established in regulation for trawl fisheries based on population abundance; attainment closes Zone 1 or Zone 2. ***C. opilio* crab**: Established in regulation for trawl fisheries in the C. opilio Bycatch Limitation Zone based on population abundance, with minimum and maximum limits; attainment closes zone. **Pacific halibut**: Halibut mortality limits established in regulation for trawl and non-trawl fisheries. **Pacific herring**: 1% of the annual biomass of eastern Bering Sea herring, for trawl fisheries; attainment may close the Herring Savings Areas. **Chum salmon**: Attainment of 42,000 fish limit in the Catcher Vessel Operational Area between August 15 and October 14 closes the Chum Salmon Savings Area for the rest of that time period. **Chinook salmon**: Attainment of Chinook PSC limit established in regulation for the Bering Sea or the Aleutian Islands subarea closes the Bering Sea or Aleutian Island Chinook Salmon Savings Area to directed pollock trawl fishing. **Apportionment**: For trawl fisheries, may be apportioned by target fishery and season; for non-trawl fisheries, may be apportioned by target fishery, gear type, area, and season.
Retention and Utilization Requirements	**Pollock**: Roe-stripping is prohibited; see also below. **Improved Retention/Improved Utilization Program**: All pollock and Pacific cod must be retained and processed.
Fixed Gear Sablefish Fishery	The directed fixed gear sablefish fisheries are managed under an Individual Fishing Quota program. The FMP specifies requirements for the initial allocation of quota share in 1995, as well as transfer, use, ownership, and general provisions. **Annual Allocation**: The ratio of a person's quota share to the quota share pool is multiplied by the fixed gear TAC (adjusted for the community development quota allocation - see below), to arrive at the annual individual fishing quota.
Bering Sea Pollock Fishery	Subtitle II of the American Fisheries Act (AFA), incorporated by reference in the FMP, implemented a cooperative program for the pollock fishery. **Access**: Limits pollock fishery access to named vessels and processors; included a buyout of 9 catcher/processor vessels. **Allocation**: After adjustment for the community development quota allocation (see below) and incidental catch of pollock in other fisheries, the pollock TAC is apportioned 50% to vessels harvesting pollock for inshore processing, 40% to vessels harvesting pollock for catcher/processor processing, and 10% to vessels harvesting pollock for mothership processing. **Cooperatives**: Creates standards and limitations for the creation and operation of cooperatives. **Sideboards**: Establishes harvesting and processing restrictions on AFA pollock participants to protect other fisheries. **Catch monitoring**: Increases observer coverage and scale requirements for catcher/processors.

Aleutian Islands Pollock Fishery	The non-CDQ directed pollock fishery in the Aleutian Islands is fully allocated to the Aleut Corporation for the purpose of economic development in Adak, Alaska. **Allocation**: To be funded, to the extent possible in whole or in part, from the difference between the sum of all BSAI groundfish fishery TACs and the 2 million mt OY cap, if the difference is large enough to do so. The remainder of the funding comes from a reduction in the Bering Sea pollock recommended TAC. A mechanism for determining “A” and “B” season allowances is specified.
Community Development Quota (CDQ) Multispecies Fishery	Eligible fishery-dependent communities in western Alaska will receive a percentage of all groundfish species or species group TACs, except squid, and a pro-rata share of PSC species. **Sablefish**: 20% of the fixed gear TAC **Pollock**: 10% of the TAC **Other groundfish species**: 7.5% of the TAC, to come out of the groundfish reserve
Flexible Authority	The Regional Administrator of NMFS is authorized to make inseason adjustments through gear modifications, closures, or fishing area/quota restrictions, for conservation reasons, to protect identified habitat problems, or to increase vessel safety.
Recordkeeping and Reporting	Recordkeeping that is necessary and appropriate to determine catch, production, effort, price, and other information necessary for conservation and management may be required. May include the use of catch and/or product logs, product transfer logs, effort logs, or other records as specified in regulations. **Processors**: Shall report necessary information for the management of the groundfish fisheries as specified in regulations. **At-sea processor vessels**: Must submit a weekly catch/receipt and product transfer report and record cargo transfer and off-loading information in a separate transfer log. Catcher/processors are also required to check in and check out of any fishing area for which TAC is established, as specified in regulations.
Observer Program	U.S. fishing vessels that catch groundfish in the EEZ, or receive groundfish caught in the EEZ, and shoreside processors that receive groundfish caught in the EEZ, are required to accommodate NMFS-certified observers as specified in regulations, in order to verify catch composition and quantity, including at-sea discards, and collect biological information on marine resources.
Evaluation and Review of the FMP	The Council will maintain a continuing review of the fisheries managed under this FMP, and all critical components of the FMP will be reviewed periodically. **Management Policy**: Objectives in the management policy statement will be reviewed annually. **Essential Fish Habitat (EFH)**: The Council will conduct a complete review of EFH once every 5 years, and in between will solicit proposals on Habitat Areas of Particular Concern and/or conservation and enhancement measures to minimize potential adverse effects from fishing. Annually, EFH information will be reviewed in the “Ecosystems Considerations” chapter of the SAFE report.

Table 2.1b Summary of management measures for the GOA groundfish fishery.

Management Area	U.S. Exclusive Economic Zone (EEZ) of the eastern Bering Sea and that portion of the North Pacific Ocean adjacent to the Aleutian Islands which is west of 170° W. up to the U.S.-Russian Convention Line of 1867. **Subareas:** The area is divided into two subareas, the Bering Sea and the Aleutian Islands.
Stocks	All stocks of finfish and marine invertebrates in the management area except salmonids, shrimps, scallops, snails, king crab, Tanner crab, Dungeness crab, corals, surf clams, horsehair crab, lyre crab, Pacific halibut, and Pacific herring. Those stocks and stock complexes that are commercially important and for which an annual TAC is established include: walleye pollock, Pacific cod, sablefish, yellowfin sole, Greenland turbot, arrowtooth flounder, rock sole, flathead sole, Alaska plaice, “other flatfish”, Pacific ocean perch, northern rockfish, shortraker and rougheye rockfish, “other rockfish”, Atka mackerel, and squid.
Maximum Sustainable Yield (MSY)	The historical estimate of MSY for the BSAI groundfish complex is in the range of 1.7 to 2.4 million mt.
Optimum Yield (OY)	The OY of the BSAI groundfish complex (consisting of stocks listed in the ‘target species’ and ‘other species’ categories, as listed in Table 3-1) is 85% of the historical estimate of MSY, or 1.4 to 2.0 million mt, plus the incidental harvest of nonspecified species.
Procedure to set Total Allowable Catch (TAC)	Based on the annual Stock Assessment and Fishery Evaluation (SAFE) report, the Council will recommend to the Secretary of Commerce TACs and apportionments thereof for each target species and the “other species” category. The Secretary will implement annual TACs which may cover up to 2 fishing years, following public comment and Council recommendations at the December Council meeting. **Reserve**: 15% of the TAC for each target species (except pollock and fixed-gear sablefish) and the “other species” category is set aside to form the reserve, used for correcting operational problems of the fleets, adjusting species TACs for conservation, or apportionments. The reserve is not designated by species or species groups.
Apportionment of TAC	**Pollock**: the amount of pollock that may be taken with non-pelagic trawls may be limited; pollock TAC shall be divided into roe-bearing (“A” season) and non roe-bearing (“B” season) allowances. **Sablefish**: vessels using fixed gear may harvest no more than 50% of the TAC in the Bering Sea and 75% of the TAC in the Aleutian Islands; vessels using trawl gear may harvest no more than 50% of the TAC in the Bering Sea and 25% of the TAC in the Aleutian Islands. **Pacific cod**: TAC shall be allocated 2% to vessels using jig gear, 47% to vessels using trawl gear, and 51% to vessels using hook-and-line or pot gear. The trawl gear allocation is allocated 50% to catcher/processor vessels and 50% to catcher vessels. The allocation to hook-and-line and pot gear is apportioned 80% to hook-and-line catcher/processor vessels, 0.3% to hook-and-line catcher vessels, 3.3% to pot catcher/processor vessels, 15% to pot catcher vessels, and 1.4% to catcher vessels less than 60' LOA. Allocations may be seasonally apportioned. **Atka mackerel**: up to 2% of the eastern Aleutian Islands and Bering Sea TACs will be allocated to vessels using jig gear. **Shortraker and rougheye rockfish**: after subtraction of reserves, the Aleutian Islands TAC will be allocated 70% to vessels using trawl gear and 30% to vessels using non-trawl gear.
Attainment of TAC	The attainment of a TAC for a species will result in the closure of the target fishery for that species. Further retention of that species will be prohibited.
Permit	All vessels participating in the BSAI groundfish fisheries, other than fixed gear sablefish, require a Federal groundfish license, except for: vessels fishing in State of Alaska waters; vessels less than 32' LOA; and jig gear vessels less than 60' LOA that meet specific effort restrictions. Licenses are endorsed with area, gear, and vessel type and length designations. Fixed gear vessels engaged in directed fishing for Pacific cod must qualify for a Pacific cod endorsement. Fishing permits may be authorized, for limited experimental purposes, for the target or incidental harvest of groundfish that would otherwise be prohibited.
Authorized Gear	Gear types authorized by the FMP are trawls, hook-and-line, pots, jigs, and other gear as defined in regulations. **Pollock**: The use of non-pelagic trawl gear in the directed fishery for pollock is prohibited.

Time and Area Restrictions	**All trawl**: Fishing with trawl vessels is not permitted year-round in the Crab and Halibut Protection Zone and the Pribilof Islands Habitat Conservation Area. The Nearshore Bristol Bay Trawl Closure area is also closed year-round except for a subarea that remains open between April 1 and June 15 each year. The Chum Salmon Savings Area is closed to trawling from August 1 through August 31. **Non-pelagic trawl**: The Red King Crab Savings Area is closed to non-pelagic trawling year-round, except for a subarea that may be opened at the discretion of the Council and NMFS when a guideline harvest level for Bristol Bay red king crab has been established. **Directed pollock fishery**: Catcher/processor vessels identified in the American Fisheries Act are prohibited from engaging in directed fishing for pollock in the Catcher Vessel Operational Area during the non-roe ("B") season unless they are participating in a community development quota fishery. **Marine mammal measures**: Regulations implementing the FMP may include conservation measures that temporally and spatially limit fishing effort around areas important to marine mammals. **Gear test area exemption**: Specific gear test areas for use when the fishing grounds are closed to that gear type are established in regulations that implement the FMP.
Prohibited Species	Pacific halibut, Pacific herring, Pacific salmon and steelhead, king crab, and Tanner crab are prohibited species and must be returned to the sea with a minimum of injury except when their retention is authorized by other applicable law. Groundfish species and species under this FMP for which TAC has been achieved shall be treated in the same manner as prohibited species.
Prohibited Species Catch (PSC) Limits	When a target fishery attains a PSC limit apportionment or seasonal allocation, the bycatch zone or management area to which the PSC limit applies will be closed to that target fishery for the remainder of the year or season. **Red king crab**: Based on the size of the spawning biomass of red king crab, the PSC limit in Zone 1 for trawl fisheries is either 23,000, 97,000 or 197,000 red king crab; attainment closes Zone 1. ***C. bairdi* crab**: Established in regulation for trawl fisheries based on population abundance; attainment closes Zone 1 or Zone 2. ***C. opilio* crab**: Established in regulation for trawl fisheries in the C. opilio Bycatch Limitation Zone based on population abundance, with minimum and maximum limits; attainment closes zone. **Pacific halibut**: Halibut mortality limits established in regulation for trawl and non-trawl fisheries. **Pacific herring**: 1% of the annual biomass of eastern Bering Sea herring, for trawl fisheries; attainment may close the Herring Savings Areas. **Chum salmon**: Attainment of 42,000 fish limit in the Catcher Vessel Operational Area between August 15 and October 14 closes the Chum Salmon Savings Area for the rest of that time period. **Chinook salmon**: Attainment of Chinook PSC limit established in regulation for the Bering Sea or the Aleutian Islands subarea closes the Bering Sea or Aleutian Island Chinook Salmon Savings Area to directed pollock trawl fishing. **Apportionment**: For trawl fisheries, may be apportioned by target fishery and season; for non-trawl fisheries, may be apportioned by target fishery, gear type, area, and season.
Retention and Utilization Requirements	**Pollock**: Roe-stripping is prohibited; see also below. **Improved Retention/Improved Utilization Program**: All pollock and Pacific cod must be retained and processed.
Fixed Gear Sablefish Fishery	The directed fixed gear sablefish fisheries are managed under an Individual Fishing Quota program. The FMP specifies requirements for the initial allocation of quota share in 1995, as well as transfer, use, ownership, and general provisions. **Annual Allocation**: The ratio of a person's quota share to the quota share pool is multiplied by the fixed gear TAC (adjusted for the community development quota allocation - see below), to arrive at the annual individual fishing quota.
Bering Sea Pollock Fishery	Subtitle II of the American Fisheries Act (AFA), incorporated by reference in the FMP, implemented a cooperative program for the pollock fishery. **Access**: Limits pollock fishery access to named vessels and processors; included a buyout of 9 catcher/processor vessels. **Allocation**: After adjustment for the community development quota allocation (see below) and incidental catch of pollock in other fisheries, the pollock TAC is apportioned 50% to vessels harvesting pollock for inshore processing, 40% to vessels harvesting pollock for catcher/processor processing, and 10% to vessels harvesting pollock for mothership processing. **Cooperatives**: Creates standards and limitations for the creation and operation of cooperatives. **Sideboards**: Establishes harvesting and processing restrictions on AFA pollock participants to protect other fisheries. **Catch monitoring**: Increases observer coverage and scale requirements for catcher/processors.

Aleutian Islands Pollock Fishery	The non-CDQ directed pollock fishery in the Aleutian Islands is fully allocated to the Aleut Corporation for the purpose of economic development in Adak, Alaska. **Allocation**: To be funded, to the extent possible in whole or in part, from the difference between the sum of all BSAI groundfish fishery TACs and the 2 million mt OY cap, if the difference is large enough to do so. The remainder of the funding comes from a reduction in the Bering Sea pollock recommended TAC. A mechanism for determining "A" and "B" season allowances is specified.
Community Development Quota (CDQ) Multispecies Fishery	Eligible fishery-dependent communities in western Alaska will receive a percentage of all groundfish species or species group TACs, except squid, and a pro-rata share of PSC species. **Sablefish**: 20% of the fixed gear TAC **Pollock**: 10% of the TAC **Other groundfish species**: 7.5% of the TAC, to come out of the groundfish reserve
Flexible Authority	The Regional Administrator of NMFS is authorized to make inseason adjustments through gear modifications, closures, or fishing area/quota restrictions, for conservation reasons, to protect identified habitat problems, or to increase vessel safety.
Recordkeeping and Reporting	Recordkeeping that is necessary and appropriate to determine catch, production, effort, price, and other information necessary for conservation and management may be required. May include the use of catch and/or product logs, product transfer logs, effort logs, or other records as specified in regulations. **Processors**: Shall report necessary information for the management of the groundfish fisheries as specified in regulations. **At-sea processor vessels**: Must submit a weekly catch/receipt and product transfer report and record cargo transfer and off-loading information in a separate transfer log. Catcher/processors are also required to check in and check out of any fishing area for which TAC is established, as specified in regulations.
Observer Program	U.S. fishing vessels that catch groundfish in the EEZ, or receive groundfish caught in the EEZ, and shoreside processors that receive groundfish caught in the EEZ, are required to accommodate NMFS-certified observers as specified in regulations, in order to verify catch composition and quantity, including at-sea discards, and collect biological information on marine resources.
Evaluation and Review of the FMP	The Council will maintain a continuing review of the fisheries managed under this FMP, and all critical components of the FMP will be reviewed periodically. **Management Policy**: Objectives in the management policy statement will be reviewed annually. **Essential Fish Habitat (EFH)**: The Council will conduct a complete review of EFH once every 5 years, and in between will solicit proposals on Habitat Areas of Particular Concern and/or conservation and enhancement measures to minimize potential adverse effects from fishing. Annually, EFH information will be reviewed in the "Ecosystems Considerations" chapter of the SAFE report.

Table 2.2 Target species in the BSAI and GOA groundfish fisheries. These stocks, their status, and the fisheries on each stock are described in detail in the 2005 Stock Assessment and Fishery Evaluation reports for the BSAI and GOA groundfish fisheries.

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

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

Table 2.3 Survey CVs by species/species groups. (BSAI = Bering Sea Aleutian Islands, EBS = Eastern Bering Sea, SBSEA = Southern Bering Sea, AI = Aleutian Islands, GOA = Gulf of Alaska, EIT = echo integration trawl, ADMB = AD model builder)

Species or species group	FMP/Area	Survey Type	Survey CV	Assessment Method	ABC/OFL Tier
Alaska plaice	BSAI	Bottom trawl	11%	ADMB	3a
Arrowtooth flounder	BSAI	Bottom trawl	10%	ADMB	3a
Arrowtooth flounder	GOA	Bottom trawl	7%	ADMB	3a
Atka mackerel	BSAI	Bottom trawl	17%	ADMB	3a
Atka mackerel	GOA	Bottom trawl	50%	Bycatch	6
Deepwater flatfish	GOA	Bottom trawl	8%	ADMB/ave.catch	3a, 6[1]
Demersal shelf rockfish	GOA	Line transact	17%	Survey index	4
Flathead sole	BSAI	Bottom trawl	9%	ADMB	3a
Flathead sole	GOA	Bottom trawl	8%	ADMB	3a
Greenland turbot	BSAI	Bottom trawl	17%	ADMB	3b
Northern rockfish	BSAI	Bottom trawl	22%	ADMB	3a
Northern rockfish	GOA	Bottom trawl	37%	ADMB	3a
Northern rocksole	BSAI	Bottom trawl	7%	ADMB	3a
Octopus	BSAI	Bottom trawl	--	Survey index	5
Other flatfish	BSAI	Bottom trawl	20%	Survey index	5
Other rockfish	BSAI	Bottom trawl	9%/67%/18%[5]	Survey index	5
Other slope rockfish	GOA	Bottom trawl	25%	Survey index	4, 5[2]
Pacific cod	BSAI	Bottom trawl	7%	Stock synthesis 2	3b
Pacific cod	GOA	Bottom trawl	26%	Stock synthesis 2	3a
Pacific ocean perch	BSAI	Bottom trawl	13%	ADMB	3b
Pacific ocean perch	GOA	Bottom trawl	19%	ADMB	3a
Pelagic shelf rockfish	GOA	Bottom trawl	30%	ADMB/survey	3a, 5[3]
Pollock	BSAI/EBS	Bottom trawl/EIT	20%	ADMB	1a
Pollock	BSAI/AI	Bottom trawl	18%	Survey index	5
Pollock	BSAI/Bogoslof	EIT	20%	Survey index	5
Pollock	GOA	Bottom trawl/EIT	15%/4%	ADMB	3b
Pollock	GOA/Southeast	Bottom trawl	8%	Survey index	5
Rex sole	GOA	Bottom trawl	8%	ADMB	5
Rougheye rockfish	BSAI	Bottom trawl	25%	Survey index	5
Rougheye rockfish	GOA	Bottom trawl	18%	ADMB	3a
Sablefish	BSAI/EBS	Longline	10%	ADMB	3b
Sablefish	BSAI/AI	Longline	10%	ADMB	3b
Sablefish	GOA	Longline	10%	ADMB	3b
Sculpins	BSAI	Bottom trawl	10-52%/14-47%[6]	Survey index	5
Shallow water flatfish	GOA	Bottom trawl	7%	Survey index	4, 5[4]
Sharks	BSAI	Bottom trawl	71%/34%/55%[7]	Survey index	5
Shortraker rockfish	BSAI	Bottom trawl	37%	Survey index	5
Shortraker rockfish	GOA	Bottom trawl	20%	Survey index	5
Skates	BSAI	Bottom trawl	5%/8%/16%[8]	Survey index	5
Skates	GOA	Bottom trawl	9%	Survey index	5
Squid	BSAI	Bottom trawl	--	Average catch	6
Thornyhead rockfish	GOA	Bottom trawl	4%	Survey index	5
Yellowfin sole	BSAI	Bottom trawl	13%	ADMB	3a

[1] Dover sole Tier 3a, other deepwater flatfish Tier 6.
[2] Sharpchin rockfish Tier 4, remaining other slope rockfish Tier 5.
[3] Dusky rockfish Tier 3a, widow and yellowtail rockfish Tier 5.
[4] Northern and southern rocksole Tier 4, remaining shallow water flatfish Tier 5.
[5] Other rockfish CVs of 9%/67%/18% correspond to the EBS slope/SBSEA/AI surveys.
[6] Sculpin CVs of 10-52% corresponds to major sp. in 2005 EBS shelf survey, CVs of 14-47% corresponds to major sp.in 2004 AI survey.
[7] Shark CVs of 71%/34%/55% correspond to the EBS shelf/EBS slope/Al surveys.
[8] Skate CVs of 5%/8%/16% correspond to the EBS shelf/EBS slope/Al surveys.

Table 2.4 Thousands of tons of female spawning biomass relative to the current (2205) $B_{100\%}$ level (in parentheses) from 1980-2005. Source: 2005 SAFE reports. Note that Model 3 was selected for the GOA and BSAI Pacific cod assessment (NMFS 2006b).

	GOA Pollock	GOA Pacific cod	BSAI Atka mackerel	EBS Pollock	BSAI Pacific cod
$B_{100\%}$	559 (100%)	329 (100%)	240 (100%)	6,563 (100%)	863 (100%)
1980	617 (110%)	118 (36%)	78 (33%)	1,033 (16%)	140 (16%)
1981	500 (89%)	137 (42%)	96 (40%)	1,761 (27%)	249 (29%)
1982	570 (102%)	169 (51%)	147 (61%)	2,666 (41%)	390 (45%)
1983	688 (123%)	197 (60%)	162 (67%)	3,273 (50%)	518 (60%)
1984	712 (127%)	223 (68%)	149 (62%)	3,492 (53%)	594 (69%)
1985	641 (115%)	249 (76%)	127 (53%)	3,757 (57%)	615 (71%)
1986	519 (93%)	264 (80%)	103 (43%)	3,981 (61%)	609 (71%)
1987	436 (78%)	267 (81%)	90 (37%)	4,064 (62%)	609 (71%)
1988	397 (71%)	277 (84%)	93 (39%)	3,967 (60%)	605 (70%)
1989	386 (69%)	294 (89%)	110 (46%)	3,536 (54%)	577 (67%)
1990	347 (62%)	298 (91%)	133 (56%)	2,810 (43%)	544 (63%)
1991	329 (59%)	289 (88%)	156 (65%)	2,030 (31%)	490 (57%)
1992	294 (53%)	281 (85%)	176 (73%)	2,073 (32%)	410 (48%)
1993	331 (59%)	280 (85%)	209 (87%)	3,119 (48%)	369 (43%)
1994	377 (67%)	294 (89%)	204 (85%)	3,400 (52%)	371 (43%)
1995	343 (61%)	301 (91%)	173 (72%)	3,791 (58%)	375 (43%)
1996	309 (55%)	289 (88%)	158 (66%)	3,960 (60%)	360 (42%)
1997	267 (48%)	273 (83%)	147 (61%)	3,633 (55%)	347 (40%)
1998	204 (36%)	252 (77%)	124 (52%)	3,355 (51%)	311 (36%)
1999	187 (33%)	243 (74%)	112 (47%)	3,395 (52%)	292 (34%)
2000	176 (31%)	231 (70%)	117 (49%)	3,323 (51%)	285 (33%)
2001	173 (31%)	219 (67%)	101 (42%)	3,373 (51%)	288 (33%)
2002	149 (27%)	212 (64%)	88 (37%)	3,175 (48%)	299 (35%)
2003	146 (26%)	210 (64%)	115 (48%)	3,447 (53%)	305 (35%)
2004	165 (30%)	214 (65%)	166 (69%)	3,434 (52%)	316 (37%)
2005	208 (37%)	207 (63%)	187 (78%)	3,221 (49%)	321 (37%)

Table 2.5 Council recommendations for GOA groundfish 2006 - 2007 OFLs , ABCs and TACs

	2005					2006			2007		
Stock/ Assemblage	Area	OFL	ABC	TAC	Catch*	OFL	ABC	TAC	OFL	ABC	TAC
Pollock	W (61)		30,380	30,380	31,116		29,187	29,187		23,291	23,291
	C (62)		34,404	34,404	27,838		30,775	30,775		24,558	24,558
	C (63)		18,718	18,718	19,348		18,619	18,619		14,858	14,858
	WYAK		1,688	1,688	1,879		1,809	1,809		1,443	1,443
	Subtotal	144,340	85,190	85,190	80,181	110,100	80,390	80,390	89,500	64,150	64,150
	EYAK/SEO	8,690	6,520	6,520	0	8,209	6,157	6,157	8,209	6,157	6,157
	Total	153,030	91,710	91,710	80,181	118,309	86,547	86,547	97,709	70,307	70,307
Pacific Cod	W		20,916	15,687	12,208		26,855	20,141		19,292	14,469
	C		33,117	25,086	21,241		37,873	28,405		27,206	20,405
	E		4,067	3,660	14		4,131	3,718		2,968	2,671
	Total	86,200	58,100	44,433	33,462	95,500	68,859	52,264	59,100	49,466	37,545
Sablefish	W		2,540	2,540	1,892		2,670	2,670		2,360	2,360
	C		7,250	7,250	6,602		6,370	6,370		5,630	5,630
	WYAK		2,580	2,580	1,825		2,280	2,280		2,014	2,014
	SEO		3,570	3,570	3,335		3,520	3,520		3,116	3,116
	Total	19,280	15,940	15,940	13,654	17,880	14,840	14,840	15,800	13,120	13,120
Deep-water flatfish[1]	W		330	330	3		420	420		421	421
	C		3,340	3,340	395		4,139	4,139		4,145	4,145
	WYAK		2,120	2,120	4		2,661	2,661		2,665	2,665
	EYAK/SEO		1,030	1,030	4		1,445	1,445		1,446	1,446
	Total	8,490	6,820	6,820	406	11,008	8,665	8,665	11,022	8,677	8,677
Rex sole	W		1,680	1,680	576		1,159	1,159		1,096	1,096
	C		7,340	7,340	1,576		5,506	5,506		5,207	5,207
	WYAK		1,340	1,340	0		1,049	1,049		992	992
	EYAK/SEO		2,290	2,290	0		1,486	1,486		1,405	1,405
	Total	16,480	12,650	12,650	2,152	12,000	9,200	9,200	11,400	8,700	8,700
Shallow-water flatfish[2]	W		21,580	4,500	108		24,720	4,500		24,720	4,500
	C		27,250	13,000	4,516		24,258	13,000		24,258	13,000
	WYAK		2,030	2,030	0		628	628		628	628
	EYAK/SEO		1,210	1,210	6		1,844	1,844		1,844	1,844
	Total	63,840	52,070	20,740	4,630	62,418	51,450	19,972	62,418	51,450	19,972
Flathead sole	W		11,690	2,000	611		10,548	2,000		10,932	2,000
	C		30,020	5,000	1,904		25,195	5,000		26,111	5,000
	WYAK		3,000	3,000	0		2,022	2,022		2,096	2,096
	EYAK/SEO		390	390	0		55	55		57	57
	Total	56,500	45,100	10,390	2,515	47,003	37,820	9,077	48,763	39,196	9,153
Arrowtooth flounder	W		26,250	8,000	2,531		20,154	8,000		21,011	8,000
	C		168,950	25,000	16,681		134,906	25,000		140,640	25,000
	WYAK		11,790	2,500	23		15,954	2,500		16,632	2,500
	EYAK/SEO		9,910	2,500	29		6,830	2,500		7,120	2,500
	Total	253,900	216,900	38,000	19,264	207,678	177,844	38,000	216,500	185,403	38,000

		2005				2006			2007		
Stock/ Assemblage	Area	OFL	ABC	TAC	Catch*	OFL	ABC	TAC	OFL	ABC	TAC
Other Slope rockfish[3]	W		40	40	93		577	577		577	577
	C		300	300	565		386	386		386	386
	WYAK		130	130	70		317	317		317	317
	EYAK/SEO		3,430	200	36		2,872	200		2,872	200
	Total	5,150	3,900	670	764	5,394	4,152	1,480	5,394	4,152	1,480
Northern rockfish[3]	W		808	808	570		1,483	1,483		1,483	1,483
	C		4,283	4,283	4,208		3,608	3,608		3,608	3,608
	E		0	0	0		0	0		0	0
	Total	6,050	5,091	5,091	4,778	7,673	5,091	5,091	7,618	5,091	5,091
Pacific ocean perch	W	3,076	2,567	2,567	2,340	4,931	4,155	4,155	4,997	4,290	4,290
	C	10,226	8,535	8,535	8,145	8,806	7,418	7,418	8,923	7,660	7,660
	WYAK		841	841	872		1,101	1,101		1,137	1,137
	SEO		1,632	1,632	0		1,587	1,587		1,639	1,639
	E(subtotal)	2,964				3,190	2,688	2,688	3,232	2,776	2,776
	Total	16,266	13,575	13,575	11,357	16,927	14,261	14,261	17,152	14,726	14,726
Shortraker	W		155	155	70		153	153		153	153
	C		324	324	224		353	353		353	353
	E		274	274	203		337	337		337	337
	Total	982	753	753	497	1,124	843	843	1,124	843	843
Rougheye	W		188	188	52		136	136		133	133
	C		557	557	122		608	608		596	596
	E		262	262	122		239	239		235	235
	Total	1,531	1,007	1,007	296	1,180	983	983	1,161	964	964
Pelagic shelf rockfish	W		377	377	120		1,438	1,438		1,463	1,463
	C		3,067	3,067	1,845		3,262	3,262		3,318	3,318
	WYAK		211	211	215		301	301		306	306
	EYAK/SEO		898	898	3		435	435		443	443
	Total	5,680	4,553	4,553	2,183	6,662	5,436	5,436	6,779	5,530	5,530
Demersal rockfish											
	SEO	640	410	410	289	650	410	410	650	410	410
Thornyhead rockfish	W		410	410	189		513	513		513	513
	C		1,010	1,010	388		989	989		989	989
	E		520	520	134		707	707		707	707
	Total	2,590	1,940	1,940	711	2,945	2,209	2,209	2,945	2,209	2,209
Atka mack.	Total	6,200	600	600	882	6,200	4,700	1,500	6,200	4,700	1,500
Big skate	W		727	727	26		695	695		695	695
	C		2,463	2,463	758		2,250	2,250		2,250	2,250
	E		809	809	60		599	599		599	599
	Total	5,332	3,999	3,999	844	4,726	3,544	3,544	4,726	3,544	3,544
Longnose skate	W		66	66	15		65	65		65	65
	C		1,972	1,972	947		1,969	1,969		1,969	1,969
	E		780	780	135		861	861		861	861
	Total	3,757	2,818	2,818	1,097	3,860	2,895	2,895	3,860	2,895	2,895
Other skates	Total	1,769	1,327	1,327	663	2,156	1,617	1,617	2,156	1,617	1,617
Other species	Total	NA	NA	13,871	2232	NA	NA	13,942		NA	12,266
Total		**713,667**	**539,263**	**291,298**	**182,957**	**631,293**	**501,366**	**292,776**	**582,477**	**473,000**	**258,549**

[*] Catch through November 6, 2005
[1] "Deep water flatfish" includes Dover sole, Greenland turbot and deepsea sole.
[2] "Shallow water flatfish" includes rock sole, yellowfin sole, butter sole, starry flounder, English sole, Alaska plaice, and sand sole.
[3] The EGOA ABC of 2 mt for northern rockfish has been included in the WYAK ABC for other slope rockfish.

Table 2.6 Council recommended ABC, OFL, and 2006 and 2007 TAC specifications for the BSAI.

Species	Area	2005				2006			2007		
		OFL	ABC	TAC	Catch**	OFL	ABC	TAC	OFL	ABC	TAC
Pollock	EBS	2,100,000	1,960,000	1,478,500	1,483,096	2,090,000	1,930,000	1,485,000	1,930,000	1,790,000	1,500,000
	Aleutian Islands	39,100	29,400	19,000	1,621	39,100	29,400	19,000	39,100	29,400	19,000
	Bogoslof District	39,600	2,570	10	0	50,600	5,500	10	50,600	5,500	10
Pacific cod	BSAI	265,000	206,000	206,000	183,020	230,000	194,000	194,000	176,000	148,000	148,000
Sablefish	BS	2,950	2,440	2,440	1,037	3,680	3,060	2,820	3,260	2,700	2,700
	AI	3,170	2,620	2,620	1,480	3,740	3,100	3,000	3,300	2,740	2,740
Yellowfin sole	BSAI	148,000	124,000	90,686	91,684	144,000	121,000	95,701	137,000	116,000	107,641
Greenland turbot	Total	19,200	3,930	3,500	2,530	14,200	2,740	2,740	13,400	2,630	2,630
	BS		2,720	2,700	2,105		1,890	1,890		1,815	1,815
	AI		1,210	800	425		850	850		815	815
Arrowtooth flounder	BSAI	132,000	108,000	12,000	13,888	166,000	136,000	13,000	174,000	142,000	18,000
Rock sole	BSAI	157,000	132,000	41,500	37,237	150,000	126,000	41,500	145,000	122,000	44,000
Flathead sole	BSAI	70,200	58,500	19,500	15,818	71,800	59,800	19,500	67,900	56,600	22,000
Alaska plaice	BSAI	237,000	189,000	8,000	11,183	237,000	188,000	8,000	231,000	183,000	15,000
Other flatfish	BSAI	28,500	21,400	3,500	4,466	24,200	18,100	3,500	24,200	18,100	5,000
Pacific Ocean perch	BSAI	17,300	14,600	12,600	10,360	17,600	14,800	12,600	17,600	14,800	14,800
	BS		2,920	1,400	811		2,960	1,400		2,960	2,960
	AI total		11,680	11,200	9,549		11,840	11,200		11,840	11,840
	WAI		5,305	5,085	4,725		5,372	5,085		5,372	5,372
	CAI		3,165	3,035	2,238		3,212	3,035		3,212	3,212
	EAI		3,210	3,080	2,586		3,256	3,080		3,256	3,256
Northern rockfish	BSAI	9,810	8,260	5,000	3,959	10,100	8,530	4,500	9,890	8,320	5,000
Shortraker rockfish	BSAI	794	596	596	166	774	580	580	774	580	580
Rougheye rockfish	BSAI	298	223	223	92	299	224	224	299	224	224
Other rockfish	BSAI	1,870	1,400	1,050	468	1,870	1,400	1,050	1,870	1,400	1,400
	BS		810	460	188		810	460		810	810
	AI		590	590	280		590	590		590	590
Atka mackerel	Total	147,000	124,000	63,000	61,958	130,000	110,000	63,000	107,000	91,000	63,000
	WAI		46,620	20,000	19,736		41,360	15,500		34,220	17,500
	CAI		52,830	35,500	35,105		46,860	40,000		38,760	38,000
	EAI/BS		24,550	7,500	7,133		21,780	7,500		18,020	7,500
Squid	BSAI	2,620	1,970	1,275	1,183	2,620	1,970	1,275	2,620	1,970	1,275
Other species	BSAI	87,920	53,860	29,000	24,666	89,404	58,882	29,000	89,404	62,950	27,000
Total	BSAI	3,509,332	3,044,769	2,000,000	1,949,912	3,476,987	3,045,586	2,000,000	3,224,217	2,832,414	2,000,000

**2005 catch is through October 29, and includes CDQ. The preferred alternative is Alternative 2. The 2006 and 2007 OFLs, ABCs, and TACs were adopted by the Council in December 2005.

Table 2.7 TAC projections for 2006, 2007, and 2008 for pollock, Pacific cod and Atka mackerel. Also included is biomass projections and overall catch ratio for each managed area (AFSC unpublished data).

TAC				
Species	**Area**	**2006**	**2007**	**2008**
Pollock	GOA	85,807	70,507	72,007
Pollock	EBS	1,485,000	1,419,800	1,168,700
Pollock	AI	19,000	19,000	19,000
Pacific cod	GOA	52,264	44,705	30,436
Pacific cod	BSAI	188,180	144,045	118,049
Atka mackerel	GOA	1,500	1,500	1,500
Atka mackerel	BSAI	63,000	90,900	65,100

Biomass				
Species	**Area**	**2006**	**2007**	**2008**
Pollock	GOA	771,457	819,510	896,227
Pollock	EBS	9,681,630	9,570,530	9,877,730
Pollock	AI	130,000	130,000	130,000
Pacific cod	GOA	438,295	412,970	420,938
Pacific cod	BSAI	1,241,710	1,167,570	1,215,240
Atka mackerel	GOA	n/a	n/a	n/a
Atka mackerel	BSAI	550,517	496,627	460,297

Ratio				
Species	**Area**	**2006**	**2007**	**2008**
Pollock	Eastern GOA	0.11	0.09	0.08
Pollock	Central GOA	0.11	0.09	0.08
Pollock	Western GOA	0.11	0.09	0.08
Pollock	Pribilof Islands	0.15	0.15	0.12
Pollock	Eastern AI	0.15	0.15	0.15
Pollock	Central AI	0.15	0.15	0.15
Pollock	Western AI	0.15	0.15	0.15
Pacific cod	Eastern GOA	0.12	0.11	0.07
Pacific cod	Central GOA	0.12	0.11	0.07
Pacific cod	Western GOA	0.12	0.11	0.07
Pacific cod	Pribilof Islands	0.15	0.12	0.10
Pacific cod	Eastern AI	0.15	0.12	0.10
Pacific cod	Central AI	0.15	0.12	0.10
Pacific cod	Western AI	0.15	0.12	0.10
Atka mackerel	Eastern GOA	n/a	n/a	n/a
Atka mackerel	Central GOA	n/a	n/a	n/a
Atka mackerel	Western GOA	n/a	n/a	n/a
Atka mackerel	Pribilof Islands	n/a	n/a	n/a
Atka mackerel	Eastern AI	0.11	0.18	0.14
Atka mackerel	Central AI	0.11	0.18	0.14
Atka mackerel	Western AI	0.11	0.18	0.14

Table 2.8 Fisheries and target species for GOA (first panel) and BSAI (second panel). For further information on fisheries targets see section 2.1 of the BA.

Species	**Trawl**	**Hook-and-line**	**Pot**	**Jig**
Walleye pollock	X			
Pacific cod	X	X	X	X
Deepwater flatfish	X			
Rex sole	X			
Flathead sole	X			
Shallow water flatfish	X			
Arrowtooth flounder	X			
Sablefish	X (bycatch only)	X (IFQ fishery)		
Pacific ocean perch	X			
Shortraker rockfish (bycatch only)				
Rougheye rockfish (bycatch only)				
Other rockfish (bycatch only)				
Northern rockfish	X			
Pelagic shelf rockfish	X			
Thornyhead rockfish (bycatch only)				
Big skates	X			
Longnose skates (W GOA bycatch only)				
Other skates (bycatch only)				
Demersal Shelf rockfish		X		X
Atka mackerel (bycatch only)				
Other species*				

*octopus, squid, shark, and sculpins

Table 2.8 Continued, BSAI.

Species	Trawl	Hook-and-line	Pot	Jig
Walleye pollock	X			
Pacific cod	X	X	X	X
Greenland turbot	X	X		
Rock sole	X			
Yellowfin sole	X			
Flathead sole	X			
Arrowtooth flounder	X			
Other flatfish	X			
Alaska Plaice	X			
Sablefish	X (bycatch only)	X (IFQ fishery) **	X	
Pacific ocean perch (Bering Sea bycatch only)				
Shortraker rockfish (bycatch only)				
Rougheye rockfish (bycatch only)				
Other rockfish (bycatch only)				
Northern rockfish (bycatch only)				
Atka mackerel	X			
squid				
Other species* (bycatch only)				

*octopus, skates, shark, and sculpins
** individual fishing quota

Table 2.9a Groundfish catches (metric tons) in the Bering Sea(a), Aleutian Islands(b), and Gulf of Alaska(c).

Bering Sea (BS)	**Percent pollock/BS Groundfish**		**Percent P. cod/BS Groundfish**		**Percent Atka mackerel/BS Groundfish**		**Total BS Groundfish**
Year	**Pollock**	**%**	**P. cod**	**%**	**A. mackerel**	**%**	**Total**
1964	174,792	44%	13,408	3%		0%	393,891
1965	230,551	67%	14,719	4%		0%	344,369
1966	261,678	58%	18,200	4%		0%	452,081
1967	550,362	66%	32,064	4%		0%	836,308
1968	702,181	73%	57,902	6%		0%	967,083
1969	862,789	72%	50,351	4%		0%	1,192,020
1970	1,256,565	79%	70,094	4%		0%	1,593,649
1971	1,743,763	82%	43,054	2%		0%	2,137,326
1972	1,874,534	87%	42,905	2%		0%	2,149,092
1973	1,758,919	85%	53,386	3%		0%	2,064,444
1974	1,588,390	84%	62,462	3%		0%	1,900,092
1975	1,356,736	82%	51,551	3%		0%	1,645,232
1976	1,177,822	82%	50,481	4%		0%	1,428,565
1977	978,370	84%	33,335	3%		0%	1,168,144
1978	979,431	75%	42,543	3%	831	25%	1,302,509
1979	913,881	79%	33,761	3%	1,985	35%	1,159,547
1980	958,279	78%	45,861	4%	4,955	86%	1,221,944
1981	973,505	77%	51,996	4%	3,027	29%	1,259,666
1982	955,964	79%	55,040	5%	328	21%	1,211,483
1983	982,363	77%	83,212	6%	141	1%	1,280,285
1984	1,098,783	75%	110,944	8%	57	0%	1,458,299
1985	1,179,759	72%	132,736	8%	4	0%	1,649,109
1986	1,188,449	73%	130,555	8%	12	0%	1,633,911
1987	1,237,597	76%	144,539	9%	12	0%	1,639,121
1988	1,228,000	68%	192,726	11%	428	8%	1,810,470
1989	1,230,000	75%	164,800	10%	3,126	76%	1,630,382
1990	1,353,000	82%	162,927	10%	480	6%	1,644,109
1991	1,268,360	77%	165,444	10%	2,265	34%	1,647,455
1992	1,384,376	76%	163,240	9%	2,610	6%	1,831,954
1993	1,301,574	78%	133,156	8%	201	1%	1,674,406
1994	1,362,694	75%	174,151	10%	190	1%	1,818,628
1995	1,264,578	72%	228,496	13%	340	2%	1,745,890
1996	1,189,296	72%	209,201	13%	780	2%	1,653,355
1997	1,115,268	68%	209,475	13%	171	1%	1,640,590
1998	1,101,428	74%	160,681	11%	901	3%	1,486,739
1999	889,589	74%	134,647	11%	2,008	7%	1,200,387
2000	1,132,736	76%	151,372	10%	239	1%	1,497,520
2001	1,387,452	82%	142,452	8%	264	1%	1,694,677
2002	1,481,815	81%	166,552	9%	572	2%	1,839,170
2003	1,492,039	80%	180,592	10%	6,362	20%	1,871,273
2004	1,481,678	79%	184,961	10%	7,079	25%	1,877,389
2005	1,483,096	80%	160,922	9%	3,495	16%	1,849,054

Table 2.9b

Aleutian Islands (AI)	Percent pollock/AI Groundfish		Percent P. cod/AI Groundfish		Percent Atka mackerel/AI Groundfish		Total AI Groundfish
Year	**Pollock**	**%**	**P. cod**	**%**	**A. mackerel**	**%**	**Total**
1964		0%	241	0%		0%	92,652
1965		0%	451	0%		0%	111,868
1966		0%	154	0%		0%	87,589
1967		0%	293	0%		0%	66,781
1968		0%	289	1%		0%	56,023
1969		0%	220	0%		0%	44,009
1970		0%	283	0%	949	1%	80,610
1971		0%	2,078	6%		0%	32,118
1972		0%	435	1%	5,907	7%	79,717
1973		0%	977	3%	1,712	5%	34,006
1974		0%	1,379	3%	1,377	3%	49,340
1975		0%	2,838	6%	13,326	29%	46,553
1976		0%	4,190	10%	13,126	30%	43,465
1977	7,625	11%	3,262	5%	20,975	31%	67,348
1978	6,282	10%	3,295	5%	23,418	38%	61,092
1979	9,504	13%	5,593	7%	21,279	28%	75,195
1980	58,156	54%	5,788	5%	15,533	14%	108,531
1981	55,516	53%	10,462	10%	16,661	16%	104,199
1982	57,978	59%	1,526	2%	19,546	20%	98,233
1983	59,026	62%	9,955	11%	11,585	12%	94,617
1984	81,834	56%	22,216	15%	35,998	24%	147,022
1985	58,730	52%	12,690	11%	37,856	33%	113,310
1986	46,641	48%	10,332	11%	31,978	33%	96,259
1987	28,720	35%	13,207	16%	30,049	37%	81,364
1988	43,000	56%	5,165	7%	21,656	28%	77,383
1989	156,000	84%	4,118	2%	14,868	8%	186,494
1990	73,000	58%	8,081	6%	21,725	17%	124,886
1991	78,104	66%	6,714	6%	22,258	19%	117,942
1992	54,036	33%	42,889	26%	46,831	28%	164,513
1993	57,184	32%	34,234	19%	65,805	37%	179,659
1994	58,708	33%	22,421	13%	69,401	40%	175,614
1995	64,925	35%	16,534	9%	81,214	44%	183,862
1996	28,933	15%	31,389	16%	103,087	54%	190,750
1997	26,872	19%	25,166	18%	65,668	47%	139,049
1998	23,821	18%	34,964	26%	56,195	42%	134,182
1999	965	1%	27,714	27%	51,636	50%	102,582
2000	1,244	1%	39,684	36%	46,990	43%	110,327
2001	824	1%	34,207	28%	61,296	51%	120,550
2002	1,177	1%	30,801	31%	44,722	46%	98,216
2003	1,653	1%	32,459	29%	52,988	47%	111,891
2004	1,172	1%	28,869	28%	53,403	51%	104,751
2005	1,621	2%	22,098	22%	58,463	58%	100,600

Table 2.9c

Gulf of Alaska (GOA)	Percent pollock/GOA Groundfish		Percent P. cod/GOA Groundfish		Percent Atka mackerel/GOA Groundfish		Total GOA Groundfish
Year	**Pollock**	**%**	**P. cod**	**%**	**A. mackerel**	**%**	**Total**
1964	1,126	0%	196	0%		0%	248,192
1965	2,749	1%	599	0%		0%	360,131
1966	8,932	4%	1,376	1%		0%	221,172
1967	6,276	5%	2,225	2%		0%	139,206
1968	6,164	5%	1,046	1%		0%	125,822
1969	17,553	15%	1,335	1%		0%	113,333
1970	9,343	11%	1,805	2%		0%	84,983
1971	9,458	8%	523	0%		0%	115,758
1972	34,081	21%	3,513	2%		0%	158,768
1973	36,836	25%	5,963	4%		0%	144,478
1974	61,880	40%	5,182	3%		0%	153,143
1975	59,512	42%	6,745	5%		0%	142,015
1976	86,527	50%	6,764	4%		0%	174,081
1977	112,089	57%	2,267	1%	19,455	10%	195,768
1978	90,822	56%	12,190	8%	19,588	12%	160,830
1979	98,508	61%	14,904	9%	10,949	7%	162,675
1980	110,100	54%	35,345	17%	13,166	7%	202,426
1981	139,168	58%	36,131	15%	18,727	8%	239,476
1982	168,693	72%	29,465	13%	6,760	3%	234,001
1983	215,567	73%	36,540	12%	12,260	4%	296,988
1984	307,400	86%	23,896	7%	1,153	0%	356,659
1985	284,823	89%	14,428	4%	1,848	1%	320,656
1986	93,567	63%	25,012	17%	4	0%	147,483
1987	69,536	47%	32,939	22%	1	0%	146,703
1988	65,625	41%	33,802	21%	0	0%	158,411
1989	78,220	42%	43,293	23%	0	0%	188,253
1990	90,490	38%	72,517	31%	1,416	1%	236,591
1991	107,500	43%	76,997	31%	3,258	1%	247,657
1992	93,904	36%	80,100	31%	13,834	5%	261,694
1993	108,591	42%	55,994	22%	5,146	2%	256,482
1994	110,891	48%	47,985	21%	3,538	2%	232,578
1995	73,248	34%	69,053	32%	701	0%	216,585
1996	50,206	25%	67,966	34%	1,580	1%	199,992
1997	89,892	39%	68,474	30%	331	0%	231,312
1998	123,751	50%	62,101	25%	317	0%	246,113
1999	95,637	41%	68,613	30%	262	0%	231,780
2000	71,876	35%	54,492	27%	170	0%	204,396
2001	70,485	39%	41,614	23%	76	0%	182,011
2002	49,300	28%	52,270	30%	85	0%	173,554
2003	49,300	27%	52,500	29%	578	0%	180,173
2004	62,826	37%	43,104	25%	819	0%	171,734
2005	80,181	44%	33,462	18%	882	0%	182,957

Table 2.30 Comparison of current and proposed management measures to the 2000 BiOp RPA.

Management Measures	**RPA from the FMP Biological Opinion**	**SSL Protection Measures Since 2000 BiOp**	**Additional Measures That May Protect SSLs**	**Proposed Action**
Harvest Control Rule	NMFS 2000 Biological Opinion Global Control Rule	Harvest Control Rule - no directed fishing if biomass < B20% for P. cod, pollock, and Atka mackerel (679.20(d)(4))		
No Transit Zones	3 nm no-transit zones around principal rookeries	3 nm no-transit and no groundfish fishing zones around principal rookeries (Table 12 to part 679)		

Area Closures	All CH/RFRPA sites designated as restricted or closed to fishing for pollock, cod, and mackerel	• Specified closures around rookeries & haulouts by fishery, area, season, and gear type (Tables 4-6 and 12 to part 679) • Bering Sea Pollock Restriction Area closed to pollock fishing in A season (679.22(a)(7)(ii)) • Bogoslof Area and Seguam Foraging Area closed to directed fishing for pollock, cod, and mackerel. (679.22(a)(7)(I) and (a)(8)(i)) • No fishing for pollock in CH in the AI (679.22(a)(8)(ii)) • No trawl fishing for P. Cod in the Atka mackerel harvest limit area (HLA) during the Atka mackerel HLA fishery (679.22(a)(8)(iv)) • No fishing for Atka mackerel in the HLA except during assigned periods and locations of HLA fishery (679.20(a)(8)(iii)) • No directed fishing for Atka mackerel in the GOA (679.22 (b)(2)(iv))	• EFH and HAPC rule bottom contact gear closures around seamounts and coral gardens which may be used for foraging by SSLs and may be located near SSL rookeries and haulouts, reducing disturbance and potential competition. (Tables 22, 23, and 26 to part 679) • Walrus Protection Area closure to fishing 3-12 nm around Round Island and the Twins 4/1-9/30 (679.22(a)(4)) • No trawling in Pribilof Island Habitat Conservation Zone (679.22(a)(6)) • CVOA closed to pollock C/Ps in the B season (679.22(a)(5)) • Near Shore Bristol Bay Trawl Closure between 4/1-6/15 (679.22 (a)(9))	

Season Closures	• No trawling 1/1 to 1/20; • no trawling for pollock, cod, or mackerel 11/1 to 1/20; • no fishing for pollock, cod, or mackerel inside CH 11/1 to 1/20	• No groundfish trawling 1/1 to 1/20 (679.23(c)) • Closure period between GOA pollock B and C seasons (679.23(d)(2)) • Closure period between AI Atka mackerel A and B seasons (679.23(e)(3)) • Closure period between BSAI P. cod pot A and B seasons (679.23(e)(5)) • No trawling for Atka mackerel, pollock, or cod 11/1 to 12/31(679.23)		
Seasons and Apportionments pollock	• BSAI - 1/20 (40%), 6/11 (60%); • GOA - 1/20 (40%), 6/11 (60%)	• AI - 1/20: no more than 40 % of ABC; 6/11 remainder of annual TAC (679.20(a)(5)(iii)) • BS 1/20-6/10 (40%), 6/10-11/1 (60%); (679.20(a)(5)(i)(B)) • GOA - 1/20 -3/10 (25%); 3/10- 5/31 (25%), 8/25-10/1 (25%), 10/1-11/1 (25%) (679.20(a)(5)(iv))		
Seasons and Apportionments cod	• BSAI - 1/20 (40%), 6/11 (60%); • GOA - 1/20 (40%), 6/11 (60%)	• BSAI trawl - 1/20-4/1 (60%), 4/1-6/10 (20%), 6/10-11/1 (20%) (679.20(a)(7)(iii)) • BSAI longline- 1/1-6/10 (60%), 6/10-12/31 (40%) (679.20(a)(7)(iii)) • BSAI pot - 1/1-6/10 (60%), 9/1-12/31 (40%) (679.20(a)(7)(iii)) • BSAI jig- 1/1-4/30 (40 %), 4/30-8/31 (20 %), 8/3-12/31 (40%) (679.20(a)(7)(iii)) • W/C GOA trawl - 1/20-6/10 (60%), 9/1-12/31 (40%) (679.20(a)(11)) • W/C GOA fixed - 1/1-6/10 (60%), 9/1-12/31 (40%) (679.20(a)(11))		
Seasons and Apportionments mackerel	• BSAI - 1/20 (40%), 6/11 (60%); • GOA - 1/20 (40%), 6/11 (60%)	BSAI - 1/20 - 4/15 (50%) and 9/1-11/1 (50%) (679.20(a)(8)(ii)(A)		

Catch Limits Inside CH	Pollock, cod, and mackerel: 4 seasons (1/20, 4/1, 5/11 8/22) inside CH/RFRPA with catch limits based on season and area specific biomass estimates	- A season pollock harvest in SCA limited to 28% of annual TAC prior to April 1 (679.20(a)(5)(i)(C)) - Mackerel harvest of seasonal apportionment limited to 60% inside CH (679.20(a)(8)(ii)(C))		
Other Catch Limits		- HLA fishery in the AI does platooning of the Atka mackerel fishery to reduce effort inside CH. (679.20(a)(8)(iii)) - 50% allocation of AI pollock to vessels < 60ft by 2013 and beyond slowing fishing rate (679.20(a)(5)(iii))		
Experimental Design	Large scale: 4 sets of restricted/closed areas for comparison	Small scale experiments for Pacific cod, Atka mackerel, and pollock testing local depletion hypothesis		Adaptive management research?
Observer Coverage	No change to current observer coverage requirements	No change to current observer coverage requirements		
VMS		VMS required on all vessels (except those using jig gear) when fishing for pollock, cod, or mackerel. (679.7(a)(18))	- All vessels in AI required to operate VMS. (679.7(a)(21)) - All vessels in GOA with mobile bottom contact gear on board required to have VMS (679.7(a)(22))	

Registration Requirements	None	Preregistration required for Atka mackerel fishery	• AFA for BS pollock, slows down fishery to reduce potential competition. (Part 679, subpart F) • Registration required for AI pollock fishery (679.7(l))	

Table 2.31 Steller Sea Lion Protection Areas 3nm No Groundfish Fishing Sites (Table 12 to 50 CFR Part 679)

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		No transit[2]
		Latitude	Longitude	Latitude	Longitude	3 nm
Walrus I. (Pribilofs)	Bering Sea	57 11.00 N	169 56.00 W			Y
Attu I./Cape Wrangell	Aleutian I.	52 54.60 N	172 27.90 E	52 55.40 N	172 27.20 E	Y
Agattu I./Gillon Pt.	Aleutian I.	52 24.13 N	173 21.31 E			Y
Agattu I./Cape Sabak	Aleutian I.	52 22.50 N	173 43.30 E	52 21.80 N	173 41.40 E	Y
Buldir I.	Aleutian I.	52 20.25 N	175 54.03 E	52 20.38 N	175 53.85 E	Y
Kiska I./Cape St. Stephen	Aleutian I.	51 52.50 N	177 12.70 E	51 53.50 N	177 12.00 E	Y
Kiska I./Lief Cove	Aleutian I.	51 57.16 N	177 20.41 E	51 57.24 N	177 20.53 E	Y
Ayugadak Point	Aleutian I.	51 45.36 N	178 24.30 E			Y
Amchitka I./Column Rocks	Aleutian I.	51 32.32 N	178 49.28 E			Y
Amchitka I./East Cape	Aleutian I.	51 22.26 N	179 27.93 E	51 22.00 N	179 27.00 E	Y
Semisopochnoi/Petrel Pt.	Aleutian I.	52 01.40 N	179 36.90 E	52 01.50 N	179 39.00 E	Y
Semisopochnoi I./Pochnoi Pt.	Aleutian I.	51 57.30 N	179 46.00 E			Y
Ulak I./Hasgox Pt.	Aleutian I.	51 18.90 N	178 58.90 W	51 18.70 N	178 59.60 W	Y
Tag I.	Aleutian I.	51 33.50 N	178 34.50 W			Y
Gramp Rock	Aleutian I.	51 28.87 N	178 20.58 W			Y
Adak I.	Aleutian I.	51 35.50 N	176 57.10 W	51 37.40 N	176 59.60 W	Y
Kasatochi I.	Aleutian I.	52 11.11 N	175 31.00 W			Y
Agligadak I.	Aleutian I.	52 06.09 N	172 54.23 W			Y
Seguam I./Saddleridge Pt.	Aleutian I.	52 21.05 N	172 34.40 W	52 21.02 N	172 33.60 W	Y
Yunaska I.	Aleutian I.	52 41.40 N	170 36.35 W			Y
Adugak I.	Bering Sea	52 54.70 N	169 10.50 W			Y
Ogchul I.	Gulf of Alaska	52 59.71 N	168 24.24 W			Y
Bogoslof I./Fire I.	Bering Sea	53 55.69 N	168 02.05 W			Y
Akutan I./Cape Morgan	Gulf of Alaska	54 03.39 N	165 59.65 W	54 03.70 N	166 03.68 W	Y
Akun I./Billings Head	Bering Sea	54 17.62 N	165 32.06 W	54 17.57 N	165 31.71 W	Y

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		No transit[2]
		Latitude	Longitude	Latitude	Longitude	3 nm
Ugamak I.	Gulf of Alaska	54 13.50 N	164 47.50 W	54 12.80 N	164 47.50 W	Y
Sea Lion Rock (Amak)	Bering Sea	55 27.82 N	163 12.10 W			Y
Clubbing Rocks (S)	Gulf of Alaska	54 41.98 N	162 26.7 W			Y
Clubbing Rocks (N)	Gulf of Alaska	54 42.75 N	162 26.7 W			Y
Pinnacle Rock	Gulf of Alaska	54 46.06 N	161 45.85 W			Y
Chernabura I.	Gulf of Alaska	54 45.18 N	159 32.99 W	54 45.87 N	159 35.74 W	Y
Atkins I.	Gulf of Alaska	55 03.20 N	159 17.40 W			Y
Chowiet I.	Gulf of Alaska	56 00.54 N	156 41.42 W	55 00.30 N	156 41.60 W	Y
Chirikof I.	Gulf of Alaska	55 46.50 N	155 39.50 W	55 46.44 N	155 43.46 W	Y
Sugarloaf I.	Gulf of Alaska	58 53.25 N	152 02.40 W			Y
Marmot I.	Gulf of Alaska	58 13.65 N	151 47.75 W	58 09.90 N	151 52.06 W	Y
Outer (Pye) I.	Gulf of Alaska	59 20.50 N	150 23.00 W	59 21.00 N	150 24.50 W	Y
Wooded I. (Fish I.)	Gulf of Alaska	59 52.90 N	147 20.65 W			
Seal Rocks (Cordova)	Gulf of Alaska	60 09.78 N	146 50.30 W			

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

[2] See 50 CFR 223.202(a)(2)(i) for regulations regarding 3 nm no transit zones.

Note: No groundfish fishing zones are the waters between 0 nm to 3 nm surrounding each site.

Table 2.32 Steller Sea Lion Protection Areas Pollock Fisheries Restrictions (Table 4 to 50 CFR Part 679)

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pollock No-fishing Zones for Trawl Gear [2,8](nm)
		Latitude	Longitude	Latitude	Longitude	
St. Lawrence I./S Punuk I.	Bering Sea	63 04.00 N	168 51.00 W			20
St. Lawrence I./SW Cape	Bering Sea	63 18.00 N	171 26.00 W			20
Hall I.	Bering Sea	60 37.00 N	173 00.00 W			20
St. Paul I./Sea Lion Rock	Bering Sea	57 06.00 N	170 17.50 W			3
St. Paul I./NE Pt.	Bering Sea	57 15.00 N	170 06.50 W			3
Walrus I. (Pribilofs)	Bering Sea	57 11.00 N	169 56.00 W			10
St. George I./Dalnoi Pt.	Bering Sea	56 36.00 N	169 46.00 W			3
St. George I./S Rookery	Bering Sea	56 33.50 N	169 40.00 W			3
Cape Newenham	Bering Sea	58 39.00 N	162 10.50 W			20
Round (Walrus Islands)	Bering Sea	58 36.00 N	159 58.00 W			20
Attu I./Cape Wrangell	Aleutian I.	52 54.60 N	172 27.90 E	52 55.40 N	172 27.20 E	20
Agattu I./Gillon Pt.	Aleutian I.	52 24.13 N	173 21.31 E			20
Attu I./Chirikof Pt.	Aleutian I.	52 49.75 N	173 26.00 E			20
Agattu I./Cape Sabak	Aleutian I.	52 22.50 N	173 43.30 E	52 21.80 N	173 41.40 E	20
Alaid I.	Aleutian I.	52 46.50 N	173 51.50 E	52 45.00 N	173 56.50 E	20
Shemya I.	Aleutian I.	52 44.00 N	174 08.70 E			20
Buldir I.	Aleutian I.	52 20.25 N	175 54.03 E	52 20.38 N	175 53.85 E	20
Kiska I./Cape St. Stephen	Aleutian I.	51 52.50 N	177 12.70 E	51 53.50 N	177 12.00 E	20
Kiska I./Sobaka & Vega	Aleutian I.	51 49.50 N	177 19.00 E	51 48.50 N	177 20.50 E	20
Kiska I./Lief Cove	Aleutian I.	51 57.16 N	177 20.41 E	51 57.24 N	177 20.53 E	20
Kiska I./Sirius Pt.	Aleutian I.	52 08.50 N	177 36.50 E			20
Tanadak I. (Kiska)	Aleutian I.	51 56.80 N	177 46.80 E			20
Segula I.	Aleutian I.	51 59.90 N	178 05.80 E	52 03.06 N	178 08.80 E	20
Ayugadak Point	Aleutian I.	51 45.36 N	178 24.30 E			20

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pollock No-fishing Zones for Trawl Gear [2,8](nm)
		Latitude	Longitude	Latitude	Longitude	
Rat I./Krysi Pt.	Aleutian I.	51 49.98 N	178 12.35 E			20
Little Sitkin I.	Aleutian I.	51 59.30 N	178 29.80 E			20
Amchitka I./Column Rocks	Aleutian I.	51 32.32 N	178 49.28 E			20
Amchitka I./East Cape	Aleutian I.	51 22.26 N	179 27.93 E	51 22.00 N	179 27.00 E	20
Amchitka I./Cape Ivakin	Aleutian I.	51 24.46 N	179 24.21 E			20
Semisopochnoi/Petrel Pt.	Aleutian I.	52 01.40 N	179 36.90 E	52 01.50 N	179 39.00 E	20
Semisopochnoi I./Pochnoi Pt.	Aleutian I.	51 57.30 N	179 46.00 E			20
Amatignak I. Nitrof Pt.	Aleutian I.	51 13.00 N	179 07.80 W			20
Unalga & Dinkum Rocks	Aleutian I.	51 33.67 N	179 04.25 W	51 35.09 N	179 03.66 W	20
Ulak I./Hasgox Pt.	Aleutian I.	51 18.90 N	178 58.90 W	51 18.70 N	178 59.60 W	20
Kavalga I.	Aleutian I.	51 34.50 N	178 51.73 W	51 34.50 N	178 49.50 W	20
Tag I.	Aleutian I.	51 33.50 N	178 34.50 W			20
Ugidak I.	Aleutian I.	51 34.95 N	178 30.45 W			20
Gramp Rock	Aleutian I.	51 28.87 N	178 20.58 W			20
Tanaga I./Bumpy Pt.	Aleutian I.	51 55.00 N	177 58.50 W	51 55.00 N	177 57.10 W	20
Bobrof I.	Aleutian I.	51 54.00 N	177 27.00 W			20
Kanaga I./Ship Rock	Aleutian I.	51 46.70 N	177 20.72 W			20
Kanaga I./North Cape	Aleutian I.	51 56.50 N	177 09.00 W			20
Adak I.	Aleutian I.	51 35.50 N	176 57.10 W	51 37.40 N	176 59.60 W	20
Little Tanaga Strait	Aleutian I.	51 49.09 N	176 13.90 W			20
Great Sitkin I.	Aleutian I.	52 06.00 N	176 10.50 W	52 06.60 N	176 07.00 W	20
Anagaksik I.	Aleutian I.	51 50.86 N	175 53.00 W			20
Kasatochi I.	Aleutian I.	52 11.11 N	175 31.00 W			20
Atka I./North Cape	Aleutian I.	52 24.20 N	174 17.80 W			20
Amlia I./Sviech. Harbor[11]	Aleutian I.	52 01.80 N	173 23.90 W			20
Sagigik I.[11]	Aleutian I.	52 00.50 N	173 09.30 W			20

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pollock No-fishing Zones for Trawl Gear [2,8](nm)
		Latitude	Longitude	Latitude	Longitude	
Amlia I./East[11]	Aleutian I.	52 05.70 N	172 59.00 W	52 05.75 N	172 57.50 W	20
Tanadak I. (Amlia[11])	Aleutian I.	52 04.20 N	172 57.60 W			20
Agligadak I.[11]	Aleutian I.	52 06.09 N	172 54.23 W			20
Seguam I./Saddleridge Pt.[11]	Aleutian I.	52 21.05 N	172 34.40 W	52 21.02 N	172 33.60 W	20
Seguam I./Finch Pt.	Aleutian I.	52 23.40 N	172 27.70 W	52 23.25 N	172 24.30 W	20
Seguam I./South Side	Aleutian I.	52 21.60 N	172 19.30 W	52 15.55 N	172 31.22 W	20
Amukta I. & Rocks	Aleutian I.	52 27.25 N	171 17.90 W			20
Chagulak I.	Aleutian I.	52 34.00 N	171 10.50 W			20
Yunaska I.	Aleutian I.	52 41.40 N	170 36.35 W			20
Uliaga[3]	Bering Sea	53 04.00 N	169 47.00 W	53 05.00 N	169 46.00 W	20,10
Chuginadak	Gulf of Alaska	52 46.70 N	169 41.90 W			20
Kagamil[3]	Bering Sea	53 02.10 N	169 41.00 W			20,10
Samalga	Gulf of Alaska	52 46.00 N	169 15.00 W			20
Adugak I.[3]	Bering Sea	52 54.70 N	169 10.50 W			10
Umnak I./Cape Aslik[3]	Bering Sea	53 25.00 N	168 24.50 W			BA
Ogchul I.	Gulf of Alaska	52 59.71 N	168 24.24 W			20
Bogoslof I./Fire I.[3]	Bering Sea	53 55.69 N	168 02.05 W			BA
Polivnoi Rock	Gulf of Alaska	53 15.96 N	167 57.99 W			20
Emerald I.	Gulf of Alaska	53 17.50 N	167 51.50 W			20
Unalaska/Cape Izigan	Gulf of Alaska	53 13.64 N	167 39.37 W			20
Unalaska/Bishop Pt.[9]	Bering Sea	53 58.40 N	166 57.50 W			10
Akutan I./Reef-lava[9]	Bering Sea	54 08.10 N	166 06.19 W	54 09.10 N	166 05.50 W	10
Unalaska I./Cape Sedanka[6]	Gulf of Alaska	53 50.50 N	166 05.00 W			20
Old Man Rocks[6]	Gulf of Alaska	53 52.20 N	166 04.90 W			20
Akutan I./Cape Morgan[6]	Gulf of Alaska	54 03.39 N	165 59.65 W	54 03.70 N	166 03.68 W	20
Akun I./Billings Head[9]	Bering Sea	54 17.62 N	165 32.06 W	54 17.57 N	165 31.71 W	10

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pollock No-fishing Zones for Trawl Gear [2,8](nm)
		Latitude	Longitude	Latitude	Longitude	
Rootok[6]	Gulf of Alaska	54 03.90 N	165 31.90 W	54 02.90 N	165 29.50 W	20
Tanginak I.[6]	Gulf of Alaska	54 12.00 N	165 19.40 W			20
Tigalda/Rocks NE[6]	Gulf of Alaska	54 09.60 N	164 59.00 W	54 09.12 N	164 57.18 W	20
Unimak/Cape Sarichef[9]	Bering Sea	54 34.30 N	164 56.80 W			10
Aiktak[6]	Gulf of Alaska	54 10.99 N	164 51.15 W			20
Ugamak I.[6]	Gulf of Alaska	54 13.50 N	164 47.50 W	54 12.80 N	164 47.50 W	20
Round (GOA)[6]	Gulf of Alaska	54 12.05 N	164 46.60 W			20
Sea Lion Rock (Amak)[9]	Bering Sea	55 27.82 N	163 12.10 W			10
Amak I. And rocks[9]	Bering Sea	55 24.20 N	163 09.60 W	55 26.15 N	163 08.50 W	10
Bird I.	Gulf of Alaska	54 40.00 N	163 17.2 W			10
Caton I.	Gulf of Alaska	54 22.70 N	162 21.30 W			3
South Rocks	Gulf of Alaska	54 18.14 N	162 41.3 W			10
Clubbing Rocks (S)	Gulf of Alaska	54 41.98 N	162 26.7 W			10
Clubbing Rocks (N)	Gulf of Alaska	54 42.75 N	162 26.7 W			10
Pinnacle Rock	Gulf of Alaska	54 46.06 N	161 45.85 W			3
Sushilnoi Rocks	Gulf of Alaska	54 49.30 N	161 42.73 W			10
Olga Rocks	Gulf of Alaska	55 00.45 N	161 29.81 W	54 59.09 N	161 30.89 W	10
Jude I.	Gulf of Alaska	55 15.75 N	161 06.27 W			20
Sea Lion Rocks (Shumagins)	Gulf of Alaska	55 04.70 N	160 31.04 W			3
Nagai I./Mountain Pt.	Gulf of Alaska	54 54.20 N	160 15.40 W	54 56.00 N	160 15.00 W	3
The Whaleback	Gulf of Alaska	55 16.82 N	160 05.04 W			3
Chernabura I.	Gulf of Alaska	54 45.18 N	159 32.99 W	54 45.87 N	159 35.74 W	20
Castle Rock	Gulf of Alaska	55 16.47 N	159 29.77 W			3
Atkins I.	Gulf of Alaska	55 03.20 N	159 17.40 W			20
Spitz I.	Gulf of Alaska	55 46.60 N	158 53.90 W			3
Mitrofania	Gulf of Alaska	55 50.20 N	158 41.90 W			3

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pollock No-fishing Zones for Trawl Gear [2,8](nm)
		Latitude	Longitude	Latitude	Longitude	
Kak	Gulf of Alaska	56 17.30 N	157 50.10 W			20
Lighthouse Rocks	Gulf of Alaska	55 46.79 N	157 24.89 W			20
Sutwik I.	Gulf of Alaska	56 31.05 N	157 20.47 W	56 32.00 N	157 21.00 W	20
Chowiet I.	Gulf of Alaska	56 00.54 N	156 41.42 W	55 00.30 N	156 41.60 W	20
Nagai Rocks	Gulf of Alaska	55 49.80 N	155 47.50 W			20
Chirikof I.	Gulf of Alaska	55 46.50 N	155 39.50 W	55 46.44 N	155 43.46 W	20
Puale Bay[12]	Gulf of Alaska	57 40.60 N	155 23.10 W			3,10
Kodiak/Cape Ikolik	Gulf of Alaska	57 17.20 N	154 47.50 W			3
Takli I.	Gulf of Alaska	58 01.75 N	154 31.25 W			10
Cape Kuliak	Gulf of Alaska	58 08.00 N	154 12.50 W			10
Cape Gull	Gulf of Alaska	58 11.50 N	154 09.60 W	58 12.50 N	154 10.50 W	10
Kodiak/Cape Ugat	Gulf of Alaska	57 52.41 N	153 50.97 W			10
Sitkinak/Cape Sitkinak	Gulf of Alaska	56 34.30 N	153 50.96 W			10
Shakun Rock	Gulf of Alaska	58 32.80 N	153 41.50 W			10
Twoheaded I.	Gulf of Alaska	56 54.50 N	153 32.75 W	56 53.90 N	153 33.74 W	10
Cape Douglas (Shaw I.)[12]	Gulf of Alaska	59 00.00 N	153 22.50 W			20,10
Kodiak/Cape Barnabas	Gulf of Alaska	57 10.20 N	152 53.05 W			3
Kodiak/Gull Point[4]	Gulf of Alaska	57 21.45 N	152 36.30 W			10, 3
Latax Rocks	Gulf of Alaska	58 40.10 N	152 31.30 W			10
Ushagat I./SW	Gulf of Alaska	58 54.75 N	152 22.20 W			10
Ugak I.[4]	Gulf of Alaska	57 23.60 N	152 17.50 W	57 21.90 N	152 17.40 W	10, 3
Sea Otter I.	Gulf of Alaska	58 31.15 N	152 13.30 W			10
Long I.	Gulf of Alaska	57 46.82 N	152 12.90 W			10
Sud I.	Gulf of Alaska	58 54.00 N	152 12.50 W			10
Kodiak/Cape Chiniak	Gulf of Alaska	57 37.90 N	152 08.25 W			10
Sugarloaf I.	Gulf of Alaska	58 53.25 N	152 02.40 W			20

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pollock No-fishing Zones for Trawl Gear [2,8](nm)
		Latitude	Longitude	Latitude	Longitude	
Sea Lion Rocks (Marmot)	Gulf of Alaska	58 20.53 N	151 48.83 W			10
Marmot I.[5]	Gulf of Alaska	58 13.65 N	151 47.75 W	58 09.90 N	151 52.06 W	15, 20
Nagahut Rocks	Gulf of Alaska	59 06.00 N	151 46.30 W			10
Perl	Gulf of Alaska	59 05.75 N	151 39.75 W			10
Gore Point	Gulf of Alaska	59 12.00 N	150 58.00 W			10
Outer (Pye) I.	Gulf of Alaska	59 20.50 N	150 23.00 W	59 21.00 N	150 24.50 W	20
Steep Point	Gulf of Alaska	59 29.05 N	150 15.40 W			10
Seal Rocks (Kenai)	Gulf of Alaska	59 31.20 N	149 37.50 W			10
Chiswell Islands	Gulf of Alaska	59 36.00 N	149 34.00 W			10
Rugged Island	Gulf of Alaska	59 50.00 N	149 23.10 W	59 51.00 N	149 24.70 W	10
Point Elrington[7, 10]	Gulf of Alaska	59 56.00 N	148 15.20 W			20
Perry I.[7]	Gulf of Alaska	60 44.00 N	147 54.60 W			
The Needle[7]	Gulf of Alaska	60 06.64 N	147 36.17 W			
Point Eleanor[7]	Gulf of Alaska	60 35.00 N	147 34.00 W			
Wooded I. (Fish I.)	Gulf of Alaska	59 52.90 N	147 20.65 W			20
Glacier Island[7]	Gulf of Alaska	60 51.30 N	147 14.50 W			
Seal Rocks (Cordova)[10]	Gulf of Alaska	60 09.78 N	146 50.30 W			20
Cape Hinchinbrook[10]	Gulf of Alaska	60 14.00 N	146 38.50 W			20
Middleton I.	Gulf of Alaska	59 28.30 N	146 18.80 W			10
Hook Point[10]	Gulf of Alaska	60 20.00 N	146 15.60 W			20
Cape St. Elias	Gulf of Alaska	59 47.50 N	144 36.20 W			20

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

[2] Closures as stated in 50 CFR 679.22(a)(7)(iv), (a)(8)(ii) and (b)(2)(ii).

[3] This site lies within the Bogoslof area (BA). The BA consists of all waters of area 518 as described in Figure 1 of this part south of a straight line connecting 55°00' N/170°00' W, and 55°00' N/168°11'4.75" W. Closure to directed fishing for pollock around Uliaga and Kagamil is 20 nm for waters west of 170°W long. and 10 nm for waters east of 170°W long.

[4] The trawl closure between 0 nm to 10 nm is effective from January 20 through May 31. Trawl closure between 0 nm to 3 nm is effective from August 25 through November 1.

[5] Trawl closure between 0 nm to 15 nm is effective from January 20 through May 31. Trawl closure between 0 nm to 20 nm is effective from August 25 to November 1.

[6] Restriction area includes only waters of the Gulf of Alaska Area.

[7] Contact the Alaska Department of Fish and Game for fishery restrictions at these sites.

[8] No-fishing zones are the waters between 0 nm and the nm specified in column 7 around each site and within the BA.

[9] This site is located in the Bering Sea Pollock Restriction Area, closed to pollock trawling during the A season. This area consists of all waters of the Bering Sea subarea south of a line connecting the points 163° 0'00" W long./55°46'30" N lat., 165°08'00" W long./54°42'9" N lat., 165°40'00" long./54°26'30" N lat., 166°12'00" W long./54°18'40" N lat., and 167°0'00" W long./54°8'50" N lat.

[10] The 20 nm closure around this site is effective in federal waters outside of State of Alaska waters of Prince William Sound.

[11] Some or all of the restricted area is located in the Seguam Foraging area (SFA) which is closed to all gears types. The SFA is established as all waters within the area between 52°N lat. and 53°N lat. and between 173°30' W long. and 172°30' W long.

[12]The 3 nm trawl closure around Puale Bay and the 20 nm trawl closure around Cape Douglas/Shaw I. are effective January 20 through May 31. The 10 nm trawl closure around Puale Bay and the 10 nm trawl closure around Cape Douglas/Shaw I. are effective August 25 through November 1.

Table 2.33 Steller Sea Lion Protection Areas Pacific Cod Fisheries Restrictions (Table 5 to 50 CFR Part 679)

Column Number 1	2	3	4	5	6	7	8	9
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pacific Cod No-fishing Zones for Trawl Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Hook-and-Line Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Pot Gear[2,3] (nm)
		Latitude	Longitude	Latitude	Longitude			
St. Lawrence I./S Punuk I.	BS	63 04.00 N	168 51.00 W			20	20	20
St. Lawrence I./SW Cape	BS	63 18.00 N	171 26.00 W			20	20	20
Hall I.	BS	60 37.00 N	173 00.00 W			20	20	20
St. Paul I./Sea Lion Rock	BS	57 06.00 N	170 17.50 W			3	3	3
St. Paul I./NE Pt.	BS	57 15.00 N	170 06.50 W			3	3	3
Walrus I. (Pribilofs)	BS	57 11.00 N	169 56.00 W			10	3	3
St George I./Dalnoi Pt.	BS	56 36.00 N	169 46.00 W			3	3	3
St. George I./S. Rookery	BS	56 33.50 N	169 40.00 W			3	3	3
Cape Newenham	BS	58 39.00 N	162 10.50 W			20	20	20
Round (Walrus Islands)	BS	58 36.00 N	159 58.00 W			20	20	20
Attu I./Cape Wrangell[11]	AI	52 54.60 N	172 27.90 E	52 55.40 N	172 27.20 E	20, 10	3	3
Agattu I./Gillon Pt.[11]	AI	52 24.13 N	173 21.31 E			20, 10	3	3
Attu I./Chirikof Pt.[11]	AI	52 49.75 N	173 26.00 E			20, 3		
Agattu I./Cape Sabak[11]	AI	52 22.50 N	173 43.30 E	52 21.80 N	173 41.40 E	20, 10	3	3
Alaid I.[11]	AI	52 46.50 N	173 51.50 E	52 45.00 N	173 56.50 E	20, 3		
Shemya I.[11]	AI	52 44.00 N	174 08.70 E			20, 3		
Buldir I.[11]	AI	52 20.25 N	175 54.03 E	52 20.38 N	175 53.85 E	20, 10	10	10
Kiska I./Cape St. Stephen[11]	AI	51 52.50 N	177 12.70 E	51 53.50 N	177 12.00 E	20, 10	3	3
Kiska I. Sobaka & Vega[11]	AI	51 49.50 N	177 19.00 E	51 48.50 N	177 20.50 E	20, 3		
Kiska I./Lief Cove[11]	AI	51 57.16 N	177 20.41 E	51 57.24 N	177 20.53 E	20, 10	3	3
Kiska I./Sirius Pt.[11]	AI	52 08.50 N	177 36.50 E			20, 3		
Tanadak I. (Kiska)[11]	AI	51 56.80 N	177 46.80 E			20, 3		

Column Number 1	2	3	4	5	6	7	8	9
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pacific Cod No-fishing Zones for Trawl Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Hook-and-Line Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Pot Gear[2,3] (nm)
		Latitude	Longitude	Latitude	Longitude			
Segula I.[11]	AI	51 59.90 N	178 05.80 E	52 03.06 N	178 08.80 E	20, 3		
Ayugadak Point[11]	AI	51 45.36 N	178 24.30 E			20, 10	3	3
Rat I./Krysi Pt.[11]	AI	51 49.98 N	178 12.35 E			20, 3		
Little Sitkin I.[11]	AI	51 59.30 N	178 29.80 E			20, 3		
Amchitka I./Column[11]	AI	51 32.32 N	178 49.28 E			20, 10	3	3
Amchitka I./East Cape[11]	AI	51 22.26 N	179 27.93 E	51 22.00 N	179 27.00 E	20,10	3	3
Amchitka I./Cape Ivakin[11]	AI	51 24.46 N	179 24.21 E			20, 3		
Semisopochnoi/Petrel Pt.[11]	AI	52 01.40 N	179 36.90 E	52 01.50 N	179 39.00 E	20, 10	3	3
Semisopochnoi I./Pochnoi Pt.[11]	AI	51 57.30 N	179 46.00 E			20, 10	3	3
Amatignak I./Nitrof Pt.[11]	AI	51 13.00 N	179 07.80 W			20, 3		
Unalga & Dinkum Rocks[11]	AI	51 33.67 N	179 04.25 W	51 35.09 N	179 03.66 W	20, 3		
Ulak I./Hasgox Pt.[11]	AI	51 18.90 N	178 58.90 W	51 18.70 N	178 59.60 W	20, 10	3	3
Kavalga I.[11]	AI	51 34.50 N	178 51.73 W	51 34.50 N	178 49.50 W	20, 3		
Tag I.[11]	AI	51 33.50 N	178 34.50 W			20, 10	3	3
Ugidak I.[11]	AI	51 34.95 N	178 30.45 W			20, 3		
Gramp Rock[11]	AI	51 28.87 N	178 20.58 W			20, 10	3	3
Tanaga I./Bumpy Pt.[11]	AI	51 55.00 N	177 58.50 W	51 55.00 N	177 57.10 W	20,3		
Bobrof I.	AI	51 54.00 N	177 27.00 W			3		
Kanaga I./Ship Rock	AI	51 46.70 N	177 20.72 W			3		
Kanaga I./North Cape	AI	51 56.50 N	177 09.00 W			3		
Adak I.	AI	51 35.50 N	176 57.10 W	51 37.40 N	176 59.60 W	10	3	3
Little Tanaga Strait	AI	51 49.09 N	176 13.90 W			3		
Great Sitkin I.	AI	52 06.00 N	176 10.50 W	52 06.60 N	176 07.00 W	3		
Anagaksik I.	AI	51 50.86 N	175 53.00 W			3		
Kasatochi I.	AI	52 11.11 N	175 31.00 W			10	3	3

Column Number 1	2	3	4	5	6	7	8	9
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pacific Cod No-fishing Zones for Trawl Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Hook-and-Line Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Pot Gear[2,3] (nm)
		Latitude	Longitude	Latitude	Longitude			
Atka I./N. Cape	AI	52 24.20 N	174 17.80 W			3		
Amlia I./Sviech. Harbor[4]	AI	52 01.80 N	173 23.90 W			3		
Sagigik I.[4]	AI	52 00.50 N	173 09.30 W			3		
Amlia I./East[4]	AI	52 05.70 N	172 59.00 W	52 05.75 N	172 57.50 W	3	20	20
Tanadak I. (Amlia)[4]	AI	52 04.20 N	172 57.60 W			3	20	20
Agligadak I.[4]	AI	52 06.09 N	172 54.23 W			20	20	20
Seguam I./Saddleridge Pt.[4]	AI	52 21.05 N	172 34.40 W	52 21.02 N	172 33.60 W	10	20	20
Seguam I./Finch Pt.	AI	52 23.40 N	172 27.70 W	52 23.25 N	172 24.30 W	3	20	20
Seguam I./South Side	AI	52 21.60 N	172 19.30 W	52 15.55 N	172 31.22 W	3	20	20
Amukta I. & Rocks	AI	52 27.25 N	171 17.90 W			3	20	20
Chagulak I.	AI	52 34.00 N	171 10.50 W			3	20	20
Yunaska I.	AI	52 41.40 N	170 36.35 W			10	20	20
Uliaga[5, 14]	BS	53 04.00 N	169 47.00 W	53 05.00 N	169 46.00 W	10	20	20
Chuginadak[14]	GOA	52 46.70 N	169 41.90 W			20	20,10	20
Kagamil[5, 14]	BS	53 02.10 N	169 41.00 W			10	20	20
Samalga	GOA	52 46.00 N	169 15.00 W			20	10	20
Adugak I.[5]	BS	52 54.70 N	169 10.50 W			10	BA	BA
Umnak I./Cape Aslik[5]	BS	53 25.00 N	168 24.50 W			BA	BA	BA
Ogchul I.	GOA	52 59.71 N	168 24.24 W			20	10	20
Bogoslof I./Fire I.[5]	BS	53 55.69 N	168 02.05 W			BA	BA	BA
Polivnoi Rock[9]	GOA	53 15.96 N	167 57.99 W			20	10	20
Emerald I.[13, 9]	GOA	53 17.50 N	167 51.50 W			20	10	20
Unalaska/Cape Izigan[9]	GOA	53 13.64 N	167 39.37 W			20	10	20
Unalaska/Bishop Pt.[6, 13]	BS	53 58.40 N	166 57.50 W			10	10	3
Akutan I./Reef-lava[6]	BS	54 08.10 N	166 06.19 W	54 09.10 N	166 05.50 W	10	10	3

Column Number 1	2	3	4	5	6	7	8	9
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pacific Cod No-fishing Zones for Trawl Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Hook-and-Line Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Pot Gear[2,3] (nm)
		Latitude	Longitude	Latitude	Longitude			
Unalaska I./Cape Sedanka[9]	GOA	53 50.50 N	166 05.00 W			20	10	20
Old Man Rocks[9]	GOA	53 52.20 N	166 04.90 W			20	10	20
Akutan I./Cape Morgan[9]	GOA	54 03.39 N	165 59.65 W	54 03.70 N	166 03.68 W	20	10	20
Akun I./Billings Head	BS	54 17.62 N	165 32.06 W	54 17.57 N	165 31.71 W	10	3	3
Rootok[9]	GOA	54 03.90 N	165 31.90 W	54 02.90 N	165 29.50 W	20	10	20
Tanginak I.[9]	GOA	54 12.00 N	165 19.40 W			20	10	20
Tigalda/Rocks NE[9]	GOA	54 09.60 N	164 59.00 W	54 09.12 N	164 57.18 W	20	10	20
Unimak/Cape Sarichef	BS	54 34.30 N	164 56.80 W			10	3	3
Aiktak[9]	GOA	54 10.99 N	164 51.15 W			20	10	20
Ugamak I.[9]	GOA	54 13.50 N	164 47.50 W	54 12.80 N	164 47.50 W	20	10	20
Round (GOA)[9]	GOA	54 12.05 N	164 46.60 W			20	10	20
Sea Lion Rock (Amak)	BS	55 27.82 N	163 12.10 W			10	7	7
Amak I. And rocks	BS	55 24.20 N	163 09.60 W	55 26.15 N	163 08.50 W	10	3	3
Bird I.	GOA	54 40.00 N	163 17.2 W			10		
Caton I.	GOA	54 22.70 N	162 21.30 W			3	3	
South Rocks	GOA	54 18.14 N	162 41.3 W			10		
Clubbing Rocks (S)	GOA	54 41.98 N	162 26.7 W			10	3	3
Clubbing Rocks (N)	GOA	54 42.75 N	162 26.7 W			10	3	3
Pinnacle Rock	GOA	54 46.06 N	161 45.85 W			3	3	3
Sushilnoi Rocks	GOA	54 49.30 N	161 42.73 W			10		
Olga Rocks	GOA	55 00.45 N	161 29.81 W	54 59.09 N	161 30.89 W	10		
Jude I.	GOA	55 15.75 N	161 06.27 W			20		
Sea Lion Rocks (Shumagins)	GOA	55 04.70 N	160 31.04 W			3	3	3
Nagai I./Mountain Pt.	GOA	54 54.20 N	160 15.40 W	54.56.00 N	160.15.00 W	3	3	3
The Whaleback	GOA	55 16.82 N	160 05.04 W			3	3	3

Column Number 1	2	3	4	5	6	7	8	9
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pacific Cod No-fishing Zones for Trawl Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Hook-and-Line Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Pot Gear[2,3] (nm)
		Latitude	Longitude	Latitude	Longitude			
Chernabura I.	GOA	54 45.18 N	159 32.99 W	54 45.87 N	159 35.74 W	20	3	3
Castle Rock	GOA	55 16.47 N	159 29.77 W			3	3	
Atkins I.	GOA	55 03.20 N	159 17.40 W			20	3	3
Spitz I.	GOA	55 46.60 N	158 53.90 W			3	3	3
Mitrofania	GOA	55 50.20 N	158 41.90 W			3	3	3
Kak	GOA	56 17.30 N	157 50.10 W			20	20	3
Lighthouse Rocks	GOA	55 46.79 N	157 24.89 W			20	20	20
Sutwik I.	GOA	56 31.05 N	157 20.47 W	56 32.00 N	157 21.00 W	20	20	20
Chowiet I.	GOA	56 00.54 N	156 41.42 W	56 00.30 N	156 41.60 W	20	20	20
Nagai Rocks	GOA	55 49.80 N	155 47.50 W			20	20	20
Chirikof I.	GOA	55 46.50 N	155 39.50 W	55 46.44 N	155 43.46 W	20	20	20
Puale Bay	GOA	57 40.60 N	155 23.10 W			10		
Kodiak/Cape Ikolik	GOA	57 17.20 N	154 47.50 W			3	3	3
Takli I.	GOA	58 01.75 N	154 31.25 W			10		
Cape Kuliak	GOA	58 08.00 N	154 12.50 W			10		
Cape Gull	GOA	58 11.50 N	154 09.60 W	58 12.50 N	154 10.50 W	10		
Kodiak/Cape Ugat	GOA	57 52.41 N	153 50.97 W			10		
Sitkinak/Cape Sitkinak	GOA	56 34.30 N	153 50.96 W			10		
Shakun Rock	GOA	58 32.80 N	153 41.50 W			10		
Twoheaded I.	GOA	56 54.50 N	153 32.75 W	56 53.90 N	153 33.74 W	10		
Cape Douglas (Shaw I.)	GOA	59 00.00 N	153 22.50 W			10		
Kodiak/Cape Barnabas	GOA	57 10.20 N	152 53.05 W			3	3	
Kodiak/Gull Point[7]	GOA	57 21.45 N	152 36.30 W			10, 3		
Latax Rocks	GOA	58 40.10 N	152 31.30 W			10		
Ushagat I./SW	GOA	58 54.75	152 22.20 W			10		
Ugak I.[7]	GOA	57 23.60 N	152 17.50 W	57 21.90 N	152 17.40 W	10, 3		

Column Number 1	2	3	4	5	6	7	8	9
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Pacific Cod No-fishing Zones for Trawl Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Hook-and-Line Gear[2,3] (nm)	Pacific Cod No-fishing Zone for Pot Gear[2,3] (nm)
		Latitude	Longitude	Latitude	Longitude			
Sea Otter I.	GOA	58 31.15 N	152 13.30 W			10		
Long I.	GOA	57 46.82 N	152 12.90 W			10		
Sud I.	GOA	58 54.00 N	152 12.50 W			10		
Kodiak/Cape Chiniak	GOA	57 37.90 N	152 08.25 W			10		
Sugarloaf I.	GOA	58 53.25 N	152 02.40 W			20	10	10
Sea Lion Rocks (Marmot)	GOA	58 20.53 N	151 48.83 W			10		
Marmot I.[8]	GOA	58 13.65 N	151 47.75 W	58 09.90 N	151 52.06 W	15, 20	10	10
Nagahut Rocks	GOA	59 06.00 N	151 46.30 W			10		
Perl	GOA	59 05.75 N	151 39.75 W			10		
Gore Point	GOA	59 12.00 N	150 58.00 W			10		
Outer (Pye) I.	GOA	59 20.50 N	150 23.00 W	59 21.00 N	150 24.50 W	20	10	10
Steep Point	GOA	59 29.05 N	150 15.40 W			10		
Seal Rocks (Kenai)	GOA	59 31.20 N	149 37.50 W			10		
Chiswell Islands	GOA	59 36.00 N	149 34.00 W			10		
Rugged Island	GOA	59 50.00 N	149 23.10 W			10		
Point Elrington[10, 12]	GOA	59 56.00 N	148 15.20 W			20		
Perry I.[10]	GOA	60 44.00 N	147 54.60 W					
The Needle[10]	GOA	60 06.64 N	147 36.17 W					
Point Eleanor[10]	GOA	60 35.00 N	147 34.00 W					
Wooded I. (Fish I.)	GOA	59 52.90 N	147 20.65 W			20	3	3
Glacier Island[10]	GOA	60 51.30 N	147 14.50 W					
Seal Rocks (Cordova)[12]	GOA	60 09.78 N	146 50.30 W			20	3	3
Cape Hinchinbrook[12]	GOA	60 14.00 N	146 38.50 W			20		
Middleton I.	GOA	59 28.30 N	146 18.80 W			10		
Hook Point[12]	GOA	60 20.00 N	146 15.60 W			20		
Cape St. Elias	GOA	59 47.50 N	144 36.20 W			20		

BS = Bering Sea, AI = Aleutian Islands, GOA = Gulf of Alaska

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

[2] Closures as stated in 50 CFR 679.22(a)(7)(v), (a)(8)(iv) and (b)(2)(iii).

[3] No-fishing zones are the waters between 0 nm and the nm specified in columns 7, 8, and 9 around each site and within the Bogoslof area (BA) and the Seguam Foraging Area (SFA).

[4] Some or all of the restricted area is located in the SFA which is closed to all gears types. The SFA is established as all waters within the area between 52° N lat. and 53° N lat. and between 173° 30' W long. and 172° 30' W long. Amlia I./East, and Tanadak I. (Amlia) haulouts 20 nm hook-and-line and pot closures apply only to waters located east of 173° W longitude.

[5] This site lies within the BA which is closed to all gear types. The BA consists of all waters of area 518 as described in Figure 1 of this part south of a straight line connecting 55° 00'N/170° 00'W, and 55° 00' N/168° 11'4.75" W.

[6] Hook-and-line no-fishing zones apply only to vessels greater than or equal to 60 feet LOA in waters east of 167° W long. For Bishop Point the 10 nm closure west of 167° W. long. applies to all hook and line and jig vessels.

[7] The trawl closure between 0 nm to 10 nm is effective from January 20 through June 10. Trawl closure between 0 nm to 3 nm is effective from September 1 through November 1.

[8] The trawl closure between 0 nm to 15 nm is effective from January 20 through June 10. Trawl closure between 0 nm to 20 nm is effective from September 1 through November 1.

[9] Restriction area includes only waters of the Gulf of Alaska Area.

[10] Contact the Alaska Department of Fish and Game for fishery restrictions at these sites.

[11] Directed fishing for Pacific cod using trawl gear is prohibited in the harvest limit area (HLA) as defined at § 679.2 until the HLA Atka mackerel directed fishery in the A or B seasons is completed. The 20 nm closure around Gramp Rock and Tanaga I./Bumpy Pt. applies only to waters west of 178° W long. and only during the HLA directed fishery. After closure of the Atka mackerel HLA directed fishery, directed fishing for Pacific cod using trawl gear is prohibited in the HLA between 0 nm to 10 nm of rookeries and between 0 nm to 3 nm of haulouts. Directed fishing for Pacific cod using trawl gear is prohibited between 0-3 nm of Tanaga I./Bumpy Pt.

[12] The 20 nm closure around this site is effective only in waters outside of the State of Alaska waters of Prince William Sound.

[13] See 50 CFR 679.22(a)(7)(i)(C) for exemptions for catcher vessels less than 60 feet (18.3 m) LOA using jig or hook-and-line gear between Bishop Point and Emerald Island closure areas.

[14] Trawl closure around this site is limited to waters east of 170° 00'00" W long. Closure to hook-and-line fishing around Chuginadak is 20 nm for waters west of 170° W long. and 10 nm for waters east of 170° W long.

Table 2.34 Steller Sea Lion Protection Areas Atka Mackerel Fisheries Restrictions (Table 6 to 50 CFR Part 679)

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Atka mackerel No-fishing Zones for Trawl Gear [2,3](nm)
		Latitude	Longitude	Latitude	Longitude	
St. Lawrence I./S Punuk I.	Bering Sea	63 04.00 N	168 51.00 W			20
St. Lawrence I./SW Cape	Bering Sea	63 18.00 N	171 26.00 W			20
Hall I.	Bering Sea	60 37.00 N	173 00.00 W			20
St. Paul I./Sea Lion Rock	Bering Sea	57 06.00 N	170 17.50 W			20
St. Paul I./NE Pt.	Bering Sea	57 15.00 N	170 06.50 W			20
Walrus I. (Pribilofs)	Bering Sea	57 11.00 N	169 56.00 W			20
St. George I./Dalnoi Pt.	Bering Sea	56 36.00 N	169 46.00 W			20
St. George I./S Rookery	Bering Sea	56 33.50 N	169 40.00 W			20
Cape Newenham	Bering Sea	58 39.00 N	162 10.50 W			20
Round (Walrus Islands)	Bering Sea	58 36.00 N	159 58.00 W			20
Attu I./Cape Wrangell	Aleutian Islands	52 54.60 N	172 27.90 E	52 55.40 N	172 27.20 E	10
Agattu I./Gillon Pt.	Aleutian Islands	52 24.13 N	173 21.31 E			10
Attu I./Chirikof Pt.	Aleutian Islands	52 49.75 N	173 26.00 E			3
Agattu I./Cape Sabak	Aleutian Islands	52 22.50 N	173 43.30 E	52 21.80 N	173 41.40 E	10
Alaid I.	Aleutian Islands	52 46.50 N	173 51.50 E	52 45.00 N	173 56.50 E	3
Shemya I.	Aleutian Islands	52 44.00 N	174 08.70 E			3
Buldir I.	Aleutian Islands	52 20.25 N	175 54.03 E	52 20.38 N	175 53.85 E	15
Kiska I./Cape St. Stephen	Aleutian Islands	51 52.50 N	177 12.70 E	51 53.50 N	177 12.00 E	10
Kiska I./Sobaka & Vega	Aleutian Islands	51 49.50 N	177 19.00 E	51 48.50 N	177 20.50 E	3
Kiska I./Lief Cove	Aleutian Islands	51 57.16 N	177 20.41 E	51 57.24 N	177 20.53 E	10
Kiska I./Sirius Pt.	Aleutian Islands	52 08.50 N	177 36.50 E			3
Tanadak I. (Kiska)	Aleutian Islands	51 56.80 N	177 46.80 E			3
Segula I.	Aleutian Islands	51 59.90 N	178 05.80 E	52 03.06 N	178 08.80 E	3
Ayugadak Point	Aleutian Islands	51 45.36 N	178 24.30 E			10

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Atka mackerel No-fishing Zones for Trawl Gear [2,3](nm)
		Latitude	Longitude	Latitude	Longitude	
Rat I./Krysi Pt.	Aleutian Islands	51 49.98 N	178 12.35 E			3
Little Sitkin I.	Aleutian Islands	51 59.30 N	178 29.80 E			3
Amchitka I./Column Rocks	Aleutian Islands	51 32.32 N	178 49.28 E			10
Amchitka I./East Cape	Aleutian Islands	51 22.26 N	179 27.93 E	51 22.00 N	179 27.00 E	10
Amchitka I./Cape Ivakin	Aleutian Islands	51 24.46 N	179 24.21 E			3
Semisopochnoi/Petrel Pt.	Aleutian Islands	52 01.40 N	179 36.90 E	52 01.50 N	179 39.00 E	10
Semisopochnoi I./Pochnoi Pt.	Aleutian Islands	51 57.30 N	179 46.00 E			10
Amatignak I. Nitrof Pt.	Aleutian Islands	51 13.00 N	179 07.80 W			3
Unalga & Dinkum Rocks	Aleutian Islands	51 33.67 N	179 04.25 W	51 35.09 N	179 03.66 W	3
Ulak I./Hasgox Pt.	Aleutian Islands	51 18.90 N	178 58.90 W	51 18.70 N	178 59.60 W	10
Kavalga I.	Aleutian Islands	51 34.50 N	178 51.73 W	51 34.50 N	178 49.50 W	3
Tag I.	Aleutian Islands	51 33.50 N	178 34.50 W			10
Ugidak I.	Aleutian Islands	51 34.95 N	178 30.45 W			3
Gramp Rock[7]	Aleutian Islands	51 28.87 N	178 20.58 W			10, 20
Tanaga I./Bumpy Pt.	Aleutian Islands	51 55.00 N	177 58.50 W	51 55.00 N	177 57.10 W	20
Bobrof I.	Aleutian Islands	51 54.00 N	177 27.00 W			20
Kanaga I./Ship Rock	Aleutian Islands	51 46.70 N	177 20.72 W			20
Kanaga I./North Cape	Aleutian Islands	51 56.50 N	177 09.00 W			20
Adak I.	Aleutian Islands	51 35.50 N	176 57.10 W	51 37.40 N	176 59.60 W	20
Little Tanaga Strait	Aleutian Islands	51 49.09 N	176 13.90 W			20
Great Sitkin I.	Aleutian Islands	52 06.00 N	176 10.50 W	52 06.60 N	176 07.00 W	20
Anagaksik I.	Aleutian Islands	51 50.86 N	175 53.00 W			20
Kasatochi I.	Aleutian Islands	52 11.11 N	175 31.00 W			20
Atka I./North Cape	Aleutian Islands	52 24.20 N	174 17.80 W			20
Amlia I./Sviech. Harbor[5]	Aleutian Islands	52 01.80 N	173 23.90 W			20
Sagigik I.[5]	Aleutian Islands	52 00.50 N	173 09.30 W			20

Column Number 1	2	3	4	5	6	7
Site Name	Area or Subarea	Boundaries from		Boundaries to[1]		Atka mackerel No-fishing Zones for Trawl Gear [2,3](nm)
		Latitude	Longitude	Latitude	Longitude	
Amlia I./East[5]	Aleutian Islands	52 05.70 N	172 59.00 W	52 05.75 N	172 57.50 W	20
Tanadak I. (Amlia)[5]	Aleutian Islands	52 04.20 N	172 57.60 W			20
Agligadak I.[5]	Aleutian Islands	52 06.09 N	172 54.23 W			20
Seguam I./Saddleridge Pt.[5]	Aleutian Islands	52 21.05 N	172 34.40 W	52 21.02 N	172 33.60 W	20
Seguam I./Finch Pt.[5]	Aleutian Islands	52 23.40 N	172 27.70 W	52 23.25 N	172 24.30 W	20
Seguam I./South Side[5]	Aleutian Islands	52 21.60 N	172 19.30 W	52 15.55 N	172 31.22 W	20
Amukta I. & Rocks	Aleutian Islands	52 27.25 N	171 17.90 W			20
Chagulak I.	Aleutian Islands	52 34.00 N	171 10.50 W			20
Yunaska I.	Aleutian Islands	52 41.40 N	170 36.35 W			20
Uliaga[6]	Bering Sea	53 04.00 N	169 47.00 W	53 05.00 N	169 46.00 W	20
Kagamil[6]	Bering Sea	53 02.10 N	169 41.00 W			20
Adugak I.[6]	Bering Sea	52 54.70 N	169 10.50 W			20
Umnak I./Cape Aslik[6]	Bering Sea	53 25.00 N	168 24.50 W			BA
Bogoslof I./Fire I.[6]	Bering Sea	53 55.69 N	168 02.05 W			BA
Unalaska/Bishop Pt.	Bering Sea	53 58.40 N	166 57.50 W			20
Akutan I./Reef-lava	Bering Sea	54 08.10 N	166 06.19 W	54 09.10 N	166 05.50 W	20
Akun I./Billings Head	Bering Sea	54 17.62 N	165 32.06 W	54 17.57 N	165 31.71 W	20
Unimak/Cape Sarichef	Bering Sea	54 34.30 N	164 56.80 W			20
Sea Lion Rock (Amak)	Bering Sea	55 27.82 N	163 12.10 W			20
Amak I. And rocks	Bering Sea	55 24.20 N	163 09.60 W	55 26.15 N	163 08.50 W	20

[1] Where two sets of coordinates are given, the baseline extends in a clock-wise direction from the first set of geographic coordinates along the shoreline at mean lower-low water to the second set of coordinates.

[2] Closures as stated in 50 CFR 679.22 (a)(7)(vi) and (a)(8)(v).

[3] No-fishing zones are the waters between 0 nm and the nm specified in column 7 around each site and within the Bogoslof area (BA).

[4] The 20 nm Atka mackerel fishery closure around the Tanaga I./Bumpy Pt. Rookery is established only for that portion of the area east of 178□ W longitude.

[5] Some or all of the restricted area is located in the Seguam Foraging Area (SFA) which is closed to all gears types. The SFA is established as all waters within the area between 52° N lat. and 53° N lat. and between 173°30' W long. and 172°30' W long.

[6] This site lies in the BA, closed to all gear types. The BA consists of all waters of Area 518 described in Figure 1 of this part south of a straight line connecting 55°00'N/170°00'W and 55°00'N/168°11'4.75" W.

[7] Directed fishing for Atka mackerel by vessels using trawl gear is prohibited in waters located 0-20 nm seaward of Gramp Rock and east of 178°W long.

Table 2.35 The amount of area closed in the BSAI and GOA under the Steller sea lion conservation measures. Given the complexity of the conservation measures, closure areas are described for each fishery and area. Includes year round closures only; areas open seasonally are not included in "closure areas". Forgaing Area values in this table do not include the area inside 0-20 nm critical habitat. This allows all the data to be additive to get total critical habitat. GOA values in red are those updated since the last consultation and changes made in 2004 to the GOA pollock and Pacific cod fisheries.

			Area Closed To Fishing Km^2				Critical Habitat Base Values Km^2						0-20 nm Area of Critical Habitat		
Region	Fishery	Gear	0-3	3-10	10-20	Foraging Area	0-3	3-10	10-20	Foraging Area	(Area)	Total CH	Total Closed 0-20	Total 0-20 CH	% 0-20 Closed
AI	Pollock	Trawl	4,294	31,182	61,364	2,631	4,294	31,182	61,364	2,631	Seguam	99,472	96,841	96,841	100
	Pacific Cod	Trawl	4,294	15,775	2,611	2,631	4,294	31,182	61,364	2,631	Seguam	99,472	22,681	96,841	23
		Pot	4,294	18,092	11,080	2,631	4,294	31,182	61,364	2,631	Seguam	99,472	33,466	96,841	35
		Longline	4,294	18,092	11,080	2,631	4,294	31,182	61,364	2,631	Seguam	99,472	33,466	96,841	35
	Atka Mackerel	Trawl	4,294	23,526	27,640	2,631	4,294	31,182	61,364	2,631	Seguam	99,472	55,460	96,841	57
EBS	Pollock	Trawl	1,661	12,759	22,497	24,098	1,661	13,849	37,419	53,020	SCA	105,948	36,916	52,928	70
	Pacific Cod	Trawl	1,661	12,759	22,497	24,098	1,661	13,849	37,419	53,020	SCA	105,948	36,916	52,928	70
		Pot	1,661	8,689	22,496	24,098	1,661	13,849	37,419	53,020	SCA	105,948	32,845	52,928	62
		Longline	1,661	8,472	21,446	23,252	1,661	13,849	37,419	53,020	SCA	105,948	31,578	52,928	60
	Atka Mackerel	Trawl	1,661	13,849	37,426	24,098	1,661	13,849	37,419	53,020	SCA	105,948	52,935	52,928	100
GOA	Pollock	Trawl	6,128	37,394	40,571	0	6,128	46,109	78,997	12,875	Shelikof	144,109	84,093	131,234	64
	Pacific Cod	Trawl	6,128	38,165	38,243	0	6,128	46,109	78,997	12,875	Shelikof	144,109	82,536	131,234	63
		Pot	3,436	12,691	19,899	0	6,128	46,109	78,997	12,875	Shelikof	144,109	36,027	131,234	27
		Longline	3,530	13,325	12,574	0	6,128	46,109	78,997	12,875	Shelikof	144,109	29,430	131,234	22
BSAI/GOA	Pollock	Trawl	12,083	81,335	124,432	26,729	12,083	91,140	177,780	68,526	Foraging	349,529	217,851	281,003	78
	Pacific Cod	Trawl	12,083	66,699	63,351	26,729	12,083	91,140	177,780	68,526	Foraging	349,529	142,134	281,003	51
		Pot	9,391	39,472	53,475	26,729	12,083	91,140	177,780	68,526	Foraging	349,530	102,339	281,003	36
		Longline	9,485	39,890	45,100	25,883	12,083	91,140	177,780	68,526	Foraging	349,531	94,475	281,003	34
	Atka Mackerel (BSAI)	Trawl	5,955	37,375	65,066	26,729	5,955	45,031	98,783	55,651	Foraging	205,420	108,396	149,769	72

Table 2.36 The amount of area closed in the BSAI and GOA under the Steller sea lion conservation measures as a percentage of each zone. Given the complexity of the conservation measures, closure areas are described for each fishery and area.

% Area Closed								
Region	**Fishery**	**Gear**	**0-3**	**3-10**	***[0-10]***	**10-20**	**Foraging Area**	**Total CH**
AI	Pollock	Trawl	100%	100%	*100%*	100%	100%	100%
	Pacific Cod	Trawl	100%	51%	*57%*	4%	100%	25%
		Pot	100%	58%	*63%*	18%	100%	36%
		Longline	100%	58%	*63%*	18%	100%	36%
	Atka Mackerel	Trawl	100%	75%	*78%*	45%	100%	58%
EBS	Pollock	Trawl	100%	92%	*93%*	60%	45%	58%
	Pacific Cod	Trawl	100%	92%	*93%*	60%	45%	58%
		Pot	100%	63%	*67%*	60%	45%	54%
		Longline	100%	61%	*65%*	57%	44%	52%
	Atka Mackerel	Trawl	100%	100%	*100%*	100%	45%	73%
GOA	Pollock	Trawl	100%	81%	*83%*	51%	0%	58%
	Pacific Cod	Trawl	100%	83%	*85%*	48%	0%	57%
		Pot	56%	28%	*31%*	25%	0%	25%
		Longline	58%	29%	*32%*	16%	0%	20%
BSAI/GOA	Pollock	Trawl	100%	89%	*91%*	70%	39%	70%
	Pacific Cod	Trawl	100%	73%	*76%*	36%	39%	48%
		Pot	78%	43%	*47%*	30%	39%	37%
		Longline	78%	44%	*48%*	25%	38%	34%
	Atka Mackerel (BSAI)	Trawl	100%	83%	*85%*	66%	48%	66%

Table 2.37 The amount of area that would have been closed in the BSAI and GOA under the RPA from the 2000 BiOp. Because all fisheries (i.e., pollock, Pacific cod, and Atka mackerel) were closed in the same areas, gear types and fisheries are not presented as they are all the same.

Area	Area Closed (km ^{2})	Total Area (km ^{2})	% Closed
0-3 nm	*8,753*	*13,060*	*67.02%*
3-10 nm	*62,660*	*96,974*	*64.62%*
0-10 nm	71,413	110,034	64.90%
10-20 nm	117,959	185,687	63.53%
CH Beyond 20 nm	41,099	70,263	58.49%
Total critical habitat	230,471	365,983	62.97%

Table 2.38 Amounts in metric tons of 2005 groundfish harvested on observed vessels and in hauls sampled by observers compared with amounts estimated using the Catch Accounting System (CAS) estimation procedure. The Catch Accounting System uses observer groundfish catch estimates for catcher/processors greater than 125' LOA ("100%" to "200%" observed vessels) and weekly production reports for catcher/processors less than 125' LOA. Retained catcher vessel catch is based on scale weights from shore plants or mother ships. Catcher vessel groundfish discards are estimated from observer data. The percentages are relative to the CAS estimate.

FMP Area	Gear[1]	Target	CAS Estimate	Catch on observed Vessels[2]	Percent catch vessels/ CAS estimate	Catch in hauls observed[3]	Catch in hauls observed/ CAS estimate
BSAI	HAL	Pac Cod	143,671	140,927	98%	94,720	66%
	HAL	Sablefish	892	934	105%	678	76%
	HAL	Turbot	2,031	3,406	168%	2,892	142%
	JIG	Pac Cod	118	-	0%	-	0%
	POT	Pac Cod	17,747	6,335	36%	5,692	32%
	POT	Sablefish	1,319	1,028	78%	993	75%
	NPT	Atka Mackerel	69,661	69,809	100%	68,316	98%
	NPT	Pac Cod	81,225	56,589	70%	43,518	54%
	NPT	Other Flats	1,963	1,671	85%	644	33%
	NPT	Rockfish	8,298	8,400	101%	5,898	71%
	NPT	Flathead sole	23,535	19,101	81%	11,850	50%
	NPT	Rock sole	41,381	45,959	111%	30,782	74%
	NPT	Sablefish	36	37	102%	35	97%
	NPT	Turbot	84	89	106%	48	57%
	NPT	Arrowtooth	5,689	6,118	108%	4,059	71%
	NPT	Yellowfin Sole	120,106	118,426	99%	87,735	73%
	PTR	Pollock	1,462,105	1,464,311	100%	1,462,807	100%
		Total	1,979,862	1,943,140	98%	1,820,666	92%
GOA	HAL	Pac Cod	6,121	749	12%	467	8%
	HAL	Sablefish	14,254	5,884	41%	4,254	30%
	JIG	Pac Cod	2,864	-	0%	-	0%
	JIG	Rockfish	21	-	0%	-	0%
	POT	Pac Cod	24,634	2,430	10%	2,007	8%
	NPT	Pac Cod	12,292	3,456	28%	2,751	22%
	NPT	Shallow Flatfish	7,813	1,520	19%	1,158	15%
	NPT	Rockfish	22,038	14,670	67%	9,849	45%
	NPT	Flathead sole	3,059	1,010	33%	824	27%
	NPT	Other species	191	155	81%	133	70%
	NPT	Pollock	589	-	0%	-	0%
	NPT	Sablefish	6	-	0%	-	0%
	NPT	Arrowtooth fl.	14,694	8,758	60%	5,745	39%
	NPT	Rex sole	3,244	1,292	40%	868	27%
	PTR	Rockfish	1,255	1,369	109%	1,200	96%
	PTR	Pollock	82,623	69,006	84%	68,524	83%
		Total	195,699	110,300	56%	97,779	50%

[1] Gear defininitions are as follows: HAL is hook-and-line (longline); JIG is jig gear; POT is pot gear; NPT is non-pelagic trawl (bottom trawl); PTR is pelagic traw (mid water).

[2] 'Catch on observed vessels' is from the observer estimate of official total catch. The estimate includes hauls that are directly sampled by the observer plus unsampled hauls. Catch composition on unobseverd hauls is extrapolated from sampled hauls. Unsampled hauls weight is from the vessel operator's log book.

[3] 'Catch in hauls observed' is from hauls actually sampled by the observer.

Table 2.39 Major Alaska Steller Sea Lion Rookery Sites in Table 1 to Part 226.

Where two sets of coordinates are given, the baseline extends in a clockwise direction from the first set of geographic coordinates along the shoreline at mean lower-low water to the second set of coordinates. Where only one set of coordinates is listed, that location is the base point.

Region/site	Boundaries to–			
	Latitude	Longitude	Latitude	Longitude
Western Aleutians:				
Agattu I.				
Cape Sabak \1\	52 23.5N	173 43.5E	52 22.0N	173 41.0E
Gillon Point \1\.	52 24.0N	173 21.5E		
Attu I.\1\.	52 54.5N	172 28.5E	52 57.5N	172 31.5E
Buldir I.\1\.	52 20.5N	175 57.0E	52 23.5N.	172 51.0E
Central Aleutians:				
Adak I.\1\.	51 36.5N	176 59.0W	51 38.0N	176.59.5W
Agligadak I.\1\.	52 06.5N	172 54.0W		
Amchitka I.:\1\				
Column Rock \1\	51 32.5N	178 49.5E		
East Cape \1\.	51 22.5N	179 28.0E	51 21.5N	179 25.0E
Ayugadak I.\1\.	51 45.5N	178 24.5E		
Gramp Rock \1\.	51 29.0N	178 20.5W		
Kasatochi I.\1\.	52 10.0N	175 31.5W	52 10.5N	175 29.0W
Kiska I.:				
Lief Cove \1\.	51 57.5N	177 21.0E	51 56.5N	177 20.0E
Cape St. Stephen \1\	51 52.5N	177 13.0E	51 53.5N	177 12.0E
Seguam I./Saddleridge \1\.	52 21.0N	172 35.0W	52 21.0N	172 33.0W
Semisopochnoi I.:				
Pochnoi Pt \1\..	51 58.5N	179 45.5E	51 57.0N	179 46.0E
Petrel Pt \1\	52 01.5N	179 37.5E	52 01.5E	179 39.0E
Tag I.\1\.	51 33.5N	178 34.5W		
Ulak I.\1\..	51 20.0N	178 57.0W	51 18.5N	178 59.5W
Yunaska I.\1\	52 42.0N	170 38.5W	52 41.0N	170 34.5W
Eastern Aleutian:				
Adugak I.\1\	52 55.0N	169 10.5W		
Akun I./Billings Head \1\.	54 18.0N	165 32.5W	54 18.0N	165 31.5W
Akutan I./Cape Morgan \1\.	54 03.5N	166 00.0W	54 05.5N	166 05.0W
Bogoslof I.\1\ \2\	53 56.0N	168 02.0W		
Ogchul I.\1\..	53 00.0N	168 24.0W		
Sea Lion Rocks. (Amak) \1\.	55 28.0N	163 12.0W		
Ugamak I.\1\..	54 14.0N	164 48.0W	54 13.0N	164 48.0W
Bering Sea:				
Walrus I.\1\.	57 11.0N	169 56.0W		
Western Gulf of Alaska:				
Atkins I.\1\..	55 03.5N	159 18.5W		
Chernabura I.\1\.	54 47.5N	159 31.0W	54 45.5N	159 33.5W
Clubbing Rocks (N) \1\.	54 43.0N	162 26.5W		
Clubbing Rocks (S) \1\.	54 42.0N	162 26.5W		
Pinnacle Rock \1\	54 46.0N	161 46.0W		
Central Gulf of Alaska:	55 46.5N	155 39.5W	55 46.5N	155 43.0W
Chirikof I.\1\..	56 00.5N	156 41.5W	56 00.5N	156 42.0W
Chowiet I.\1\.	58 14.5N	151 47.5W	58 10.0N	151 51.0W
Marmot I.\1\	59 20.5N	150 23.0W	59 21.0N	150 24.5W
Outer I.\1\.	58 53.0N	152 02.0W		

Region/site	Boundaries to–			
	Latitude	Longitude	Latitude	Longitude
Sugarloaf I.\1\...				
Eastern Gulf of Alaska:				
Seal Rocks \1\..	60 10.0N	146 50.0W		
Fish I.\1\	59 53.0N	147 20.5W		
Southeast Alaska:				
Forrester I.	54 51.0N	133 32.0W	54 52.5N	133 35.5W
Hazy I.	55 52.0N	134 34.0W	55 51.5N	134 35.0W
White Sisters	57 38.0N	136 15.5W		

\1\ Includes an associated 20 NM aquatic zone.

\2\ Associated 20 NM aquatic zone lies entirely within one of the three special foraging areas.

Table 2.40 Alaska Major Steller Sea Lion Haulout Sites from Table 2 to Part 226

Where two sets of coordinates are given, the baseline extends in a clockwise direction from the first set of geographic coordinates along the shoreline at mean lower-low water to the second set of coordinates. Where only one set of coordinates is listed, that location is the basepoint.

Region/site	Boundaries to–			
	Latitude	Longitude	Latitude	Longitude
Western Aleutians:				
Alaid I.\1\.	52 45.0N	173 56.5E	52 46.5N	173 51.5E
Attu/Chirikof Pt.\1\	52 30.0N	173 26.7E		
Shemya I.\1\..	52 44.0N	174 09.0E		
Central Aleutians:				
Amatignak I.\1\	51 13.0N	179 08.0E		
Amlia I:				
East \1\	52 05.0N	172 58.5W	52 06.0N	172 57.0W
Sviech. Harbor \1\.	52 02.0N	173 23.0W		
Amukta I. & Rocks \1\.	52 31.5N	171 16.5W	52 26.5N	171 16.5W
Anagaksik I.\1\	51 51.0N	175 53.5W		
Atka I.\1\.	52 23.5N	174 17.0W	52 24.5N	174 07.5W
Bobrof I.\1	51 54.0N	177 27.0W		
Chagulak I.\1\.	52 34.0N	171 10.5W		
Chuginadak I.\1\..	52 46.5N	169 44.5W	52 46.5N	169 42.0W
Great Sitkin I.\1\.	52 06.0N	176 10.5W	52 07.0N	176 08.5W
Kagamil I.\1\..	53 02.5N	169 41.0W		
Kanaga I:				
North Cape \1\.	51 56.5N	177 09.0W		
Ship Rock \1\	51 47.0N	177 22.5W		
Kavalga I.\1\.	51 34.5N	178 51.5W	51 34.5N	178 49.5W
Kiska I./Sirius Pt.\1\.	52 08.5N	177 36.5E		
Kiska I./Sobaka & Vega \1\.	51 50.0N	177 20.0E	51 48.5N	177 20.5E
Little Sitkin I.\1\.	51 59.5N	178 30.0E		
Little Tanaga I.\1\.	51 50.5N	176 13.0W	51 49.0N	176 13.0W
Sagigik I.\1\.	52 00.5N	173 08.0W		
Seguam I:				
South \1\...	52 19.5N	172 18.0W	52 15.0N	172 37.0W
Finch Pt.\1\...	52 23.5N	172 25.5W	52 23.5N	172 24.0W
Segula I.\1\...	52 00.0N	178 06.5E	52 03.5N	178 09.0E
Tanaga I.\1\....	51 55.0N	177 58.5W	51 55.0N	177 57.0W
Tanadak I. (Amlia) \1\.	52 04.5N	172 57.0W		
Tanadak I. (Kiska) \1\..	51 57.0N	177 47.0E		
Ugidak I.\1\.	51 35.0N	178 30.5W		
Uliaga I.\1\.	53 04.0N	169 47.0W	53 05.0N	169 46.0W
Unalga & Dinkum Rocks \1\.	51 34.0N	179 04.0W	51 34.5N	179 03.0W

Region/site	Boundaries to–			
	Latitude	Longitude	Latitude	Longitude
Eastern Aleutians:				
Akutan I./Reef-Lava \1\.	54 10.5N	166 04.5W	54 07.5N	166 06.5W
Amak I.\1\.	55 24.0N	163 07.0W	55 26.0N	163 10.0W
Cape Sedanka & Island \1\.	53 50.5N	166 05.0W		
Emerald I.\1\.	53 17.5N	167 51.5W		
Old Man Rocks \1\.	53 52.0N	166 05.0W.		
Polivnoi Rock \1\	53 16.0N	167 58.0W		
Tanginak I.\1\	54 13.0N	165 19.5W		
Tigalda I.\1\..	54 08.5N	164 58.5W		
Umnak I./Cape Aslik \1\.	53 25.0N	168 24.5W		
Bering Sea:				
Cape Newenham \1\.	58 39.0N	162 10.5W		
Hall I.\1\..	60 37.0N	173 00.0W		
Round I.\1\.	58 36.0N	159 58.0W		
St. Paul I:				
Northeast Point \1\.	57 15.0N	170 06.5W		
Sea Lion Rock \1\.	57 06.0N	170 17.5W		
St. George I:				
S Rookery \1\.	56 33.5N	169 40.0W		
Dalnoi Point \1\..	56 36.0N	169 46.0W		
St. Lawrence I:				
S Punuk I.\1\.	64 04.0N	168 51.0W		
SW Cape \1\	63 18.0N.	171 26.0W		
Western Gulf of Alaska:				
Bird I. \1\.	54 40.5N	163 18.0W		
Castle Rock \1\.	55 17.0N	159 30.0W		
Caton I.\1\.	54 23.5N	162 25.5W		
Jude I.\1\.	55 16.0N	161 06.0W		
Lighthouse Rocks \1\.	55 47.5N	157 24.0W		
Nagai I.\1\.	54 52.5N	160 14.0W	54 56.0N	160 15.0W
Nagai Rocks \1\.	55 50.0N	155 46.0W		
Sea Lion Rocks (Unga) \1\.	55 04.5N	160 31.0W		
South Rock \1\	54 18.0N	162 43.5W		
Spitz I.\1\..	55 47.0N	158 54.0W		
The Whaleback \1\.	55 16.5N	160 06.0W		
Central Gulf of Alaska:				
Cape Barnabas \1\.	57 10.0N	152 55.0W	57 07.5N	152 55.0W
Cape Chiniak \1\	57 35.0N	152 09.0W	57 37.5N	152 09.0W
Cape Gull \1\ \2\	58 13.5N	154 09.5W	58 12.5N	154 10.5W
Cape Ikolik \1\ \2\	57 17.0N	154 47.5W		
Cape Kuliak \1\ \2\	58 08.0N	154 12.5W		
Cape Sitkinak \1\.	56 32.0N	153 52.0W		
Cape Ugat \1\ \2\	57 52.0N	153 51.0W		
Gore Point \1\.	59 12.0N	150 58.0W		

Region/site	Boundaries to–			
	Latitude	Longitude	Latitude	Longitude
Gull Point \1\..	57 21.5N	152 36.5W	57 24.5N	152 39.0W
Latax Rocks \1\	58 42.0N	152 28.5W	58 40.5N	152 30.0W
Long I.\1\	57 45.5N	152 16.0W		
Nagahut Rocks \1\	59 06.0N	151 46.0W		
Puale Bay \1\ \2\	57 41.0N	155 23.0W		
Sea Lion Rocks (Marmot) \1\.	58 21.0N	151 48.5W		
Sea Otter I.\1\	58 31.5N	152 13.0W		
Shakun Rock \1\ \2\	58 33.0N	153 41.5W		
Sud I.\1\.	58 54.0N	152 12.5W		
Sutwik I.\1\..	56 32.0N	157 14.0W	56 32.0N	157 20.0W
Takli I. \1\ \2\	58 03.0N	154 27.5W	58 03.0N	154 30.0W
Two-headed I.\1\	56 54.5N	153 33.0W	56 53.5N	153 35.5W
Ugak I.\1\.	57 23.0N	152 15.5W	57 22.0N	152 19.0W
Ushagat I. \1	58 55.0N	152 22.0W		
Eastern Gulf of Alaska:				
Cape Fairweather	58 47.5N	137 56.3W		
Cape St. Elias \1\.	59 48.0N	144 36.0W		
Chiswell Islands \1\.	59 36.0N	149 34.0W		
Graves Rock	58 14.5N	136 45.5W		
Hook Point \1\	60 20.0N	146 15.5W		
Middleton I.\1\	59 26.5N	146 20.0W		
Perry I.\1\.	60 39.5N	147 56.0W		
Point Eleanor \1\	60 35.0N	147 34.0W		
Point Elrington \1\	59 56.0N	148 13.5W		
Seal Rocks \1\	60 10.0N	146 50.0W		
The Needle \1\	60 07.0N	147 37.0W		
Southeast Alaska:				
Benjamin I	58 33.5N	134 54.5W		
Biali Rock	56 43.0N	135 20.5W		
Biorka I	56 50.0N	135 34.0W		
Cape Addington..	55 26.5N	133 49.5W		
Cape Cross	57 55.0N	136 34.0W		
Cape Ommaney	56 10.5N	134 42.5W		
Coronation I.	55 56.0N	134 17.0W		
Gran Point	59 08.0N	135 14.5W		
Lull Point	57 18.5N	134 48.5W		
Sunset I	57 30.5N	133 35.0W		
Timbered I	55 42.0N	133 48.0W		

\1\ Includes an associated 20 NM aquatic zone.

\2\ Associated 20 nm aquatic zone lies entirely within one of the three special foraging areas.

Table 3.1. Counts of adult and juvenile (non-pup) Steller sea lions at western DPS rookery and haul-out trend sites in Alaska during June-July surveys from 1976 to 2004 (NMFS 2000, Sease *et al.* 2001, Sease and Gudmundson 2002, and Fritz and Stinchcomb 2005). Numbers in parentheses are the number of trend sites counted in each sub-area. Percentage changes between years are shown in bold.

Year(s)	Gulf of Alaska			Aleutian Islands			Kenai-Kiska (69)	Western DPS in Alaska (82)
	Eastern (9)	Central (15)	Western (9)	Eastern (11)	Central (34)	Western (4)		
1956-60[1]		34,792	15,772	44,020	17,120		111,704	
1962					23,175			
1976-79[2]	7,053	24,678	8,311	19,743	36,632	14,011	89,364	110,428
1985		19,002	6,275	7,505	23,042		55,824	
1989	7,241	8,552	3,908	3,032	7,572		23,064	
1990	5,444	7,050	3,915	3,801	7,988	2,327[3]	22,754	30,525
1991	4,596	6,270	3,732	4,228	7,496	3,083	21,726	29,405
1992	3,738	5,739	3,716	4,839	6,398	2,869	20,692	27,299
1994	3,365	4,516	3,981	4,419	5,820	2,035	18,736	24,136
1996	2,132	3,913	3,739	4,715	5,524	2,187	17,891	22,210
1998	2,110[4]	3,467	3,360	3,841	5,749	1,911	16,417	20,438
2000	1,975	3,180	2,840	3,840	5,419	1,071	15,279	18,325
2002	2,500	3,366	3,221	3,956	5,480	817	16,023	19,340
2004[5]	2,536	2,944	3,512	4,707	5,936	898	17,099	20,533
1950s to 2000		**-91%**	**-82%**	**-91%**	**-68%**		**-86%**	
1970s to 2000	**-72%**	**-87%**	**-66%**	**-81%**	**-85%**	**-92%**	**-83%**	**-83%**
1970s to 1990	**-23%**	**-71%**	**-53%**	**-81%**	**-78%**	**-83%**	**-75%**	**-72%**
1990 to 2000	**-64%**	**-55%**	**-27%**	**+1%**	**-32%**	**-54%**	**-33%**	**-40%**
2000 to 2004	**+28%**	**-7%**	**+24%**	**+23%**	**+10%**	**-16%**	**+12%**	**+12%**

[1] 1956 counts for the western GOA, 1957 counts for the central GOA, 1959 counts for the central Aleutians and 1960 counts for the eastern Aleutians.

[2] 1976 counts for the eastern, central, and western GOA and the eastern Aleutians, and 1979 counts for the central and western Aleutians.

[3] Gillon Point rookery, Agattu Island not surveyed in 1990.

[4] 1999 counts substituted for sites in the eastern Gulf of Alaska not surveyed in 1998.

[5] 2004 counts were from medium format photographs, while all others were from 35 mm photographs, aerial counts or beach counts. 2004 data reflect a –3.64% adjustment to account for film format resolution and count differences (Fritz and Stinchcomb 2005).

Table 3.2. Counts of Steller sea lion pups at western DPS rookeries in Alaska during 1979 to 2004 (NMFS 1992, Sease and Loughlin 1999, Fritz and Stinchcomb 2005, NMFS unpublished). Percentage changes between years are shown in bold.

	Gulf of Alaska			Aleutian Islands			Eastern Bering Sea	Kenai-Kiska[7]	Western DPS in Alaska
Year(s)	Eastern[1]	Central[2]	Western[3]	Eastern[4]	Central[5]	Western[6]	Walrus Island		
1979			8,616						
1982							334		
1984			6,435						
1985-89		10,254		4,778	9,428		250	30,895[7]	
1990-92		4,904	1,923	2,115	3,568		63	12,510	
1994	903	2,831	1,662	1,756	3,109		61	9,358	
1996	584								
1997	611					979	35		
1998	689	1,876	1,493	1,474	2,834	803		7,677	9,169
2001-02	586	1,721	1,671	1,561	2,612	488	39	7,565	8,678
2003-04	716	1,609	1,577	1,731					
2005	715	1,651	1,707	1,921	2,551	343	29	7,830	8,917
Earliest count to 1994		**-72%**	**-81%**	**-63%**	**-67%**			**-70%**	
Earliest count to 2001-02	**-35%**	**-83%**	**-81%**	**-67%**	**-72%**	**-50%**	**-88%**	**-76%**	**-5%**
1994 to 2001-02	**-35%**	**-39%**	**+1%**	**-11%**	**-16%**		**-36%**	**-19%**	
2001-02 to 2005	**+22%**	**-4%**	**+2%**	**+23%**	**-2%**	**-30%**	**-25%**	**+4%**	**+3%**

[1] Seal Rocks and Fish (Wooded) Island

[2] Outer, Sugarloaf, Marmot, Chowiet and Chirikof Islands

[3] Atkins and Chernabura Islands, and Pinnacle Rock and Clubbing Rocks

[4] Ugamak, Akun, Akutan, Bogoslof and Adugak Islands

[5] Yunaska, Seguam, Kasatochi, Adak, Tag, Ulak, Ayugadak and Kiska (2) Islands, and Gramp and Column Rocks.

[6] Buldir, Agattu (2), and Attu Islands

[7] Rookeries in the Central and Western Gulf of Alaska, and Eastern and Central Aleutian Islands

Table 3.3. Counts of adult and juvenile (non-pup) Steller sea lions on terrestrial trend sites in Russia.

Year	W. Bering Sea	Commander Islands	E. Kamchatka	Kuril Islands	Tuleny Island	Sea of Okhotsk
1963		2,920[1]		14,660	60[2]	
1969				14,184		
1971		2,920				
1973		3,503				
1974					49	1,208
1975				8,397		
1977		4,480				
1978		2,807			26	
1981		2,101		5,921		
1982	4,910	1,577				
1983	3,230	1,761	2,073		65	
1984		1,930				
1985	3,370	1,700			137	
1986		2,633			450	
1987	1,231	2,267	1,690			
1988		1,221			171	1,691[3]
1989	1,199	896	1,519	4,488	190	
1990		865			410	
1991	427	752	794		350	
1992		843			463	
1993		569			549	
1994	200	543	642		557	
1995		653				
1996		804			615	2,429[4]
1997		812			679	
1998		900			836	
1999	180	860	720		770	
2000		741			1,155	
2001		718	669	5,129	857	2,324
2002	16	581	491		1,041	2,072
2003		530		5,178	1,119	
2004	91	674	548		1,084	2,357
2005				5,544	1,218	

[1] 1962 data. [2] 1964 data. [3] 1989 data for Iony Island. [4] 1995 data for Yamsky Islands and 1997 data for Iony Island.

Table 3.4. Counts of Steller sea lion pups on rookery trend sites in Russia.

Year	Commander Islands	E. Kamchatka	Kuril Islands	Tuleny Island	Sea of Okhotsk
1962	1				
1963			3,673		
1969	0		3,250		
1970	3				
1971	4				
1972	9				
1973	26				
1974				1	607
1977	19				
1978	26			0	
1980				6	
1981	48				
1982	83			0	
1983	104		1,992	5	
1984	141			0	
1986	151		1,560	25	
1987	197	211			
1988	141			38	712[1]
1989	195		1,442	45	
1990				59	
1991	229			63	
1992	222	108	1,623	90	
1993	224	115		120	
1994	226	93		146	
1995	248	84	1,972		
1996	261	87		219	1,250[2]
1997	244	96		256	
1998	280	91		303	
1999	271	87		291	
2000	180	76	1,824	340	
2001	228	61	1,807	303	1,231
2002	210	84	1,973	410	980
2003	216		2,086	480	
2004	221	107		508	1,868
2005	236		2,306	407	

[1] 1989 data for Iony Island. [2] 1995 data for Yamsky Islands and 1997 data for Iony Island.

Table 3.5. Counts of one-month-old Steller sea lion pups on rookeries in southeast Alaska, 1979-2005 (ADF&G and NMFS unpublished data).

Year	Forrester Island	Hazy Island	White Sisters	Graves Rocks	Biali Rocks	Total Pups
1979	2,187	32				2,219
1990	2,932	638	30			3,600
1991	3,261	808	95			4,164
1994	2,757	862	151			3,770
1996	2,764	768	182			3,714
1997	2,798	1,157	205			4,160
1998	2,753	1,199	282	1		4,235
2001	3,152	1,091	371	89	38	4,741
2002	3,060	1,257	403	98	59	4,877
2005	3,429	1,286	520	175	100	5,510

Table 3.6. Counts of adult and juvenile (non-pup) Steller sea lions observed at individual rookeries and rookery and haulout trend sites combined in southeast Alaska during June-July aerial surveys from 1979 to 2005 (Sease *et al.* 2001, ADF&G and NMFS unpublished data).

Year	Forrester Island	Hazy Island	White Sisters	Graves Rocks	Biali Rocks
1979	3,121	893	761	-	810
1982	3,777	1,268	934	-	722
1989	4,648	1,462	734	475	794
1990	3,324	1,187	980	937	596
1991	3,970	1,496	975	470	494
1992	3,508	1,576	860	366	398
1994	4,010	1,615	868	733	410
1996	3,551	1,759	894	475	342
1998	3,788	1,962	858	445	476
2000	3,674	1,824	1,398	558	690
2002	3,699	2,050	1,156	1,001	624
2005	5,557	2,293	1,078		598

Table 3.7. Counts of Steller sea lions on rookeries and haulouts in British Columbia, 1971-2002 (Olesiuk and Trites 2003).

Year	Non-pups	Pups	Total
1971	4,617	941	5,475
1977	5,219	963	6,274
1982	4,713	1,245	5,956
1987	6,109	1,084	7,193
1992	7,376	1,468	8,844
1994	8,091	1,186	9,277
1998	9,818	2,073	11,891
2002	12,121	3,281	15,402

Table 3.8. Counts of non-pup Steller in sea lions on rookeries and haulouts in Oregon and of pups counted during ground counts or from medium-format photographs on the Rogue Reef and Orford Reef rookeries 1976-2001 (Brown *et al.* 2002). Mean counts of Steller sea lion non-pups on Washington haulouts during the breeding season, June 16 through July 15, 1991 – 2001 (Washington Department of Fisheries and Wildlife unpublished data).

Year	Oregon Total Non-pups	Rogue Reef Pups	Orford Reef Pups	Washington Total Non-pups
1977	1,461	--	--	--
1979	1,542	--	--	--
1980	1,632	--	--	--
1981	2,105	--	--	--
1982	2,604	--	--	--
1983	2,106	--	--	--
1984	1,867	--	--	--
1985	2,210	--	--	--
1986	2,289	--	--	--
1987	2,709	--	--	--
1988	2,825	--	--	--
1989	2,183	--	--	89
1990	2,414	492	298	--
1991	--	--	--	274
1992	3,581	--	--	278
1993	2,838	--	--	--
1994	3,293	--	--	384
1995	3,837	--	--	409
1996	3,205	685	335	594
1997	3,897	--	--	352
1998	3,971	--	--	470
1999	3,275	--	--	806
2000	2,927	--	--	778
2001	3,648	600	--	516
2002	4,169	746	382	--

Table 3.9. Historical compilation of counts of adult and juvenile (non-pup) Steller sea lions on rookeries (current and former) and associated haulouts in California, 1927-2004.

Year	San Miguel Island	Año Nuevo Island	FarallonI slands	Sugarloaf Island/ Cape Mendocino	Saint George Reef	Total
1927	595[a]	1,500 [a]	700 [a]	700 [a]	1,500 [a]	4,995
1930	620[b]	2,500[b]	900[b]	900[b]	700[b]	5,620
1936	1,359	1,000	500	700	652	4,211
1938	1,902	2,000	357	500	325	5,084
1947	950[b]	2,050 [b]	750 [b]	625 [b]	200 [b]	4,575
1962	--	2,265[c]	--	--	--	--
1964	61[d]	--	--	--	--	--
1974	--	673[e]	133[f]	--	--	--
1983	--	319 [e]	141[f]	--	--	--
1990	--	449[g]	206 [f]	--	674 [g]	--
1991	0	359[g]	178[f]	--	626[h]	--
1992	--	189[g]	87[f]	--	693[h]	--
1993	--	218[g]	107[f]	--	496[g]	--
1994	--	387[g]	121[f]	--	538[g]	--
1995	--	288[g]	138[f]	--	--	--
1996	--	306[g]	76[f]	501[g]	987[g]	1,870
1997	--	--	--	--	937[h]	
1998	--	179[g]	--	256[g]	493[g]	
1999	0	350[g]	214[g]	270[g]	713[g]	1,547
2000	0	270[g]	79[g]	489[g]	866[g]	1,704
2001	0	227[g]	60[g]	740[g]	790[g]	1,817
2002	0	255[g]	125[g]	588[g]	716[g]	1,684
2003	0	254[g]	136[g]	513[g]	803[g]	1,706
2004	0	340[g]	85[g]	415[g]	738[g]	1,578

[a] Bonnot 1928

[b] Bonnot and Ripley 1948

[c] Orr and Poulter 1965

[d] Odell 1971

[e] LeBoeuf *et al.* 1991

[f] Point Reyes Bird Observatory, unpublished data

[g] Southwest Fisheries Science Center, unpublished data

[h] Oregon Department of Fish and Wildlife, unpublished data

Table 3.10. Recent counts of Steller sea lion pups on rookeries in California, 1990-2004.

Year	Año Nuevo	Farallons	Sugarloaf/ Cape Mendocino	Saint George Reef	Total Pups
1990	312[a]	4[c]			
1991	287[b]	2[c]			
1992	263[b]	4[c]			
1993	230[b]	5[c]			
1994	244[a]	7[c]		115[a]	
1995	226[a]	6[a]			
1996	236[a]	5[c]	62[a]	243[a]	546
1997	210[a]				
1998	186[a]		61[a]	256[a]	
1999	152[a]	10[a]	86[a]	184[a]	432
2000	184[a]	4[a]	138[a]	293[a]	619
2001	230[a]	2[a]	152[a]	338[a]	722
2002	189[a]	7[a]	150[a]	367[a]	713
2003	226	13[a]	158[a]	458[a]	855
2004	221	22[a]	131[a]	444[a]	818

[a] Southwest Fisheries Science Center, unpublished data

[b] Westlake *et al.* 1997

[c] Point Reyes Bird Observatory, unpublished data

Table 3.11. Estimates of the total number of Steller sea lions (pups and non-pups) in the eastern DPS in 2002 based on number of pups counted multiplied by the 4.5 multiplier (Calkins and Pitcher 1982) and the 5.1 multiplier (Trites and Larkin 1996).

Region	Pups Counted	Estimate with 4.5 multiplier	Estimate with 5.1 multiplier
Southeast Alaska	4,877	21,947	24,873
British Columbia	3,281	14,765	16,733
Oregon	1,128	5,076	5,753
California	713	3,209	3,636
Total	9,999	44,997	50,995

Table 3.12. Source of literature, age class/group, sample size (n), capture location, season captured, instrument deployed, and mean trip duration, distance, and time at sea for Steller sea lions tagged with radio (VHF) and satellite (e.g. SLTDR) transmitters. Error is standard deviation unless otherwise indicated.

Source	Age Class/Group	n	Capture Location	Season	Instrument	Mean Trip Duration (h)	Mean Trip Distance (km)	Mean % Time@Sea
Merrick and Loughlin (1997)	Adult Female	7	Marmot (CGOA)	Summer	VHF	21.0 ± 3.7 (SE)		53
	Adult Female	3	Ugamak (EAI)	Summer	VHF	25.0 ± 3.9		58
	Adult Female	4	EAI to CGOA	Summer	SLTDR	18.0 ± 3.1		50
	Adult Female	5	EAI to CGOA	Winter	SLTDR	204.0 ± 104.6		90
	YOY	5	EAI to CGOA	Winter	SLTDR	15.0 ± 2.2		38
Loughlin *et al.* (1998)	Adult F	8	Kuril Islands, Russia	Summer	SLTDR	short; max= 94 h	94% trips ≤ 10 km (max=263 km)	
Loughlin *et al.* (2003)[1]	YOY	12	CAI, EAI, EGOA, CGOA, and WA	All	SLTDR/SDR	7.5 ± 7.5	7.0 ± 19.0	
	Juv (>10 mo.)	13	CAI, EAI, EGOA, CGOA, and WA	All	SLTDR/SDR	18.1 ± 34.2	24.6 ± 57.2	
	Combined	25	CAI, EAI, EGOA, CGOA, and WA	All	SLTDR/SDR	12.1 ± 23.8		
Raum-Suryan *et al.*(2004)[2]	YOY (75), Juv (28)	103	see below	Spr/Sum/W	SDR	84% trips ≤ 20 h	90% trips ≤ 15 km	
	Western DPS	29	EAI, CGOA, EGOA	Spr/Sum/W	SDR		6.5 (5.08-8.26) CI	
	Eastern DPS	74	North, South, and Central SE	Spr/Sum/W	SDR		4.7 (3.92-5.53)	
Fadely *et al.* (2005)[3]	YOY/Juv	30	CAI, EAI, and CGOA	Feb-April	SDR	8.9 (8.4-9.4) CI	0.56 (0.56-0.74) CI	
				May-July	SDR	12.5 (11.3-13.9)	1.30 (0.93-1.49)	
				Nov-Jan	SDR	10.1 (8.2-12.5)	1.11 (0.74-1.67)	
Rehberg (2005)	YOY	11	CAI and GOA	Spring/Wint	SRDL			42 (38-45)
	Juv	12	CAI and GOA	Spring/Wint	SRDL			51 (49-54)

[1] Trip duration ranged from 1.0 h to 81.3 h (YOY) and 344.0 h (Juv) and trip distance ranged from 1.0 km to 260.7 km (YOY) and 447.3 km (Juv).

[2] Inter-haulout distance averaged 79.3 ± 7.7 km (max = 127 km) and dispersal distances (2 YOY, 2 Juv) included 76, 120, 500, and 1300 km, respectively. Sea lions in the western and eastern DPSs used an average of 1.6 and 2.1 haulouts, respectively.

[3] Most locations associated with diving were within 9 to 19 km (5-10 nm) of shore and in waters less than 100 m. Trip duration and use of offshore waters increased with age and coincided with spring.

YOY: young-of-the-year; Juv: juvenile (> 1 year unless otherwise specified); VHF: very high frequency radio transmitter; SLTDR: satellite-linked time-depth recorder; SDR: satellite depth recorder; SRDL: satellite relayed dive logger; CAI: central Aleutian Islands; EAI: eastern Aleutian Islands; EGOA: eastern Gulf of Alaska; CGOA: central Gulf of Alaska; SE: Southeast Alaska; WA: Washington State; CI: 95% confidence interval

Table 3.13. Source of literature, age class/group, sample size (n), capture location, season captured, instrument deployed, mean depth of dives, mean depth of maximum dives, maximum depth, mean duration of dives, and maximum duration of dives for Steller sea lions tagged with satellite (e.g. SLTDR) transmitters. Units for data coincide with those in the table header unless otherwise indicated and error is standard deviation unless otherwise indicated.

Source	Age Class/ Group	n	Capture Location	Season	Instrument	Mean Dive Depth (m)	Mean Max Depth (m)	Max Depth (m)	Mean Dive Duration (min)	Max Dur (min)
Merrick and Loughlin (1997)	Adult F	4	Alaska (EAI to CGOA)	Summer	SLTDR	21.0 (med)		150-250		
	Adult F	5	Alaska (EAI to CGOA)	Winter	SLTDR	24.0		> 250		
	YOY	5	Alaska (EAI to CGOA)	Winter	SLTDR	9.0		72		
Loughlin *et al.* (1998)	Adult F	8	Kuril Islands, Russia	Summer	SLTDR	53.0		250	1.9	8
Loughlin *et al.* (2003)[1]	YOY	13	CAI, EAI, EGOA, and CGOA	All	SLTDR/SDR	7.7 ± 1.7	25.7 ± 16.9	252	0.8 ± 0.1	
	Juv	5	EAI, EGOA, and CGOA	All	SLTDR/SDR	16.6 ± 10.9	63.4 ± 37.7	288	1.1 ± 0.4	
	Juv	7	WA	All	SLTDR/SDR	39.4 ± 14.9	144.5 ± 32.6	328	1.8 ± 0.6	
Pitcher *et al.* (2005)	YOY	75	Alaska (EAI to SE)	All	SDR	87% dives < 10 m		252	82% dives < 2 min	>12
	Juv	36	Alaska (EAI to SE)	All	SDR			452		
Fadely *et al.* (2005)[2]	YOY	26	CAI, EAI, and GOA	Spr/Sum/Win	SDR	10.3				
	Juv	4				13.0				
Rehberg (2005)	YOY	11	CAI and GOA	Spring/Winter	SRDL	12.4 (11.0-14.0) CI			0.87 (0.7-1.0) CI	
	Juv	12	CAI and GOA	Spring/Winter	SRDL	22.9 (20.0-28.0)			1.71 (1.5-2.0)	

[1] Dive parameters did not differ among regions in the Aleutian Islands and Gulf of Alaska.

[2] Increase in diving activity coincided with increases in SST and chlorophylll-a, but also with age.

YOY: young-of-the-year; Juv: juvenile (> 1 year unless otherwise specified); VHF: very high frequency radio transmitter; SLTDR: satellite-linked time-depth recorder; SDR: satellite depth recorder; SRDL: satellite relayed dive logger; CAI: central Aleutian Islands; EAI: eastern Aleutian Islands; EGOA: eastern Gulf of Alaska; CGOA: central Gulf of Alaska; SE: Southeast Alaska; WA: Washington State; CI: 95% confidence interval

Table 3.14 Updated Table II-6 (NMFS 2003) showing proportion of locations associated with diving to >4 m by distance from the nearest listed rookery or haulout site, and by distance from nearest point of land and stratified by season for 14,441 locations from 116 juvenile Steller sea lions instrumented during 2000-2005.

	Distance from listed rookery or haulout site		Distance from nearest point of land	
Zone	**Summer (Apr-Sept) (n=7,911)**	**Winter (Oct-Mar) (n=6,530)**	**Summer (Apr-Sept) (n=7,911)**	**Winter (Oct-Mar) (n=6,530)**
Inside CH				
0-10 nm	82.5%	93.4%	88.7%	98.2%
10-20 nm	7.4%	5.1%	2.8%	1.2%
>20 nm	0.9%	0.2%	0.3%	0.1%
Outside CH	9.2%	1.3%	8.2%	0.5%

Table 3.15 Updated Table II-7 (NMFS 2003)showing proportion of 14,441 locations associated with diving to >4 m obtained from 116 juvenile Steller sea lions during 2000-2005 within zones based on distance from nearest listed rookery or haulout site, and stratified by season and age at capture.

	Summer (Apr-Sept)		**Winter (Oct-Mar)**	
Zone	**3-10 months (n=3,095)**	**>10 Months (n=4,816)**	**3-10 months (n=4,540)**	**>10 Months (n=1,990)**
Inside CH				
0-10 nm	88.9%	78.4%	95.4%	88.9%
10-20 nm	5.4%	8.7%	3.5%	8.9%
>20 nm	0.8%	0.9%	0.1%	0.3%
Outside CH	4.9%	11.9%	1.0%	1.9%

Table 3.16 Table II-9 (NMFS 2003) updated with proportions of locations associated with diving to >4 m for juvenile Steller sea lions >10 months old at capture and instrumented during 2000-2005. Zones based on distances from nearest listed haulout or rookery, and proportions were stratified by season.

	Level of concern	**Summer (Apr-Sept)**	**Winter (Oct-Mar)**
Zone	**2001 BiOp**	**>10 months (n=4,816)**	**>10 months (n=1,990)**
Inside CH			
0-10 nm	High	78.4%	88.9%
10-20 nm	Low to moderate	8.7%	8.9%
>20 nm	Low	0.9%	0.3%
Outside CH	Low	11.9%	1.9%

Table 3.17 Proportion of 14,441 locations associated with diving to >4 m for 116 juvenile Steller sea lions based on distance to nearest listed haulout or rookery and stratified by region and season.

	Prince William Sound		**Kodiak**		**Eastern Aleutians**		**Central/Western Aleutians**	
Zone	**Summer[1]**	**Winter[2]**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
Inside CH								
0-10 nm	92.0%	94.5%	86.8%	93.0%	88.5%	91.2%	68.8%	100.0%
10-20 nm	7.1%	4.6%	7.5%	5.2%	5.5%	6.9%	8.8%	0.0%
>20 nm	0.0%	0.1%	0.3%	0.3%	2.8%	0.2%	0.5%	0.0%
Outside CH	0.9%	0.9%	5.4%	1.6%	3.3%	1.7%	21.9%	0.0%

[1] Summer is defined as April through September.

[2] Winter is defined as October through March.

Table 3.18 Steller sea lion satellite-tag deployments during 2000-2005 ($n = 116$) included in the current analysis. Data not included in the March 2003 "Addendum to the Section 7 Consultation of October 2001" (NMFS 2003*a*) are marked as "New" under the "Category" heading (data used in the previous analysis are marked by "-").

ID	Deployment Date	Age at capture (months)	Location	Group	Category
6295	29-Feb-00	9	Turf Pt. Seguam Island	NMML	-
6296	29-Feb-00	9	Turf Pt. Seguam Island	NMML	-
6297	29-Feb-00	9	Turf Pt. Seguam Island	NMML	-
6298	29-Feb-00	9	Turf Pt. Seguam Island	NMML	-
6299	9-Mar-00	9	Aiktak	NMML	-
6300	9-Mar-00	9	Aiktak	NMML	-
6302	12-Mar-00	9	Long Island, Kodiak	NMML	-
6301	12-Mar-00	21	Long Island, Kodiak	NMML	-
11212	23-Apr-00	10.5	Glacier Island, PWS	ADFG	New
11214	24-Apr-00	10.5	Glacier Island, PWS	ADFG	New
11215	24-Apr-00	10.5	Glacier Island, PWS	ADFG	New
11216	25-Apr-00	10.5	Glacier Island, PWS	ADFG	New
11217	25-Apr-00	10.5	Glacier Island, PWS	ADFG	New
11218	25-Apr-00	10.5	Glacier Island, PWS	ADFG	New
11219	25-Apr-00	10.5	Glacier Island, PWS	ADFG	New
11220	26-Apr-00	22.5	The Needle, PWS	ADFG	New
11221	28-Apr-00	22.5	Point Elrington, PWS	ADFG	New
11222	22-Aug-00	14	Glacier Island, PWS	ADFG	New
11210	23-Aug-00	14	The Needle, PWS	ADFG	New
11223	23-Aug-00	14	The Needle, PWS	ADFG	New
11211	24-Aug-00	26	The Needle, PWS	ADFG	New
6303	26-Feb-01	21	Reef Bite	NMML	-
6304	1-Mar-01	9	Aiktak	NMML	-
6305	1-Mar-01	9	Ugamak	NMML	-
6308	3-Mar-01	9	Aiktak	NMML	-
6309	3-Mar-01	9	Aiktak	NMML	-
6310	3-Mar-01	9	Aiktak	NMML	-
6307	3-Mar-01	9	Rocks off Tigalda	NMML	-
6306	3-Mar-01	21	Rocks off Tigalda	NMML	-
6312	4-Mar-01	9	Billingshead, Akun	NMML	-
6311	4-Mar-01	21	Billingshead, Akun	NMML	-
6283	6-Mar-01	9	Long Island, Kodiak	ADFG	New
6284	6-Mar-01	9	Long Island, Kodiak	ADFG	New
6285	7-Mar-01	9	Long Island, Kodiak	ADFG	New
6115	9-Mar-01	9	Sea Otter	NMML	-
6286	9-Mar-01	9	Sea Otter	NMML	-
6287	9-Mar-01	9	Sea Otter	NMML	-
6288	10-Mar-01	9	Sea Otter	NMML	-
6289	12-Mar-01	9	Long Island, Kodiak	NMML	-
6290	12-Mar-01	9	Long Island, Kodiak	NMML	-
6291	12-Mar-01	9	Long Island, Kodiak	NMML	-
6292	12-Mar-01	9	Long Island, Kodiak	NMML	-
6293	13-Mar-01	9	Long Island, Kodiak	NMML	-
6294	13-Mar-01	9	Long Island, Kodiak	NMML	-

6124	2-Aug-01	14	Cape Chiniak, Kodiak	NMML	-
6966	7-Aug-01	14	Two Headed Rock, Kodiak	NMML	-
6967	8-Aug-01	14	Two Headed Rock, Kodiak	NMML	-
7576	17-Sep-01	3	Cape Morgan, Akutan	ADFG	New
7578	17-Sep-01	3	Cape Morgan, Akutan	ADFG	New
8237	3-Nov-01	17	Two Headed Rock, Kodiak	NMML	-
7585	6-Nov-01	5	Bull Head, Glacier Island	ADFG	New
7586	6-Nov-01	17	Bull Head, Glacier Island	ADFG	New
7589	7-Nov-01	17	Bull Head, Glacier Island	ADFG	New
7592	8-Nov-01	5	NE Haulout, Perry Island	ADFG	New
7593	8-Nov-01	17	NE Haulout, Perry Island	ADFG	New
7594	8-Nov-01	17	NE Haulout, Perry Island	ADFG	New
7595	8-Nov-01	17	NE Haulout, Perry Island	ADFG	New
7600	9-Nov-01	5	NE Haulout, Perry Island	ADFG	New
7602	11-Nov-01	5	NE Haulout, Perry Island	ADFG	New
7603	11-Nov-01	5	NE Haulout, Perry Island	ADFG	New
6446	13-Nov-01	5	Ugamak	NMML	-
8238	13-Nov-01	5	Ugamak	NMML	-
8239	14-Nov-01	17	Aiktak	NMML	-
7467	28-Feb-02	9	Cape Chiniak, Kodiak	NMML	-
7468	2-Mar-02	9	Long Island, Kodiak	NMML	-
7469	2-Mar-02	9	Long Island, Kodiak	NMML	-
7471	3-Mar-02	9	Long Island, Kodiak	NMML	-
7473	3-Mar-02	9	Long Island, Kodiak	NMML	-
7474	4-Mar-02	9	Long Island, Kodiak	NMML	-
6647	5-Mar-02	9	Two Headed Rock, Kodiak	NMML	-
7478	5-Mar-02	9	Two Headed Rock, Kodiak	NMML	-
7479	5-Mar-02	9	Two Headed Rock, Kodiak	NMML	-
7476	5-Mar-02	24	Two Headed Rock, Kodiak	NMML	-
7481	10-Mar-02	9	Basalt Rock	NMML	-
7482	11-Mar-02	9	Aiktak	NMML	-
7483	11-Mar-02	9	Aiktak	NMML	-
7484	11-Mar-02	9	Aiktak	NMML	-
7485	11-Mar-02	9	Aiktak	NMML	-
7486	11-Mar-02	9	Aiktak	NMML	-
7487	11-Mar-02	9	Aiktak	NMML	-
6475	12-Mar-02	9	Aiktak	NMML	-
7488	12-Mar-02	9	Aiktak	NMML	-
7489	12-Mar-02	9	Aiktak	NMML	-
7620	7-Apr-02	9	Bay of Waterfalls, Adak Island	ADFG	New
7621	7-Apr-02	9	Bay of Waterfalls, Adak Island	ADFG	New
7824	26-Jul-02	12	Cape Chiniak, Kodiak	NMML	-
7823	26-Jul-02	24	Cape Chiniak, Kodiak	NMML	-
7825	29-Jul-02	12	Two Headed Rock, Kodiak	NMML	-
7827	29-Jul-02	12	Two Headed Rock, Kodiak	NMML	-
7829	30-Jul-02	24	Two Headed Rock, Kodiak	NMML	-
7830	1-Aug-02	12	Marmot Island	NMML	-
7831	2-Aug-02	24	Marmot Island	NMML	-
7832	2-Aug-02	24	Marmot Island	NMML	-
8243	25-Feb-03	9	Long Island, Kodiak	NMML	New
8244	27-Feb-03	9	Long Island, Kodiak	NMML	New
8246	27-Feb-03	9	Long Island, Kodiak	NMML	New

8247	27-Feb-03	9	Long Island, Kodiak	NMML	New
8248	1-Mar-03	9	Cape Ugat, Kodiak	NMML	New
8249	2-Mar-03	9	Cape Ugat, Kodiak	NMML	New
8251	6-Mar-03	9	Rocks off Tigalda	NMML	New
8253	7-Mar-03	9	Aiktak	NMML	New
11246	19-Apr-05	10	Silak Island	NMML	New
11247	19-Apr-05	10	Silak Island	NMML	New
11248	20-Apr-05	10	Little Tanaga Island	NMML	New
11249	22-Apr-05	10	Lake Point, Adak	NMML	New
11250	22-Apr-05	10	Lake Point, Adak	NMML	New
11251	22-Apr-05	10	Lake Point, Adak	NMML	New
11252	22-Apr-05	10	Lake Point, Adak	NMML	New
11253	22-Apr-05	10	Lake Point, Adak	NMML	New
11255	24-Apr-05	10	Ship Rock, Kanaga	NMML	New
11257	25-Apr-05	10	Ogalala Pt., Kagalaska	NMML	New
11258	25-Apr-05	10	Ogalala Pt., Kagalaska	NMML	New
11256	25-Apr-05	10	Ship Rock, Kanaga	NMML	New
11260	2-May-05	11	Lake Point, Adak	NMML	New
11261	2-May-05	11	Lake Point, Adak	NMML	New
11262	2-May-05	11	Lake Point, Adak	NMML	New

Table 3.19 Effect of error-checking, database matching and filtering on number of locations included in analysis of juvenile Steller sea lion diving locations during 2000-2005. A total of 65,150 locations from 116 animals were initially extracted from the database for processing.

Number of Locations	Percent of initial locations	Category
12	0.02%	Identified outliers.
207	0.32%	Timeline data only indicated dry transmission.
324	0.50%	No land/sea or timeline indication of wet or dry transmission.
418	0.64%	Land sea data only indicated dry transmission.
1535	2.36%	Conflicts between land/sea and timeline transmission status.
5307	8.15%	Timeline and land/sea data indicated dry transmission.
6703	10.29%	Removed in processing, duplicates, z-quality locations, pre- and post- deployment locations.
9281	14.25%	On-land locations.
12335	18.93%	Did not meet dive to >4 meter criteria.
14587	22.39%	B locations.
14441	**22.17%**	**Used in this analysis.**

Table 3.20a. Food habits information for Steller sea lions collected in the range of the western DPS, 1945-1998. Sample sizes and characteristics of the study (Reprinted from Fritz and Hinckley 2005).

Sample Sizes and Characteristics		Months				Region						
Reference	Years	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	CGOA	WGOA	EBS	EAI	CAI	WAI	Russia
Imler and Sarber (1947)	1945			7		7						
Wilke and Kenyon (1952)	1949, 51			3				3				
Mathisen *et al.* (1962)	1958		94				94					
Thorsteinson and Lensink (1962)	1959		56			9	27		20			
Tikhomirov (1964)	1962	X	X					X				
Fiscus and Baines (1966)	1960, 62		16			4	2	1	9			
Perlov (1975)	1966-69			?								X
Lowry *et al.* (1982)	1976	4						4				
Pitcher (1981)	1975-78	43	54	9	47	136	17					
Calkins (1998) a	1981	60										60
Calkins (1998) b	1981	32						32				
Frost and Lowry (1986)	1985	13						13				
Gearin (unpub)	1985, 86			3	8			11				
Calkins and Goodwin (1988)	1985, 86		X		X	74						
Merrick *et al.* (1997) a	1990-93			76		76						
Merrick *et al.* (1997) b	1990-93			67					67			
Merrick *et al.* (1997) c	1990-93			167						167		
Merrick *et al.* (1997) d	1990-93			28							28	
Goto and Shimazaki (1997)	1994-96	62										62
Sinclair and Zeppelin (2002) a	1990-98	X	X	X	X	574						
Sinclair and Zeppelin (2002) b	1990-98	X	X	X	X		929					
Sinclair and Zeppelin (2002) c	1990-98	X	X	X	X				889			
Sinclair and Zeppelin (2002) d	1990-98	X	X	X	X					1370		

Table 3.20b. Food habits information of Steller sea lions collected in the range of the western DPS, 1945-1998 (continued).

Food Habits Data Reference	Sample Type	Sample Location	Data Type	Percent of Sample with Prey Item (x=present)												
				Pollock	Cod	Flatfish	Greenling	Rockfish	Smelts	Sandlance	Herring	Salmon	Sculpin	Shrimp/Crab	Squid	Octopus
Imler and Sarber (1947)	Stomach	Land	FO	57		71						28				43
Wilke and Kenyon (1952)	Stomach	Land	PW	7	10	49				32			<1			2
Mathisen *et al.* (1962)	Stomach	Land	FO				13	9	14	1		1	6	10	44	
Thorsteinson and Lensink (1962)	Stomach	Land	FO			6	4	11		25			4	2	20	
Tikhomirov (1968)	Visual	At-sea									D					
Fiscus and Baines (1966)	Stomach	At-sea	FO	6		12	6	6	56	25			19			
Perlov (1975)	Stomach	At-sea	FO	63			10						1		>30	25
Lowry *et al.* (1982)	Stomach	At-sea	PV	97		1									1	1
Pitcher (1981)	Stomach	Land	FO	67	12	5		3	11		11	4	4	7	23	13
Calkins (1998) a	Stomach	At-sea	FO	83	43	3					17		>12	2	2	18
Calkins (1998) b	Stomach	At-sea	FO	100	28	>19		3			6		6	>10	19	19
Frost and Lowry (1987)	Stomach	At-sea	PV	48							48					
Gearin (unpub)	Stomach	Land	FO	>36	>45	54								18		45
Calkins and Goodwin (1988)	Stomach	Land	FO	58	7	14				7	3	3	1	>1	4	32
Merrick *et al.* (1997) a	Scat	Land	FOSS	66		4	<1		6			20	0		3	
Merrick *et al.* (1997) b	Scat	Land	FOSS	33		2	31		8			17	7		2	
Merrick *et al.* (1997) c	Scat	Land	FOSS	13		0	69		1			6	4		8	
Merrick *et al.* (1997) d	Scat	Land	FOSS	7		0	77					5	5		7	
Goto and Shimazaki (1997)	Stomach	At-sea	FO	89	76	24									69	11
Sinclair and Zeppelin (2002) a	Scat	Land	FO	>50	>5	>20	<5	x	x	>10	>10	>10	<10		<10	<10
Sinclair and Zeppelin (2002) b	Scat	Land	FO	>70	>10	>10	<5	x	x	>10	<10	>10	>10		<5	<5
Sinclair and Zeppelin (2002) c	Scat	Land	FO	>50	>10	<5	>20	x	x	<5	>5	>20	>10		<10	<10
Sinclair and Zeppelin (2002) d	Scat	Land	FO	<10	>10	<5	>60	x		<5	<5	>20	>10		<20	<20

Abbreviations: CGOA – central Gulf of Alaska; WGOA – western Gulf of Alaska; EBS – eastern Bering Sea; EAI – eastern Aleutian Islands; CAI – central Aleutian Islands; WAI – western Aleutian Islands; X – number for cell is unknown; ? – season of sample collection is unknown but likely to be as indicated; FO=frequency of occurrence; PW=percent by weight; PV=percent by volume; FOSS=Split sample FO.

Table 3.21 Percent frequency of occurrence of prey occurring in Steller sea lion scats collected from 1999 to 2005 (NMFS 2006b).

Region	Central & Western Aleutians		Eastern Aleutians		Western Gulf		Central Gulf		Eastern Gulf	Western DPS		
Season	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Summer	Winter	ALL
Number of scats	483	301	290	773	184	42	85	204	38	1080	1320	2400
Pollock	7	12	46	53	53	93	46	44	8	28	44	37
Pacific cod	6	26	18	39	36	31	2	43	5	14	37	26
Atka mackerel	96	55	32	43	21		1	2		55	38	46
Salmon	17	6	38	25	57	17	56	29	84	35	21	27
Herring			35	1	3	2	12	12	24	12	2	6
Sand lance	4	1	34	28	65	17	16	38	39	25	23	24
Arrowtooth	1	1	8	21	14	7	45	31	5	9	17	13
Irish Lord sp.	3	23	11	33	13	5		17		7	27	18
Sand fish	1	5	16	11	3	7		13		5	10	8
Halibut		1	1	10	4	5	4	12		1	8	5
Cephalopods	13	18	7	4	1		5	7	3	8	7	8
Rock sole	0	6	19	14	9	5		7		7	11	9
Snailfish sp.	1	12	1	14				4		1	12	7
Capelin			2	0	3		13	4	13	3	1	2
Poacher sp.			14	1						4	0	2

Table 3.22 Estimated size ranges of Pacific cod eaten by Steller sea lions by region, in scats collected from 1995 through 2005 (NMFS 2006b). Because some scats contain more than one Pacific cod, the frequency of size ranges sum to more than 100% (e.g., a scat may contain both a Very Large and a Medium sized P. cod).

SUMMER ROOKERIES						
Region	**EGOA**	**CGOA**	**WGOA**	**EAI**	**CAI & WAI**	**ALL**
Total Number of Scats Analyzed	38	340	200	415	966	1960
Number of Scats Containing P. Cod	2	8	73	73	60	216
Frequency of Occurrence P.Cod	5.3	2.4	36.4	17.6	6.2	11.0
VERY LARGE[1]	**100**	**75**	**82**	**62**	**82**	**75**
LARGE[1]			**40**	**33**	**13**	**28**
MEDIUM / LARGE		**13**	**1**	**10**		**4**
MEDIUM			**3**	**1**		**1**
SMALL/ MEDIUM			**1**	**1**	**2**	**1**
SMALL		**13**		**1**	**2**	**1**
VERY SMALL[1]				**1**		**0**
EXTRA SMALL					**5**	**1**

WINTER HAULOUTS					
Region	**CGOA**	**WGOA**	**EAI**	**CAI & WAI**	**ALL**
Total Number of Scats Analyzed	389	607	1080	381	2458
Number of Scats Containing P. Cod	168	188	422	100	878
Frequency of Occurrence P.Cod	43.1	31.0	39.1	26.3	35.7
VERY LARGE	**61**	**33**	**84**	**87**	**60**
LARGE	**36**	**19**	**21**	**11**	**19**
MEDIUM / LARGE	**8**	**4**	**2**	**1**	**3**
MEDIUM	**1**	**1**		**2**	**1**
SMALL/ MEDIUM	**10**	**5**	**1**	**3**	**3**
SMALL	**2**	**1**	**1**	**1**	**1**
VERY SMALL	**5**	**3**	**1**		**2**
EXTRA SMALL			**1**		**1**

[1] Size ranges: VERY LARGE = 35 - 60 cm; LARGE = 28 - 33 cm; VERY SMALL = 8 - 15 cm

Table 3.23 Estimates of the forage ratio for Steller sea lions in the Eastern Bering Sea, Gulf of Alaska, and Aleutian Islands (NMFS 2001). Includes the amount of forage required by Steller sea lions and groundfish biomass in critical habitat in the three areas.

	Annual Estimate of Forage Required (mt)	**Groundfish Biomass Estimates in 2000[1]**	**Forage Ratio[2]**	**Percent of Required Forage**
Eastern Bering Sea	41,508	18,517,619	**446**	**969%**
Gulf of Alaska	213,695	3,630,482	**17**	**37%**
Aleutian Islands	130,296	1,468,608	**11**	**24%**

[1] Biomass was calculated for all FMP species in 2000 SAFE.

[2] Theoretical foraging ratio is between 22 and 46 for pristine conditions (see NMFS 2000 and 2001).

Table 3.24 Data gaps for assessing potential biological manifestations of nutritional stress in the western DPS of Steller sea lions. Evidence is based on a comparison with the previous decade (H=historical) or with the eastern DPS (G=Geographic). Y=Yes, data are available to make a comparison and an effect was as indicated; N=No, data are available to make a comparison but the effect was opposite to that indicated; U=Unknown, no data are available; U*=Unknown, data available but not analyzed. Range-wide versus local data sets are identified by superscript "R" and "L", respectively. See text and Appendix 3 for details and references.

Potential Biological Effects	**1980s**	**1990s**	**2000-2004**
More emaciated pups (<4 wks)	U	U*	N(H)
More emaciated pups (>4 wks)	U	U	U
More emaciated juveniles	U	N(H,G)	U
More emaciated adults	U	N(H,G)	U
Reduced pup survival (to 4 wks)	U*	U*	U
Reduced adult body size	Y(H)	U	U
Reduced juvenile body size	Y(H)	U*	U
Reduced pup body size	U	N(G), U*(H)	N(H)
Reduced birth weight	N or U?	U	U
Reduced pup weight	?	N(G),U*(H)	N(H)
Reduced growth rate	Y(H)	N(G)	N(H)
Reduced pup survival	? OR U	U*	N(H)
Reduced juvenile survival	Y(H)	Y	N(H)
Reduced adult survival	Y(H)	N	N(H)
Reduced overall survival	Y(H)	Y(H,G)	N(H)
Reduced birth rate	Y(H)	Y(H)	Y(H)
Reduced pup counts	Y(H)	Y(H)	N(H)
Reduced non-pup counts	Y(H)	Y(H)	N(H)
Increased reproductive failure	Y(H)	U	U
Change in pup blood chemistry (increased fasting)	U	N(G)	N
Change in juvenile blood chemistry (increased fasting)	U	U*	N
Delayed sexual maturity	U	U	U
Change in metabolic rate	U	U	U
Decreased body condition (adult females on rookeries)	U	U* (N(G))	U
Reduced adult perinatal fast	U	N(G)	U
Longer foraging trip duration	U	N(G)	U*
Increased susceptibility to disease (haptoglobin)	U	U*	U
Increased incidence of disease	U	N(G)	N(H,G)
Increased susceptibility to predation	U	U	U
Altered weaning age	U	U*(G)	U*
Decreased weaning size	U	U	U
Traditional ecological knowledge re. body condition	?	U*	U*

Table 3.25 Numbers of females at age in the Alaskan western Steller sea lion population by region in 2004. The central Gulf of Alaska estimate is from Holmes et al (in review). The total number of females in each of the other regions is based on the regional distribution of females observed in the 2004 medium format aerial survey, while the age-structure mirrors the Holmes et al estimate for the central Gulf of Alaska.

	REGION						
	E GULF	**C GULF**	**W GULF**	**E ALEU**	**C ALEU**	**W ALEU**	**TOTAL**
% of all Females	*10.4%*	*18.0%*	*20.2%*	*21.0%*	*26.0%*	*4.4%*	*100%*
Age							
1	336	582	652	679	840	143	3,232
2	282	489	548	570	705	120	2,714
3	265	459	515	536	662	113	2,550
4	274	475	532	554	685	117	2,638
5	277	480	538	561	693	118	2,667
6	301	522	585	609	753	128	2,899
7	202	349	391	408	504	86	1,940
8	157	272	305	318	393	67	1,513
9	135	234	263	273	338	58	1,301
10	126	218	244	254	314	54	1,210
11	126	218	245	255	315	54	1,212
12	150	259	291	303	374	64	1,440
13	159	275	309	321	397	68	1,530
14	157	272	305	317	392	67	1,510
15	145	251	282	294	363	62	1,397
16	159	275	308	321	396	68	1,526
17	87	151	170	177	219	37	841
18	59	102	114	119	147	25	566
19	44	77	86	89	111	19	426
20	36	62	70	73	90	15	346
21	33	58	65	68	83	14	321
22	55	95	107	111	137	23	528
23	65	112	126	131	162	28	622
24	61	105	118	123	152	26	585
25	48	84	94	98	121	21	464
26	38	66	74	77	95	16	367
27	30	52	58	61	75	13	289
28	24	41	46	48	59	10	227
29	18	32	36	37	46	8	177
30	14	25	28	29	36	6	138
31	11	19	22	23	28	5	107
Total	**3,875**	**6,712**	**7,524**	**7,836**	**9,685**	**1,651**	**37,283**

Table 3.26 Steller sea lion pups and adult females in 2005 counted and estimated **on rookeries** in each sub-area of the western stock in Alaska. The ratio of observed pup per female was calculated using survey counts. The estimated number of adult females was obtained by applying the observation rate of 44%, which yields an estimate of the true number of pups per female on rookeries.

Region	Counted Pups	Counted Adult Females	Observed Pup per Female	Estimated Adult Females	Estimated Pup per Female
E GULF	759	1,141	67%	2,593	29%
C GULF	1,706	2,117	81%	4,811	35%
W GULF	1,924	2,328	83%	5,290	36%
E ALEU	2,112	2,459	86%	5,588	38%
C ALEU	2,772	3,122	89%	7,095	39%
W ALEU	343	578	59%	1,314	26%
TOTAL	9,616	11,745	82%	26,690	36%

Table 3.27 Steller sea lion pups and adult females in 2005 counted and estimated on haul-outs and on both rookeries and haul-outs in each sub-area of the western stock in Alaska. The estimated number of adult females on haul-outs was obtained by applying the observation rate of 44%. Pups on haul-outs were estimated from an average rate of 'successful natality' of adult females on haul-outs of 6% (see text).

	Haul-Outs Only			Rookeries and Haul-outs		
Region	Counted Adult Females	Estimated Adult Females	Estimated Pups	Estimated Total Pups	Estimated Pup per Female	Proportion of 1976 rate
E GULF	424	964	61	820	23%	52%
C GULF	594	1,350	85	1,791	29%	66%
W GULF	711	1,616	102	2,026	29%	67%
E ALEU	706	1,604	101	2,213	31%	70%
C ALEU	790	1,795	113	2,885	32%	74%
W ALEU	89	202	13	356	23%	53%
TOTAL	2,890	7,531	474	10,090	29%	67%

Table 3.28 Age-specific rates of survivorship and baseline (1976) fecundity (not equivalent to 'successful natality') for female Steller sea lions in the central Gulf of Alaska (Holmes *et al.* in press). Survivorship is from age *t* to *t*+1. Fecundity is number of female pups produced per female at age *t*.

Age (*t*)	**Survivorship**	**Fecundity**
0	0.7845	0
1	0.8331	0
2	0.8316	0
3	0.9302	0
4	0.9092	0.048
5	0.8951	0.1695
6	0.8839	0.2215
7	0.8746	0.2795
8	0.8665	0.3285
9	0.8593	0.3285
10	0.8527	0.3285
11	0.8468	0.3885
12	0.8412	0.3885
13	0.836	0.3885
14	0.8312	0.3885
15	0.8266	0.3885
16	0.8223	0.3885
17	0.8182	0.257
18	0.8142	0.257
19	0.8105	0.257
20	0.8069	0.257
21	0.8034	0.257
22	0.8001	0
23	0.7968	0
24	0.7937	0
25	0.7907	0
26	0.7878	0
27	0.785	0
28	0.7822	0
29	0.7795	0
30	0.7769	0
31	0	0

Table 3.29 Changes in juvenile (ages 0-3) survivorship relative to those calculated for the baseline year (1976) that are necessary to achieve growth rates of 0%-3% per year in the western DPS of Steller sea lions given changes in adult survivorship (from +2% to +7% greater than baseline) and rates of 'successful natality' (from -40% to +10% of baseline). Blue highlighted row indicates estimated change in 'successful natality' of central Gulf population between the baseline and 1998-2004.

	Adult Survival = 102%				Adult Survival = 103%			
	Growth Rate				**Growth Rate**			
Fecundity Change	**0%**	**1%**	**2%**	**3%**	**0%**	**1%**	**2%**	**3%**
Relative to the 1970s	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv
+10%	102.5%	106.4%	110.3%	Not possible	99.6%	103.5%	107.5%	111.4%
0%	105.6%	109.7%	113.7%	Not possible	102.7%	106.7%	110.8%	Not possible
-10%	109.2%	113.4%	Not possible	Not possible	106.2%	110.4%	Not possible	Not possible
-20%	113.3%	Not possible	Not possible	Not possible	110.1%	Not possible	Not possible	Not possible
-30%	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible
-33%	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible
-40%	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible	Not possible

	Adult Survival = 104%				Adult Survival = 105%			
	Growth Rate				**Growth Rate**			
Fecundity Change	**0%**	**1%**	**2%**	**3%**	**0%**	**1%**	**2%**	**3%**
Relative to the 1970s	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv
+10%	96.7%	100.7%	104.6%	108.6%	93.7%	97.8%	101.7%	105.7%
0%	99.7%	103.8%	107.9%	111.9%	96.7%	100.8%	104.9%	109.0%
-10%	103.1%	107.3%	111.5%	Not possible	100.0%	104.3%	108.5%	113.0%
-20%	107.0%	111.3%	Not possible	Not possible	103.8%	108.2%	112.5%	Not possible
-30%	111.4%	Not possible	Not possible	Not possible	108.1%	112.6%	Not possible	Not possible
-33%	Not possible	Not possible	Not possible	Not possible	109.6%	114.0%	Not possible	Not possible
-40%	Not possible	Not possible	Not possible	Not possible	113.2%	Not possible	Not possible	Not possible

	Adult Survival = 106%				Adult Survival = 107%			
	Growth Rate				**Growth Rate**			
Fecundity Change	**0%**	**1%**	**2%**	**3%**	**0%**	**1%**	**2%**	**3%**
Relative to the 1970s	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv	Juv Surv
+10%	90.8%	94.8%	98.8%	102.8%	87.8%	91.9%	95.9%	99.9%
0%	93.6%	97.8%	101.9%	106.0%	90.5%	94.8%	98.9%	103.1%
-10%	96.9%	101.2%	105.4%	109.6%	93.7%	98.0%	102.3%	106.6%
-20%	100.5%	105.0%	109.3%	113.7%	97.2%	101.7%	106.2%	110.5%
-30%	104.7%	109.3%	113.9%	Not possible	101.3%	106.0%	110.6%	Not possible
-33%	106.1%	110.8%	Not possible	Not possible	102.7%	107.4%	112.0%	Not possible
-40%	109.7%	Not possible	Not possible	Not possible	106.1%	111.0%	Not possible	Not possible

Table 3.30 Nineteen Steller sea lion terrestrial haul-out sites that were listed as RFRPA sites for management purposes in 1999, but not designated as critical habitat. Locations are degrees and minutes and if two are listed, they denote endpoints of a stretch of coastline. An 'X' denotes whether the site met the seasonal non-pup count threshold during the time periods specified (>200 during the breeding season May-August; >100 during the non-breeding season September-April). Regions are defined in Fritz and Stinchcomb (2005).

												Non-Pup Count Criteria					
	Latitude		Longitude			Latitude		Longitude				1990-2005			1956-2005		
Sitename	**D**	**Min**	**D**	**Min**		**D**	**Min**	**D**	**Min**		**Region**	**Breeding**	**Non-Breeding**	**Annual**	**Breeding**	**Non-Breeding**	**Annual**
CAPE HINCHINBROOK	60	14.0	146	38.5	W						E GULF	X			X		
GLACIER	60	51.3	147	14.5	W						E GULF	X	X	X	X	X	X
RUGGED	59	50.0	149	23.1	W	59	51.0	149	24.7	W	E GULF		X			X	
STEEP POINT	59	29.1	150	15.4	W						E GULF	X			X		
PERL	59	5.7	151	39.7	W						C GULF	X	X	X	X	X	X
SHAW	59	0.0	153	22.5	W						C GULF	X			X		
KAK	56	17.3	157	50.1	W						W GULF	X			X		
MITROFANIA	55	50.2	158	41.9	W						W GULF	X	X	X	X	X	X
OLGA ROCKS	55	0.5	161	29.8	W	54	59.1	161	30.9	W	W GULF	X	X	X	X	X	X
SUSHILNOI ROCKS	54	49.3	161	42.7	W						W GULF	X	X	X	X	X	X
UGAMAK/ROUND	54	12.1	164	46.6	W						E ALEU				X		
AIKTAK	54	11.0	164	51.2	W						E ALEU		X			X	
UNIMAK/CAPE SARICHEF	54	34.3	164	56.8	W						E ALEU	X	X	X	X	X	X
ROOTOK	54	3.9	165	31.9	W	54	2.9	165	29.5	W	E ALEU	X	X	X	X	X	X
UNALASKA/BISHOP POINT	53	58.4	166	57.5	W						E ALEU	X	X	X	X	X	X
UNALASKA/CAPE IZIGAN	53	13.6	167	39.4	W						E ALEU	X	X	X	X	X	X
SAMALGA	52	46.0	169	15.0	W						E ALEU				X		
RAT	51	50.0	178	12.4	E						C ALEU		X			X	
AMCHITKA/CAPE IVAKIN	51	24.5	179	24.2	E						C ALEU				X		

Table 3.31 Steller sea lion terrestrial haul-out sites that met the non-pup count threshold since 1990 but were not designated as critical habitat (summary of Tables 1 and 2). Locations are degrees and minutes and if two are listed, they denote endpoints of a stretch of coastline. Regions are defined in Fritz and Stinchcomb (2005).

	Latitude		**Longitude**			**Latitude**		**Longitude**				**Non-Pup Count Criteria**		
Sitename[1]	**Deg**	**Min**	**Dec**	**Min**		**Deg**	**Min**	**Dec**	**Min**		**Region**	**Breeding**	**Non-Breeding**	**Annual**
CAPE HINCHINBROOK	60	14.0	146	38.5	W						E GULF	X		
GLACIER	60	51.3	147	14.5	W						E GULF	X	X	X
RUGGED	59	50.0	149	23.1	W	59	51.0	149	24.7	W	E GULF		X	
STEEP POINT	59	29.1	150	15.4	W						E GULF	X		
PERL	59	5.7	151	39.7	W						C GULF	X	X	X
ELIZABETH/CAPE ELIZABETH	59	9.4	151	53	W						C GULF		X	
FLAT	59	20	151	60	W						C GULF		X	
SHAW	59	0.0	153	22.5	W						C GULF	X		
KAK	56	17.3	157	50.1	W						W GULF	X		
MITROFANIA	55	50.2	158	41.9	W						W GULF	X	X	X
UNGA/ACHEREDIN POINT	55	7.2	160	49	W						W GULF	X		
OLGA ROCKS	55	0.5	161	29.8	W	54	59.1	161	30.9	W	W GULF	X	X	X
SUSHILNOI ROCKS	54	49.3	161	42.7	W						W GULF	X	X	X
UGAMAK/ROUND	54	12.1	164	46.6	W						E ALEU	X	X	X
AIKTAK	54	11.0	164	51.2	W						E ALEU		X	
UNIMAK/CAPE SARICHEF	54	34.3	164	56.8	W						E ALEU	X	X	X
ROOTOK	54	3.9	165	31.9	W	54	2.9	165	29.5	W	E ALEU	X	X	X
UNALASKA/BISHOP POINT	53	58.4	166	57.5	W						E ALEU	X	X	X
UNALASKA/CAPE IZIGAN	53	13.6	167	39.4	W						E ALEU	X	X	X
TAGALAK	51	58	175	37	W						C ALEU		X	
SEMISOPOCHNOI/TUMAN POINT	51	58	179	29	E						C ALEU		X	
RAT	51	50.0	178	12.4	E						C ALEU		X	

[1] Sites removed from the original list of 19 sites because they did not meet the criteria: Samalga and Amchitka/Cape Ivakin.

Table 3.32 Description of important Steller sea lion rookery and haulout sites based on an assessment of usage patterns (NMFS 2006b). Sites are evaluated by season (summer and winter; May – October and November – April) to determine when sites are important. Sites that do not meet either of the seasonal criteria are rated "neither" which does not mean that sea lions are not present, just that it did not meet the thresholds used in the analysis (>200 non-pups in summer and >100 non-pups in winter from 1990-2005). This analysis provides a model for evaluating potential impacts of fisheries by season and location.

Sitename	Latitude From	Longitude From	E/W	Latitude To	Longitude To	E/W	Region	Desc.[1]	Season
ROOKERIES									
YUNASKA	52.69	170.61	W				C ALEU	R	**ALL**
SEGUAM/SADDLERIDGE	52.35	172.57	W	52.35	172.56	W	C ALEU	R	**ALL**
KASATOCHI/NORTH POINT	52.19	175.52	W				C ALEU	R	**ALL**
ADAK/LAKE POINT	51.62	176.99	W	51.59	176.95	W	C ALEU	R	**ALL**
GRAMP ROCK	51.48	178.34	W				C ALEU	R	**ALL**
TAG	51.56	178.58	W				C ALEU	R	**ALL**
ULAK/HASGOX POINT	51.32	178.98	W	51.31	178.99	W	C ALEU	R	**ALL**
KISKA/LIEF COVE	51.95	177.34	E	51.95	177.34	E	C ALEU	R	**ALL**
KISKA/CAPE ST STEPHEN	51.88	177.21	E	51.89	177.20	E	C ALEU	R	**ALL**
KANAGA/SHIP ROCK	51.78	177.35	W				C ALEU	R/H	**ALL**
OUTER (PYE)	59.34	150.38	W	59.35	150.41	W	C GULF	R	**ALL**
MARMOT	58.23	151.80	W	58.17	151.87	W	C GULF	R	**ALL**
CHIRIKOF	55.78	155.66	W	55.77	155.72	W	C GULF	R	**ALL**
CHOWIET	56.01	156.69	W	56.01	156.69	W	C GULF	R	**ALL**
SEA LION ROCK (AMAK)	55.46	163.20	W				E ALEU	R	**ALL**
UGAMAK COMPLEX	54.23	164.79	W	54.21	164.79	W	E ALEU	R	**ALL**
AKUN/BILLINGS HEAD	54.29	165.53	W	54.29	165.53	W	E ALEU	R	**ALL**
OGCHUL	53.00	168.40	W				E ALEU	R	**ALL**
SEAL ROCKS	60.16	146.84	W				E GULF	R	**ALL**
WOODED (FISH)	59.88	147.34	W				E GULF	R	**ALL**
CHISWELL ISLANDS	59.60	149.57	W				E GULF	R/H	**ALL**
BULDIR	52.36	175.97	E	52.39	175.85	E	W ALEU	R	**ALL**
AGATTU/CAPE SABAK	52.38	173.72	E	52.36	173.69	E	W ALEU	R	**ALL**
AGATTU/GILLON POINT	52.40	173.36	E				W ALEU	R	**ALL**
ATTU/CAPE WRANGELL	52.91	172.47	E	52.92	172.45	E	W ALEU	R	**ALL**
ATKINS	55.05	159.29	W				W GULF	R	**ALL**
CHERNABURA	54.75	159.55	W	54.76	159.60	W	W GULF	R	**ALL**

PINNACLE ROCK	54.77	161.76	W				W GULF	R	**ALL**
CLUBBING ROCKS (N)	54.71	162.45	W				W GULF	R	**ALL**
CLUBBING ROCKS (S)	54.70	162.45	W				W GULF	R	**ALL**
JUDE	55.26	161.10	W				W GULF	R/H	**ALL**
LIGHTHOUSE ROCKS	55.78	157.41	W				W GULF	R/H	**ALL**
AMCHITKA/COLUMN ROCK	51.54	178.82	E				C ALEU	R	**SUMMER**
AYUGADAK	51.76	178.41	E				C ALEU	R	**SUMMER**
SUGARLOAF	58.89	152.04	W				C GULF	R	**SUMMER**
USHAGAT/SW	58.91	152.37	W				C GULF	R/H	**SUMMER**
AKUTAN/CAPE MORGAN	54.06	165.99	W	54.06	166.06	W	E ALEU	R	**SUMMER**
BOGOSLOF/FIRE ISLAND	53.93	168.03	W				E ALEU	R	**SUMMER**
ADUGAK	52.91	169.18	W				E ALEU	R	**SUMMER**
WALRUS	57.18	169.93	W				BERING	R	**SUMMER**
HAULOUTS									
SEMISOPOCHNOI/POCHNOI	51.96	179.77	E				C ALEU	H/R	**ALL**
CAPE ST. ELIAS	59.79	144.60	W				E GULF	H	**ALL**
THE NEEDLE	60.11	147.60	W				E GULF	H	**ALL**
POINT ELRINGTON	59.93	148.25	W				E GULF	H	**ALL**
KODIAK/CAPE CHINIAK	57.63	152.14	W				C GULF	H	**ALL**
SEA OTTER	58.52	152.22	W				C GULF	H	**ALL**
LATAX ROCKS	58.67	152.52	W				C GULF	H	**ALL**
TWOHEADED	56.91	153.55	W	56.90	153.56	W	C GULF	H	**ALL**
SHAKUN ROCKS	58.55	153.69	W				C GULF	H	**ALL**
SITKINAK/CAPE SITKINAK	56.57	153.85	W				C GULF	H	**ALL**
KODIAK/CAPE UGAT	57.87	153.85	W				C GULF	H	**ALL**
PUALE BAY	57.68	155.39	W				C GULF	H	**ALL**
NAGAI ROCKS	55.83	155.79	W				C GULF	H	**ALL**
THE WHALEBACK	55.28	160.08	W				W GULF	H	**ALL**
SEA LION ROCKS (SHUMAGINS)	55.08	160.52	W				W GULF	H	**ALL**
SOUTH ROCKS	54.30	162.69	W				W GULF	H	**ALL**
BIRD	54.67	163.29	W				W GULF	H	**ALL**
CAPE NEWENHAM	58.65	162.18	W				BERING	H	**ALL**
AMAK+ROCKS	55.40	163.16	W	55.44	163.14	W	E ALEU	H	**ALL**
TIGALDA/ROCKS NE	54.16	164.98	W	54.15	164.95	W	E ALEU	H	**ALL**
AMLIA/EAST CAPE	52.10	172.98	W	52.10	172.96	W	C ALEU	H	**ALL**
ATKA/NORTH CAPE	52.40	174.30	W				C ALEU	H	**ALL**

LITTLE TANAGA STRAIT	51.82	176.23	W				C ALEU	H	**ALL**
ALAID	52.78	173.86	E	52.75	173.94	E	W ALEU	H	**ALL**
AMCHITKA/EAST CAPE	51.37	179.47	E	51.37	179.45	E	C ALEU	H/R	**WINTER**
SEA LION ROCKS (MARMOT)	58.34	151.81	W				C GULF	H	**WINTER**
KODIAK/GULL POINT	57.36	152.61	W				C GULF	H	**WINTER**
KODIAK/CAPE BARNABAS	57.17	152.88	W				C GULF	H	**WINTER**
ST. GEORGE/DALNOI POINT	56.60	169.77	W				BERING	H	**WINTER**
TANGINAK	54.20	165.32	W				E ALEU	H	**WINTER**
OLD MAN ROCKS	53.87	166.08	W				E ALEU	H	**WINTER**
AKUTAN/REEF-LAVA	54.14	166.10	W	54.15	166.09	W	E ALEU	H	**WINTER**
CHAGULAK	52.57	171.18	W				C ALEU	H	**WINTER**
UNALGA+DINKUM ROCKS	51.56	179.07	W	51.58	179.06	W	C ALEU	H	**WINTER**
SEMISOPOCHNOI/PETREL	52.02	179.62	E	52.03	179.65	W	C ALEU	H/R	**WINTER**
LONG ISLAND	57.78	152.22	W				C GULF	H	**WINTER**
SEGUAM/WHARF POINT	52.36	172.32	W				C ALEU	H	**WINTER**
SEGUAM/TURF POINT	52.26	172.52	W				C ALEU	H	**WINTER**
KANAGA/N CAPE	51.94	177.15	W				C ALEU	H	**WINTER**
BOBROF	51.90	177.45	W				C ALEU	H	**WINTER**
AMATIGNAK/NITROF POINT	51.22	179.13	W				C ALEU	H	**WINTER**
LITTLE SITKIN	51.99	178.50	E				C ALEU	H	**WINTER**
SEGULA/GULA POINT	52.05	178.15	E				C ALEU	H	**WINTER**
SEGULA/CHUGUL POINT	52.00	178.10	E				C ALEU	H	**WINTER**
AGLIGADAK	52.10	172.90	W				C ALEU	H/R	**SUMMER**
HOOK POINT	60.33	146.26	W				E GULF	H	**SUMMER**
SUTWIK	56.52	157.34	W	56.53	157.35	W	C GULF	H	**SUMMER**
CATON	54.38	162.36	W				W GULF	H	**SUMMER**
ROUND (WALRUS IS)	58.60	159.97	W				BERING	H	**SUMMER**
AMLIA/SVIECH. HARBOR	52.03	173.40	W				C ALEU	H	**SUMMER**
SHEMYA	52.73	174.15	E				W ALEU	H	**SUMMER**
ATTU/CHIRIKOF POINT	52.83	173.43	E				W ALEU	H	**SUMMER**
MIDDLETON	59.47	146.31	W				E GULF	H	**NEITHER**
SEAL ROCKS (KENAI)	59.52	149.63	W				E GULF	H	**NEITHER**
GORE POINT	59.20	150.97	W				C GULF	H	**NEITHER**
TAKLI	58.03	154.52	W				C GULF	H	**NEITHER**
KODIAK/CAPE IKOLIK	57.29	154.79	W				C GULF	H	**NEITHER**
CASTLE ROCK	55.27	159.50	W				W GULF	H	**NEITHER**

NAGAI/MOUNTAIN POINT	54.90	160.26	W	54.93	160.25	W	W GULF	H	**NEITHER**
UMNAK/CAPE ASLIK	53.42	168.41	W				E ALEU	H	**NEITHER**
CHUGINADAK	52.78	169.70	W				C ALEU	H	**NEITHER**
ULIAGA	53.07	169.78	W	53.08	169.77	W	C ALEU	H	**NEITHER**
SAGIGIK	52.01	173.16	W				C ALEU	H	**NEITHER**
ANAGAKSIK	51.85	175.88	W				C ALEU	H	**NEITHER**
TANAGA/BUMPY POINT	51.92	177.98	W	51.92	177.95	W	C ALEU	H	**NEITHER**
POINT ELEANOR	60.58	147.57	W				E GULF	H	**NEITHER**
PERRY	60.73	147.91	W				E GULF	H	**NEITHER**
NAGAHUT ROCKS	59.10	151.77	W				C GULF	H	**NEITHER**
SUD	58.90	152.21	W				C GULF	H	**NEITHER**
UGAK	57.39	152.29	W	57.37	152.29	W	C GULF	H	**NEITHER**
CAPE GULL	58.19	154.16	W	58.21	154.18	W	C GULF	H	**NEITHER**
CAPE KULIAK	58.13	154.21	W				C GULF	H	**NEITHER**
SPITZ	55.78	158.90	W				W GULF	H	**NEITHER**
ST. LAWRENCE-S.PUNUK	63.07	168.85	W				BERING	H	**NEITHER**
ST. GEORGE/SOUTH ROOKERY	56.56	169.67	W				BERING	H	**NEITHER**
ST. PAUL/NE POINT	57.25	170.11	W				BERING	H	**NEITHER**
ST. PAUL/SEA LION ROCK	57.10	170.29	W				BERING	H	**NEITHER**
ST. LAWRENCE-SW CAPE	63.30	171.43	W				BERING	H	**NEITHER**
HALL	60.62	173.00	W				BERING	H	**NEITHER**
UNALASKA/CAPE SEDANKA	53.84	166.08	W				E ALEU	H	**NEITHER**
EMERALD	53.29	167.86	W				E ALEU	H	**NEITHER**
POLIVNOI ROCK	53.27	167.97	W				E ALEU	H	**NEITHER**
KAGAMIL	53.04	169.68	W				C ALEU	H	**NEITHER**
AMUKTA+ROCKS	52.45	171.30	W				C ALEU	H	**NEITHER**
TANADAK (AMLIA)	52.07	172.96	W				C ALEU	H	**NEITHER**
GREAT SITKIN	52.10	176.18	W	52.11	176.12	W	C ALEU	H	**NEITHER**
UGIDAK	51.58	178.51	W				C ALEU	H	**NEITHER**
KAVALGA	51.58	178.86	W	51.58	178.83	W	C ALEU	H	**NEITHER**
TANADAK (KISKA)	51.95	177.78	E				C ALEU	H	**NEITHER**
KISKA/SIRIUS POINT	52.14	177.61	E				C ALEU	H	**NEITHER**
KISKA/SOBAKA-VEGA	51.83	177.32	E	51.81	177.34	E	C ALEU	H	**NEITHER**
SEGUAM/FINCH POINT	52.39	172.46	W	52.39	172.41	W	C ALEU	H	**NEITHER**
GLACIER	60.86	147.24	W				E GULF	N	**ALL**
PERL	59.10	151.66	W				C GULF	N	**ALL**

MITROFANIA	55.84	158.70	W				W GULF	N	**ALL**
OLGA ROCKS	55.01	161.50	W	54.98	161.51	W	W GULF	N	**ALL**
SUSHILNOI ROCKS	54.82	161.71	W				W GULF	N	**ALL**
UGAMAK/ROUND	54.20	164.78	W				E ALEU	N	**ALL**
UNIMAK/CAPE SARICHEF	54.57	164.95	W				E ALEU	N	**ALL**
ROOTOK	54.07	165.53	W	54.05	165.49	W	E ALEU	N	**ALL**
UNALASKA/BISHOP POINT	53.97	166.96	W				E ALEU	N	**ALL**
UNALASKA/CAPE IZIGAN	53.23	167.66	W				E ALEU	N	**ALL**
RUGGED	59.83	149.39	W	59.85	149.41	W	E GULF	N	**WINTER**
ELIZABETH/CAPE ELIZABETH	59.16	151.89	W				C GULF	N	**WINTER**
FLAT	59.33	152.00	W				C GULF	N	**WINTER**
AIKTAK	54.18	164.85	W				E ALEU	N	**WINTER**
TAGALAK	51.96	175.62	W				C ALEU	N	**WINTER**
SEMISOPOCHNOI/TUMAN POINT	51.96	179.48	E				C ALEU	N	**WINTER**
RAT	51.83	178.21	E				C ALEU	N	**WINTER**
CAPE HINCHINBROOK	60.23	146.64	W				E GULF	N	**SUMMER**
STEEP POINT	59.48	150.26	W				E GULF	N	**SUMMER**
SHAW	59.00	153.38	W				C GULF	N	**SUMMER**
KAK	56.29	157.84	W				W GULF	N	**SUMMER**
UNGA/ACHEREDIN POINT	55.12	160.82	W				W GULF	N	**SUMMER**

[1] N = new site (22 sites); R/H = functional rookery that is listed CH haulout; H/R = functional haulout that is listed CH rookery; R = rookery CH; H = haulout CH

Table 4.1 Estimates of EBS age-1 pollock recruitment by year-class period (millions), the coefficient of variation, and correlation among estimates from other periods.

Regime Period	Regime	Average recruitment	CV	Regime (correlation) A	B	C	D	E	F	G	H
1963-1976	A	18,649	3%	1.00							
1977-2004	B	24,304	5%	0.21	1.00						
1977-1998	C	25,173	3%	0.24	0.77	1.00					
1977-1988	D	24,683	3%	0.17	0.64	0.87	1.00				
1989-2004	E	24,020	7%	0.19	0.96	0.60	0.39	1.00			
1989-1998	F	25,762	4%	0.26	0.72	0.90	0.55	0.66	1.00		
1999-2004	G	21,116	17%	0.11	0.83	0.29	0.20	0.92	0.31	1.00	
1963-2004	H	22,419	4%	0.45	0.97	0.77	0.62	0.93	0.73	0.79	1.00

Table 4.2 Mean year class strength by decade, 1960-1999 for Gulf of Alaska pollock.

Decade	Mean year class abundance (millions at age 2)	Coefficient of Variation
1960-69	390	0.54
1970-79	1,945	0.55
1980-89	693	0.77
1990-99	393	0.79

Table 4.3 Aleutian Islands summer bottom trawl survey Alaska pollock abundance estimates. NRA is the Near, Rat, and Andreanov area as described in Barbeaux et al. (2005).

	NRA West (174W-170E)	NRA East (170W-174W)	NRA total	CV%
1991	83,337	53,865	137,202	20%
1994	47,623	29,879	77,502	19%
1997	57,577	39,935	97,512	22%
2000	76,613	28,985	105,598	28%
2002	121,915	53,368	175,283	38%
2004	19,201	111,250	130,451	78%

Table 4.4 Total catch in the Aleutian Islands management area 1990-2005 in tons. NRA is the Near, Rat, and Andreanov area as described in Barbeaux et al. (2005).

Year	NRA Total	NRA West (174W-170E)	NRA East (170W-174W)
1990	79,025	10,477	68,548
1991	98,604	561	98,043
1992	52,352	8,519	43,833
1993	57,132	16,162	40,970
1994	58,659	5,965	52,694
1995	64,925	58,203	6,722
1996	29,062	23,187	5,875
1997	25,940	25,774	166
1998	23,822	23,335	487
1999	1,010	631	379
2000	1,244	891	353
2001	824	575	249
2002	1,156	351	805
2003	1,653	1,430	223
2004	1,150	962	188
2005	1,610	1,330	280

Table 4.5 Estimated NRA region pollock catch at age (millions) from 2005 stock assessment (Barbeaux *et al.* 2005). 1978 year class is shaded. NRA is the Near, Rat, and Andreanov area as described in Barbeaux *et al.* (2005).

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	% 1978
1978	0.01	0.14	0.12	0.07	0.36	0.10	0.14	0.13	0.13	0.06	0.02	0.01		0.00	1.27	
1979	0.01	2.18	2.22	2.02	2.43	1.73	0.65	0.63	0.37	0.03	0.22			0.05	12.53	
1980	8.20	3.24	2.64	3.71	6.94	4.05	2.47	0.73	1.07	0.53	0.16	0.01	0.14	0.01	33.91	24%
1981		5.72	3.36	2.19	1.65	2.55	2.54	1.93	1.37	0.73	0.20	0.15	0.20	0.04	22.64	25%
1982		0.01	3.00	0.51	0.23	0.31	0.38	0.35	0.15	0.07	0.04	0.03	0.01	0.01	5.10	59%
1983				0.74	0.44	0.17	0.11	0.24	0.23	0.05	0.04	0.01	0.00	0.00	2.04	36%
1984	0.14	3.97		4.12	4.12	1.46	1.10	0.74	0.51	0.34	0.09	0.06	0.03	0.01	16.68	25%
1985	0.01	0.01	0.17	0.06	0.17	0.46	0.20	0.08	0.08	0.04	0.01	0.01	0.00	0.00	1.30	35%
1986																
1987			1.40	0.31	0.23	0.04	0.09	1.01	0.09	0.12	0.00	0.03	0.01	0.04	3.36	30%
1988																
1989																
1990		0.95	0.26	0.96	0.78	0.78	0.93	0.17	1.10	0.34	0.56	0.28	0.13	0.21	7.45	8%
1991																
1992			0.03	0.33	0.60	0.30	0.60	0.12	0.69	0.39	0.52	0.36	1.71	1.91	7.55	25%
1993			0.18	0.47	1.12	1.34	0.54	1.46	0.81	0.88	0.83	0.38	0.70	4.34	13.05	33%
1994			0.07	1.00	0.31	0.42	0.60	0.43	0.33	0.17	0.39	0.10	0.08	1.30	5.20	25%
1995		0.22	0.38	0.00	10.22	1.19	5.10	4.84	1.42	2.36	2.08	3.82	0.77	8.32	40.71	20%
1996		0.17	0.15	0.56	1.42	5.15	1.53	2.09	1.21	0.92	0.64	0.20	0.77	2.00	16.79	12%
1997																
1998		0.05	0.08	5.66	1.65	1.05	0.96	1.71	1.20	1.00	2.40	1.30	1.17	1.49	19.73	8%

Table 4.6 Importance of prey species in Steller sea lion diet studies collected from the 1940s to the 2000s (see Table 3.20 for citations).

	10 Stoms **1940s**	150 Stoms **1950s**	16 Stoms **1960s**	157 Stoms **1970s**	190 Stoms **1980s**	3762 Scats **1990s**	5000+ Scats **2000s**
Pollock	++		++	++	++	++	++
P. cod	+			+	+	++	++
Flatfish	++	+	+	+	++	++	++
Greenling		+	+			++	+
Rockfish		+	+	+	+	+	+
Smelts		+	++	+		+	++
Sandlance	++	+	+		+	++	++
Herring			+	+	+	+	+
Salmon	++	+		+	+	++	++
Sculpins	+	+	+	+	+	++	++
Cephalopods	+	++	+	+	+	+	+

++ indicates an important prey item (10% FO or greater)
+ indicates a prey item (10% FO or less)

Table 4.7 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.

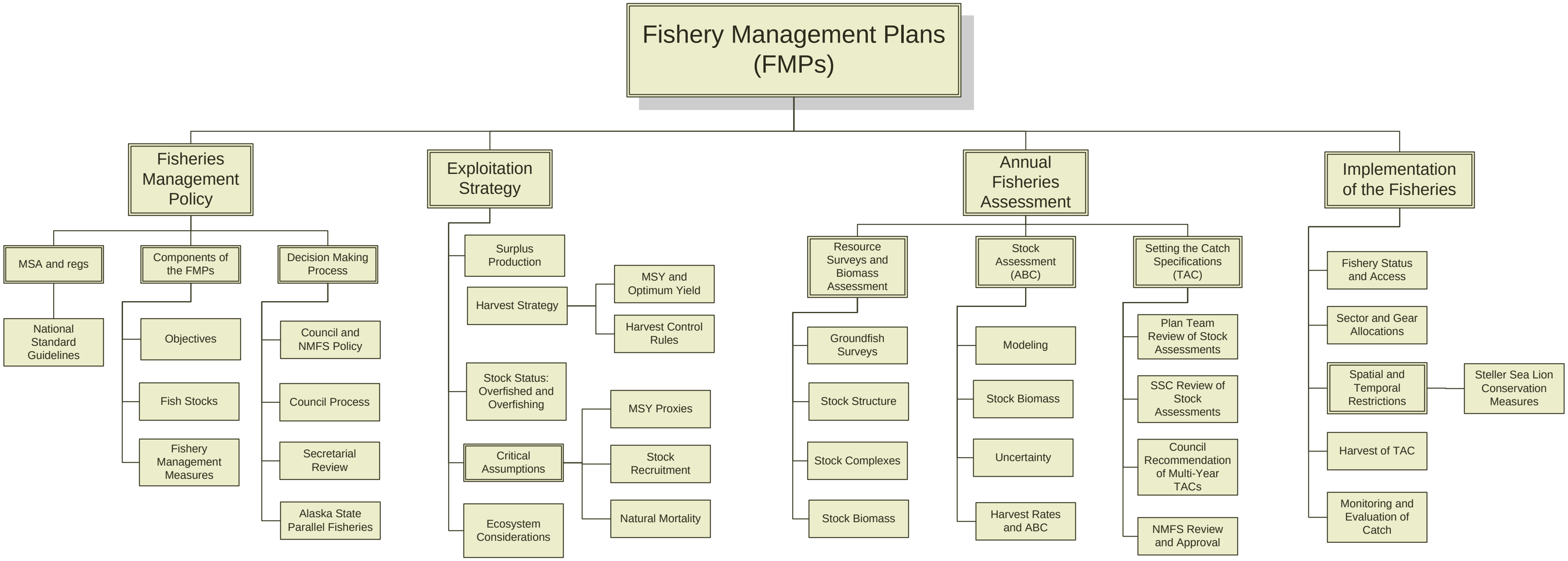
Area	Fishery	Gear	Vessel Type	Within 3 NM of SSL Haulouts During Parallel Seasons	Within all State Waters During Parallel Seasons
GOA	Pollock	Trawl	CV	1.5% (1,361 mt)	31.9% (29,380 mt)
	Pacific cod	Trawl	CV	0.9% (296 mt)	8.2% (2,696 mt)
		H & L H & L	CV CP	5.3% (369 mt) 0% (0 mt)	37.1% (2,584 mt) 0% (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.

Table 4.8 Summary of historic and current stressors acting on Steller sea lions and their critical habitat based on information presented in the Status of Species and Baseline. A comparison is provided between the information available in 2000 for the FMP Biological Opinion (NMFS 2000) and the current information available for this opinion.

	What We Knew in 2000		What We Know Now	
Hypothesis	**Contributor to Decline**	**Current Stressor**	**Contributor to Decline**	**Current Stressor**
Environmental Change	Possible	Possible	Likely	Likely
Indirect Fisheries Effects	Possible	Possible	Likely	Likely
Direct Human Effects	Likely	Possible	Yes	Unlikely
Predation				
Killer Whales	Possible	Possible	Possible	Unlikely
Sharks	Possible	Possible	No	No
Inter-specific Competition	Possible	Possible	Possible	Possible
Disease	Possible	Possible	Unlikely	Unlikely
Contaminants	Possible	Possible	Unlikely	Unlikely

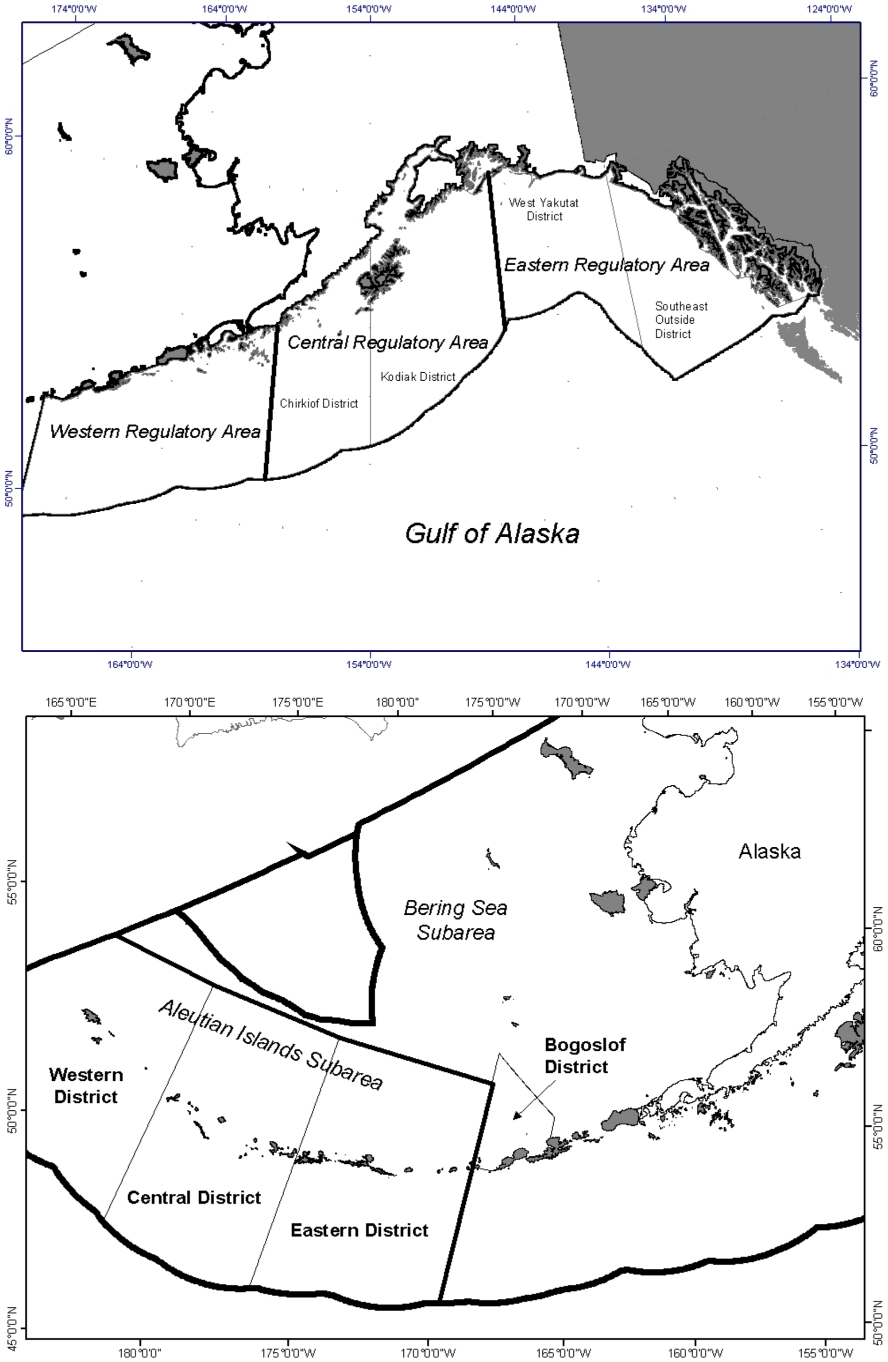
Figure 2.1 Deconstruction of the Groundfish FMPs, their implementing regulations, and Alaska State Parallel Fisheries.



Note:

This chart represents the deconstruction of the
Fishery Management Plans and the outside factors
which influence actions which result in effects to listed species

Figure 2.2 Regulatory areas of the GOA(top panel) and BSAI (bottom panel).



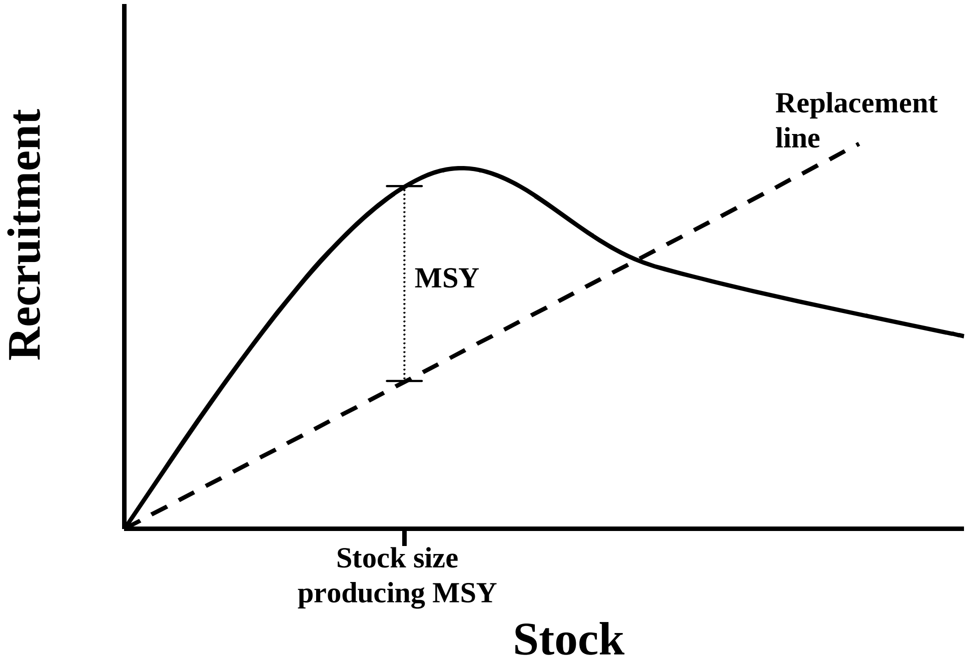


Figure 2.3 Hypothetical Ricker curve showing expected recruitment as a function of stock size. The replacement line indicates the level of recruitment necessary to sustain the population at any particular size. The positive difference between recruitment and the replacement line (to the left of the point where the two cross) indicates recruitment in excess of that needed to replace the stock, and is considered surplus in an single-species context. The maximum excess is the maximum sustainable yield (MSY) and the stock size that results in the maximum excess is the stock size producing MSY.

Figure 2.4 Schematic illustration of the relation between 1) the biomass of prey stocks and the yield curve that serves as the basis for the yield-based fishery paradigm, and 2) the simplest approximation of the relation of biomass of the prey stock to the environmental carrying capacity for Steller sea lions.

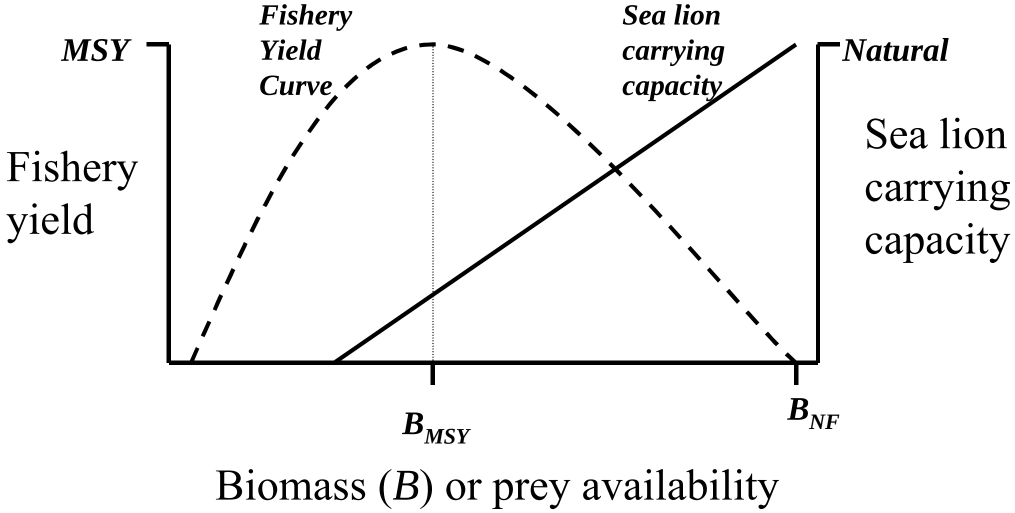


Figure 2.5 (Top left) Estimated spawning biomass of eastern Bering Sea pollock (age 3+) as described in Ianelli et. al. (1999). (Top right) Estimated biomass of eastern Bering Sea pollock (age 3+) for the period from 1964-1985 as presented in Megrey and Wespestad, 1990. (Bottom left) Spawning stock estimated exploitation rate as presented in Ianelli et al. (2005).

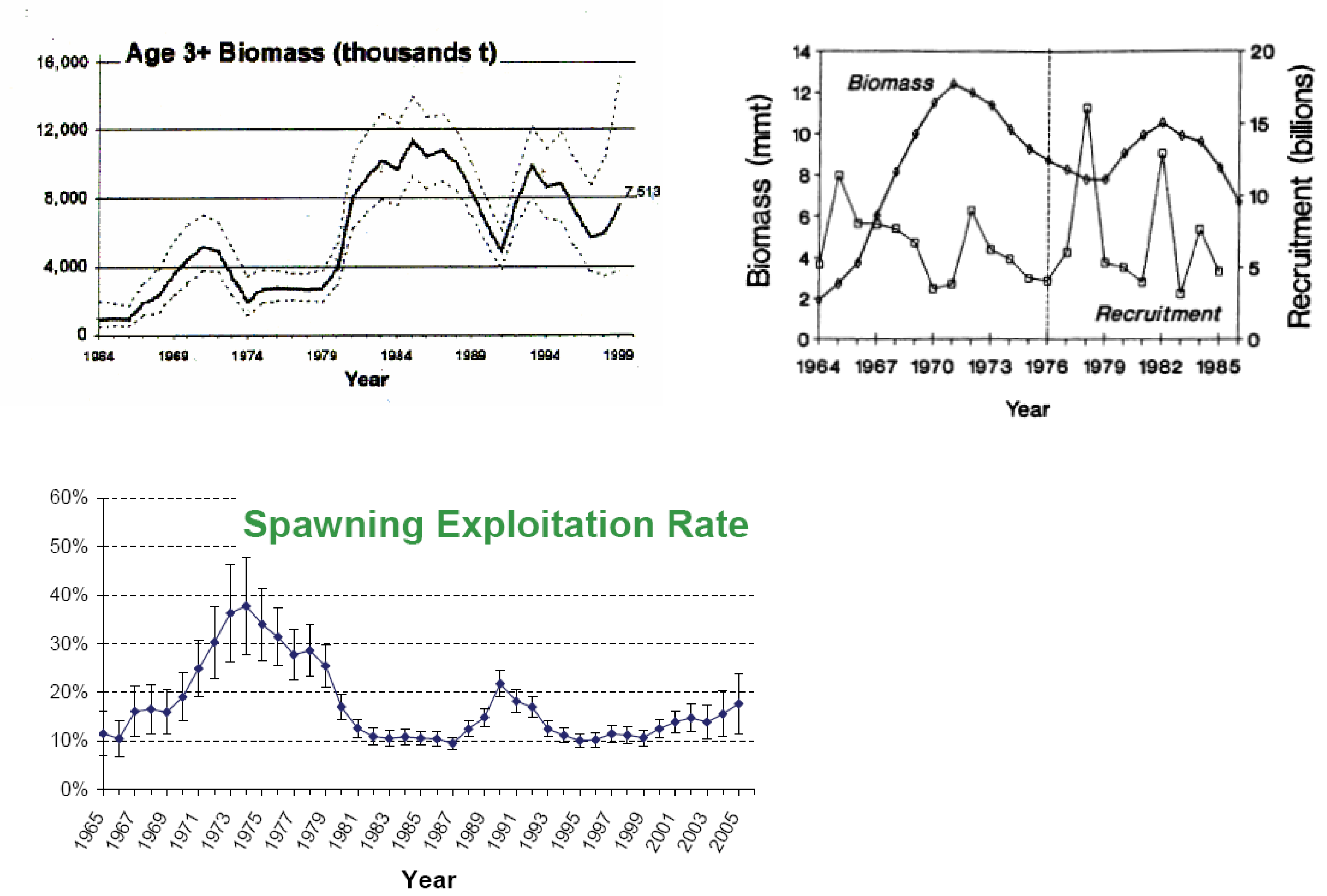
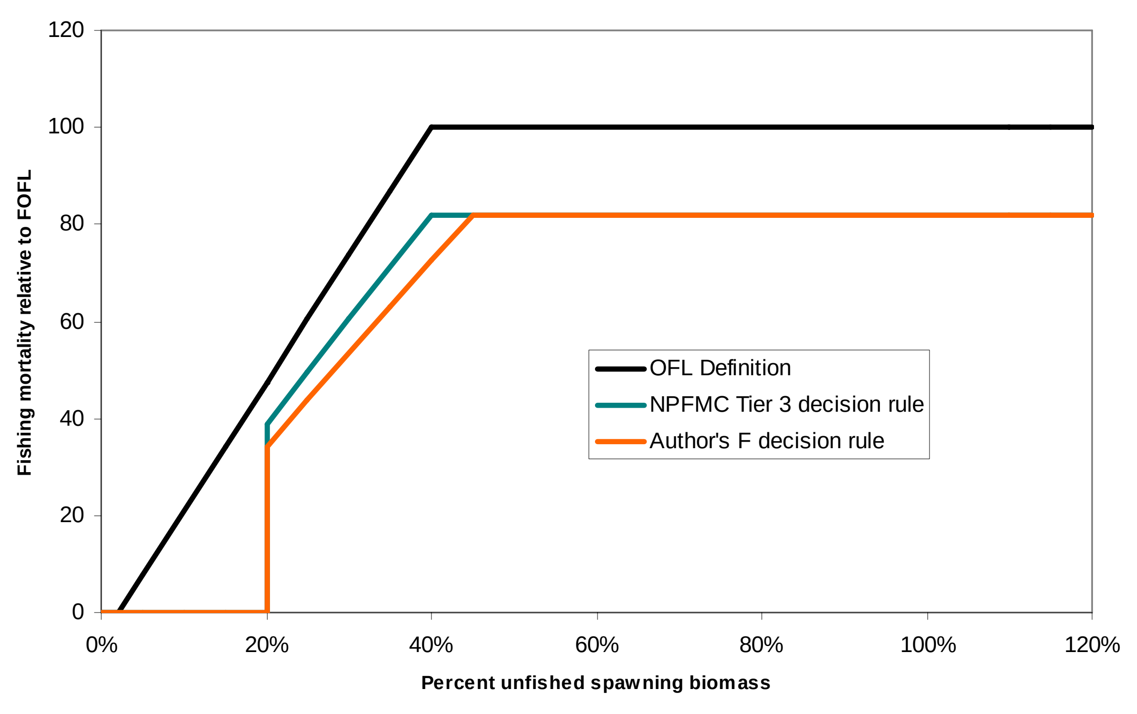


Figure 2.6 GOA pollock harvest decision rule (Dorn *et al.* 2005).



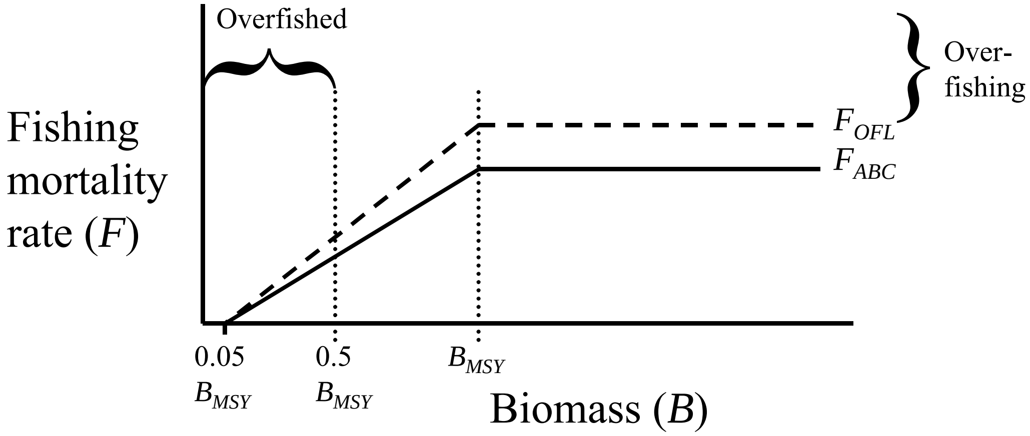


Figure 2.7 Graphic illustration of "overfishing" and "overfished." Overfishing occurs when the fishing mortality rate exceeds a prescribed maximum rate. Overfished indicates that the fished stock has declined below a certain level. The illustration indicates that the level is ½ BMSY, which may or may not be the actual level. The actual level is determined as the maximum of either ½ BMSY or the smallest level at which the population would be expected to recover to BMSY within 10 years of random recruitment and fishing at FOFL.

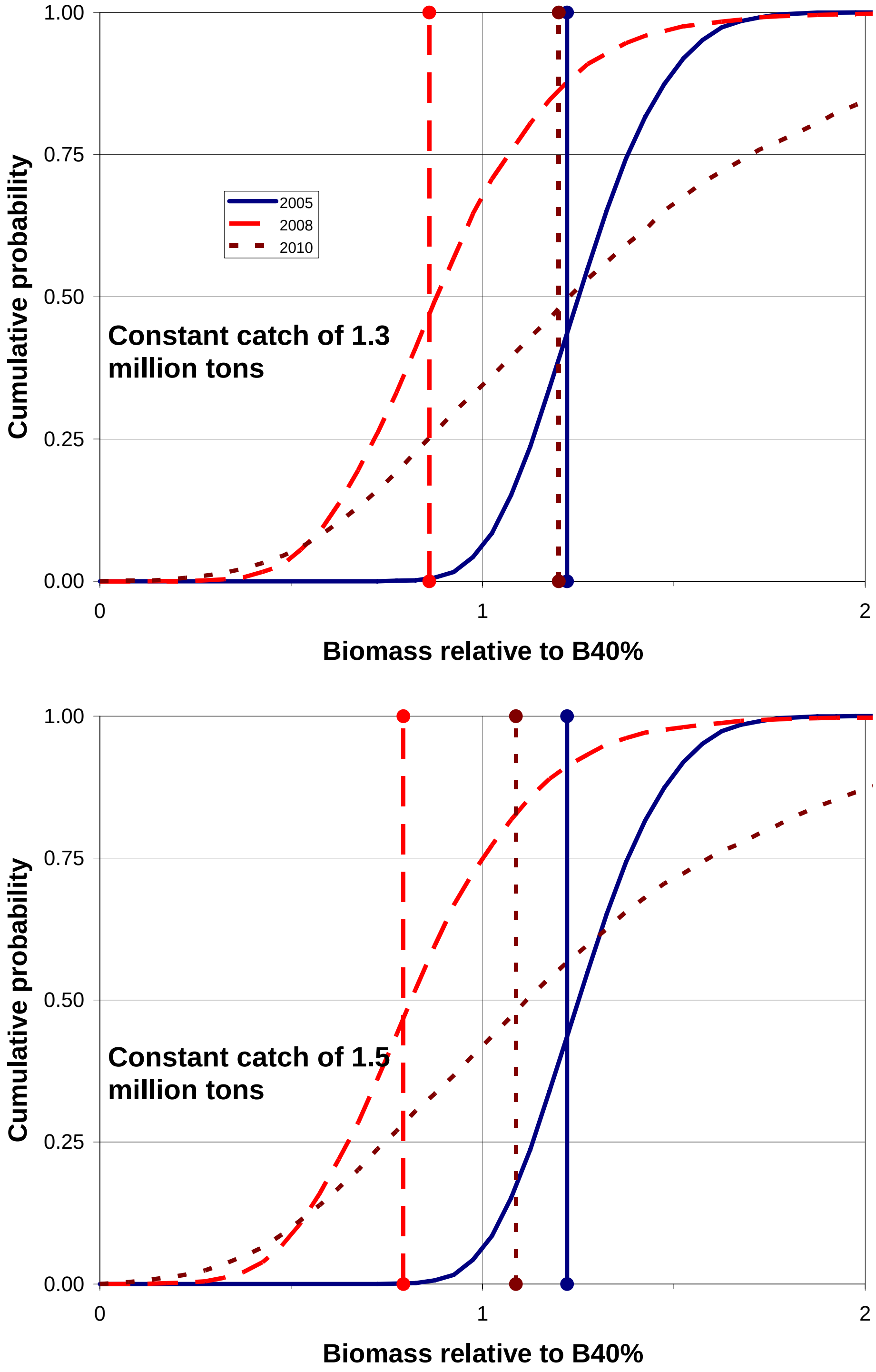


Figure 2.8 Cumulative probability that projected female spawning biomass levels will drop below $B_{40\%}$ based on a fixed constant catch levels of 1.3 (top) and 1.5 (bottom) million tons. Marginal distributions of the full joint posterior distribution based on a thinned MCMC chain used for integration. Corresponding expected values (means) are shown by the vertical lines terminated with closed circles.

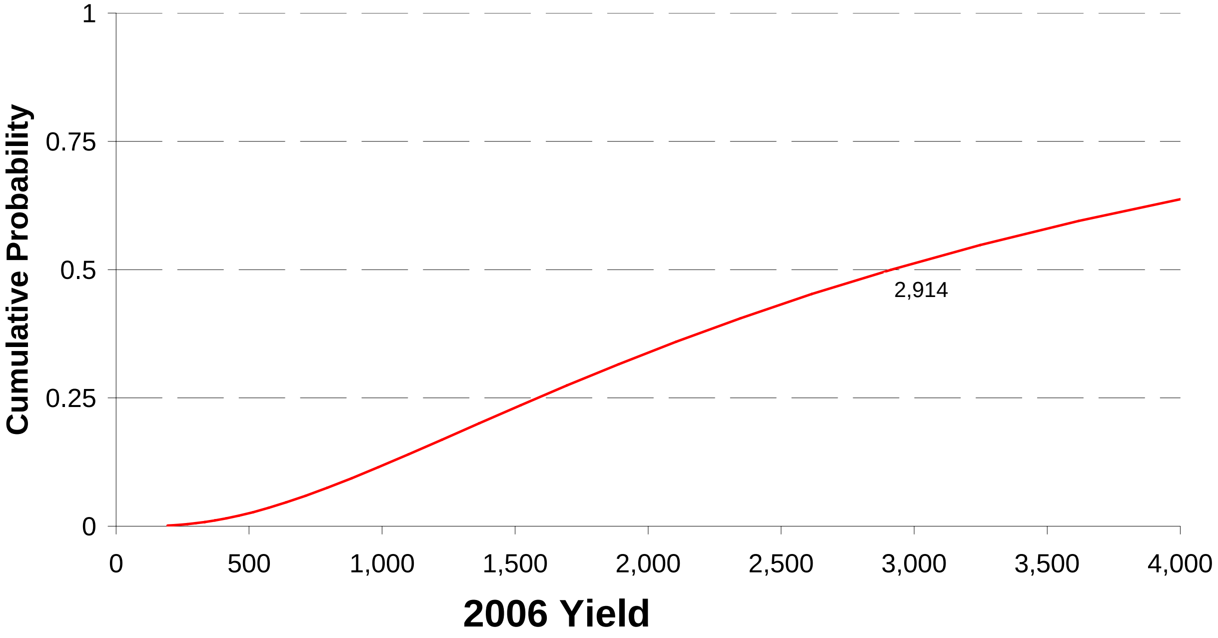


Figure 2.9 Marginal distribution of the 2006 yield (thousands of tons) at F_{MSY} for EBS pollock (Ianelli *et al.* 2005).

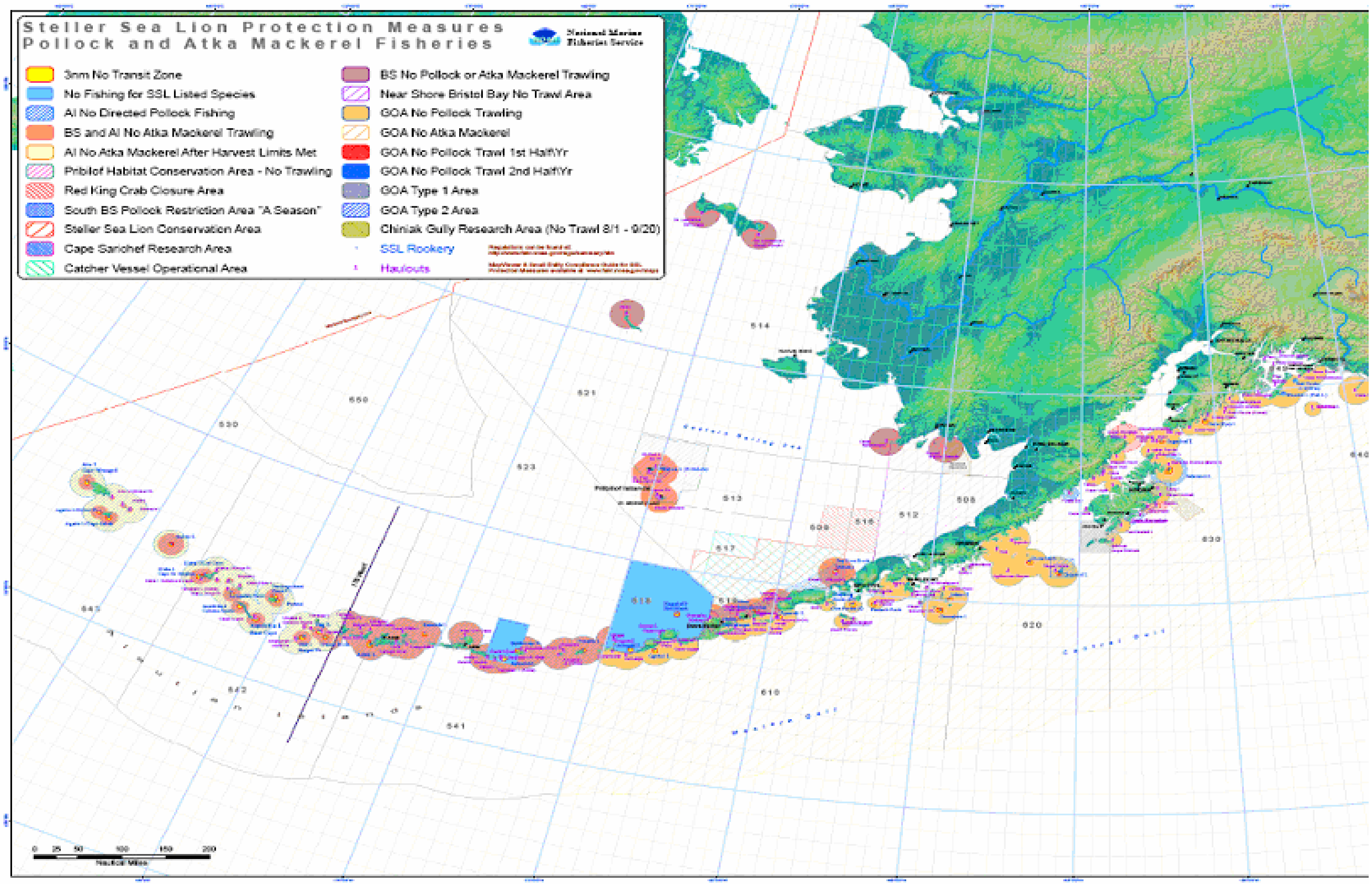


Figure 2.10 Steller sea lion protection measures for the pollock and Atka mackerel fisheries. (Source: http://www.fakr.noaa.gov/protectedresources/stellers/maps/Pollock_Atka0105.pdf)

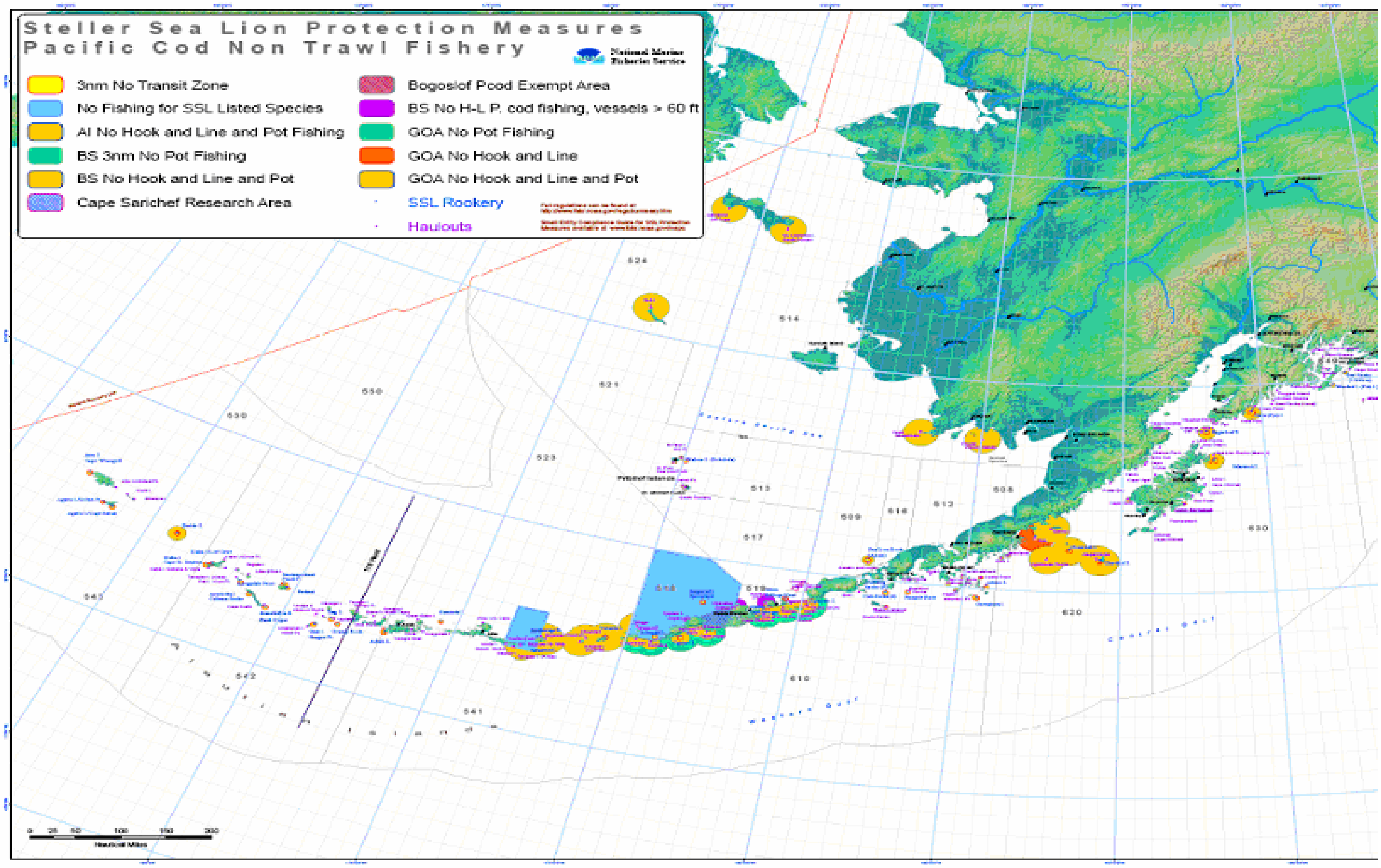


Figure 2.11 Steller sea lion protection measures for the Pacific cod non-trawl fishery.
(Source: http://www.fakr.noaa.gov/protectedresources/stellers/maps/NonTrawl _0105.pdf)

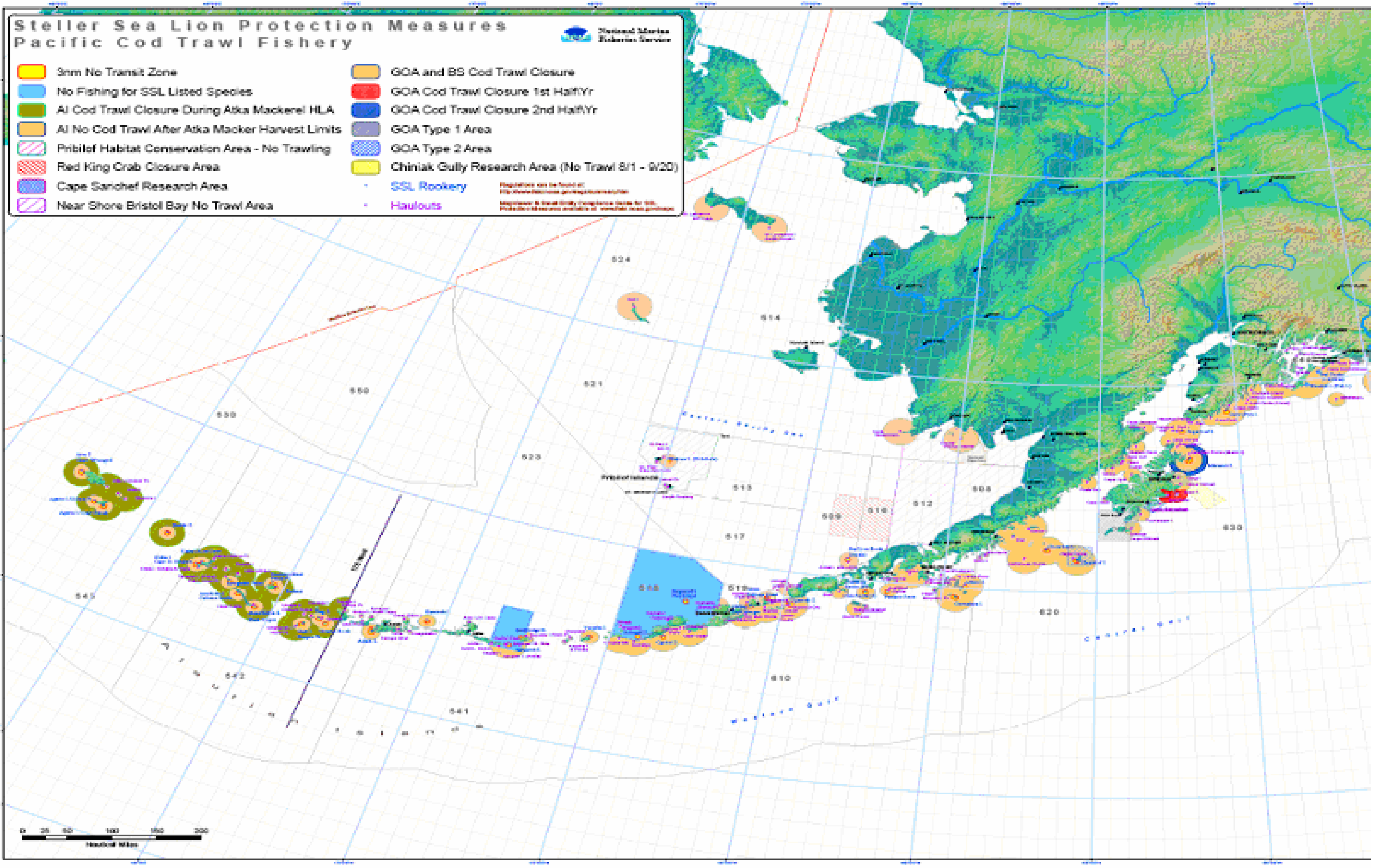
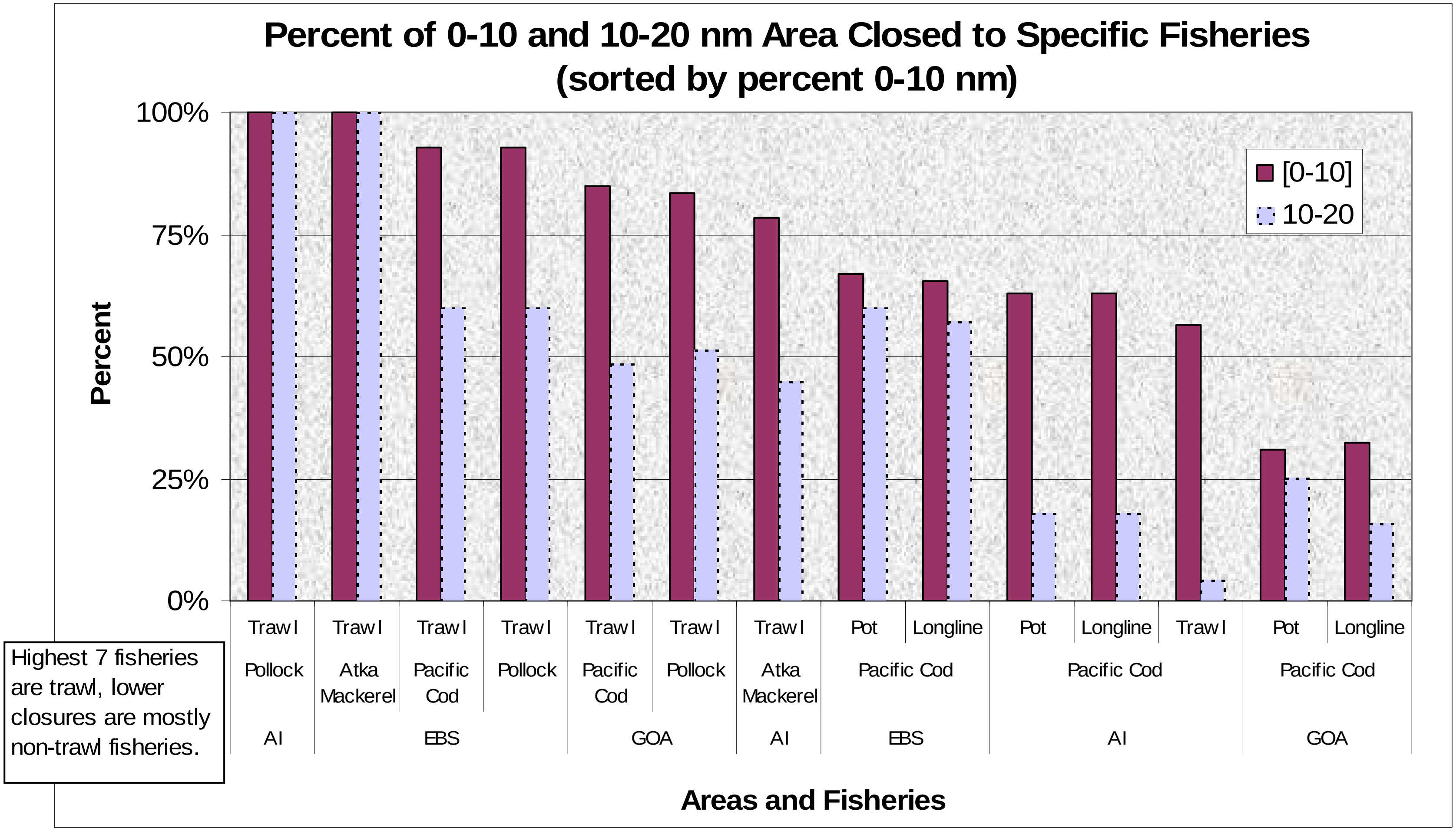


Figure 2.12 Steller sea lion protection measures for the Pacific cod trawl fishery.
(Source: http://www.fakr.noaa.gov/protectedresources/stellers/maps/Cod_Trawl0105.pdf)

Figure 2.13 The amount of area closed in the BSAI and GOA under the Steller sea lion conservation measures as a percentage of each zone from 0-10 nm and 10-20 nm. The data is sorted as descending from 100% for the 0-10 nm zone, then the associated 10-20 nm percentage is plotted (data is from Table 2.36).



Highest 7 fisheries are trawl, lower closures are mostly non-trawl fisheries.

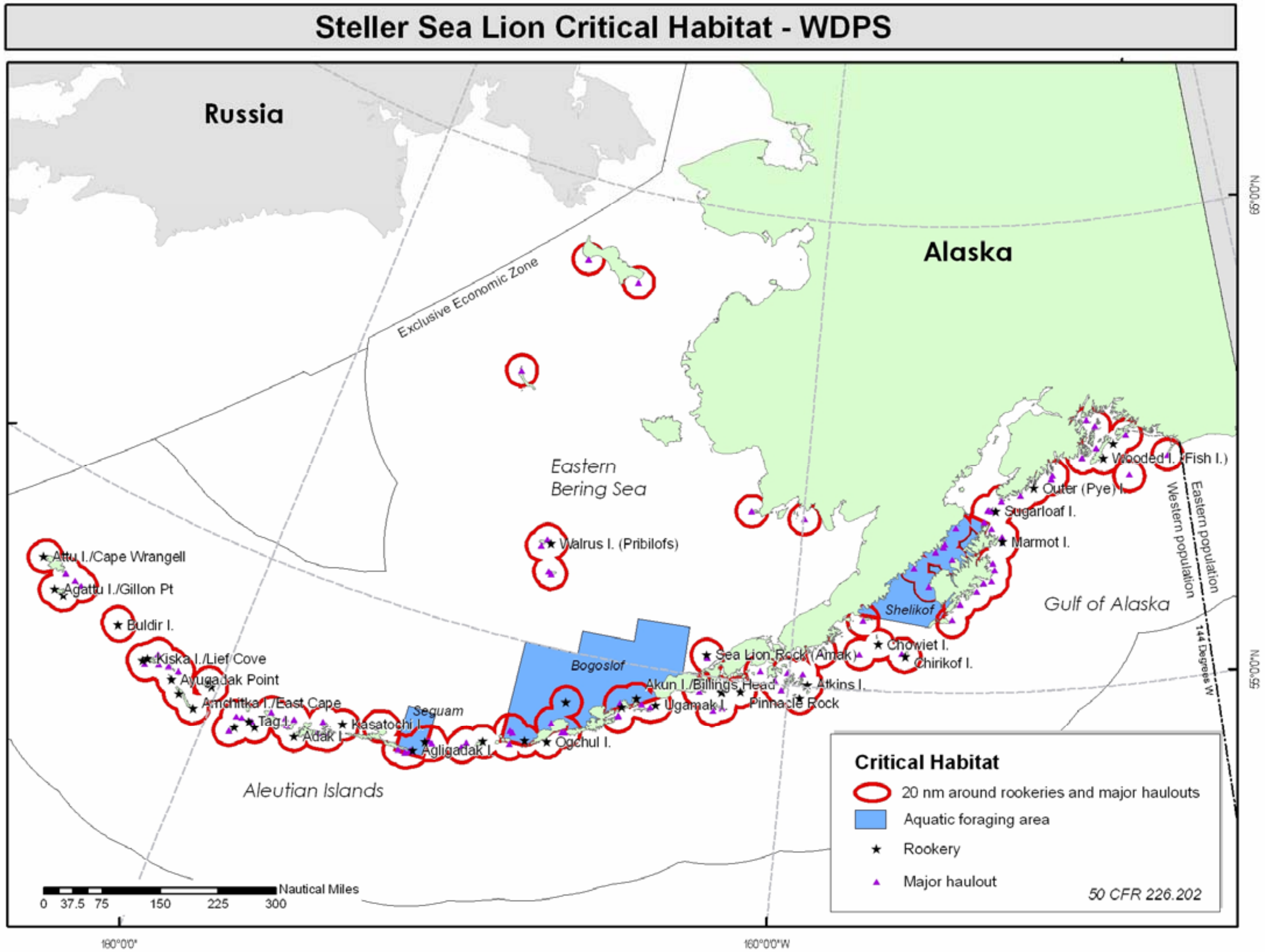


Figure 2.14 Designated critical habitat for the western DPS of Steller sea lion in Alaska. 50 CFR 226.202

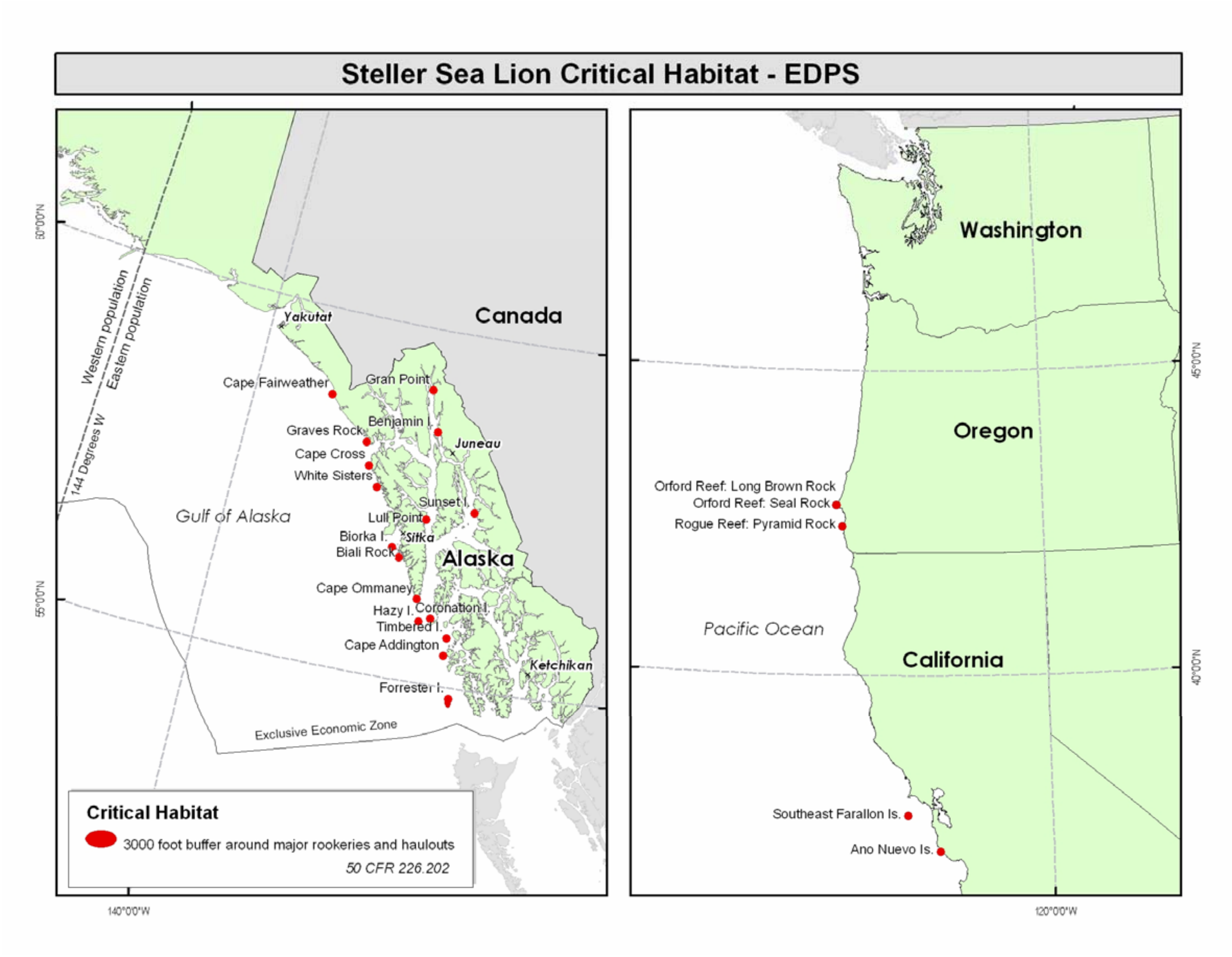


Figure 2.15 Designated critical habitat for the eastern DPS of Steller sea lion. 50 CFR 226.202

Figure 3.1 Breeding ranges of the western and eastern stocks of Steller sea lions (triangles = terrestrial locations of major rookeries) in the North Pacific.

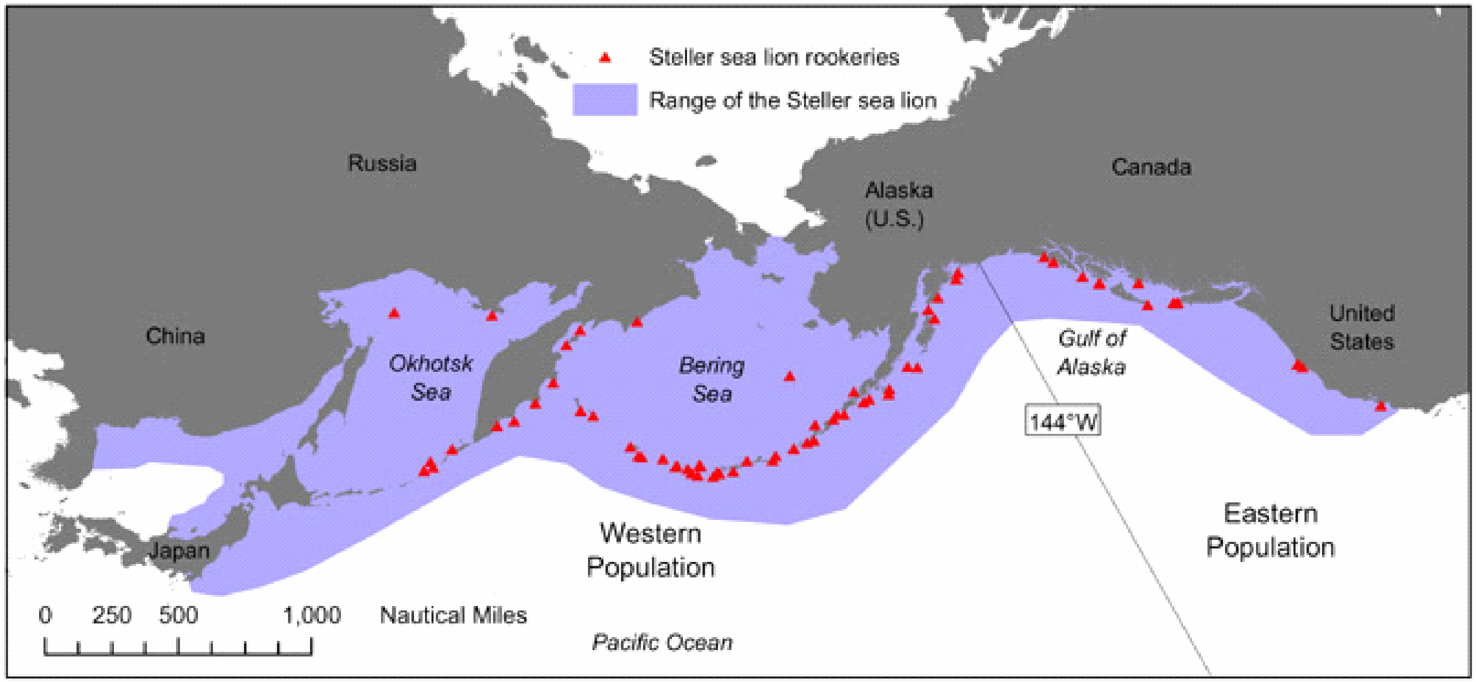
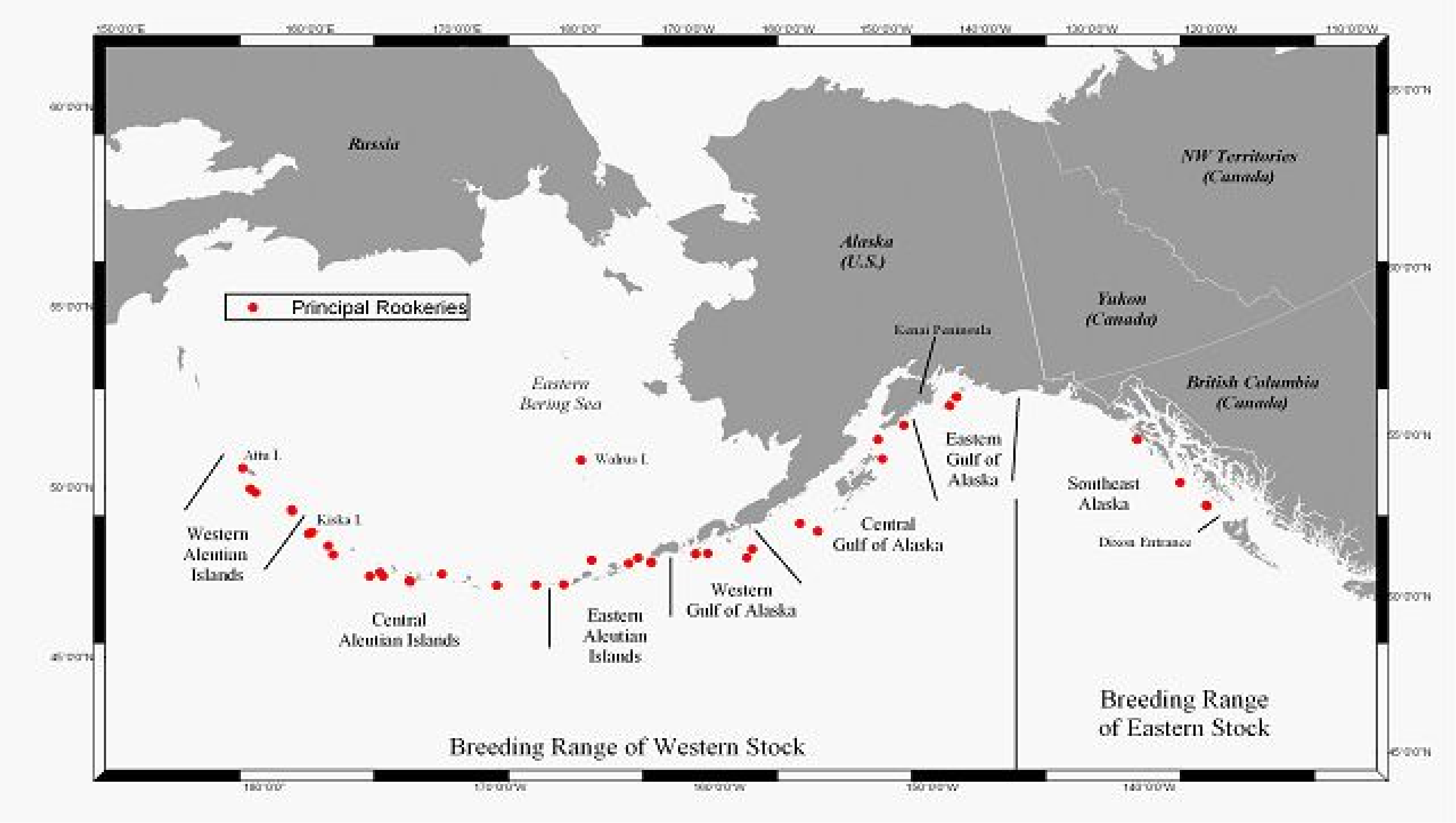


Figure 3.2 Steller sea lion survey regions from Dixon Entrance to Attu Island and the location of the principal rookeries in Alaska. Kiska Island, the Kenai Peninisula, and Walrus Island in the eastern Bering Sea are also noted, along with the boundary between the breeding ranges of the eastern and western sea lion stocks. The Central Aleutian Islands is defined as the area between Samalga Pass and Kiska Island.



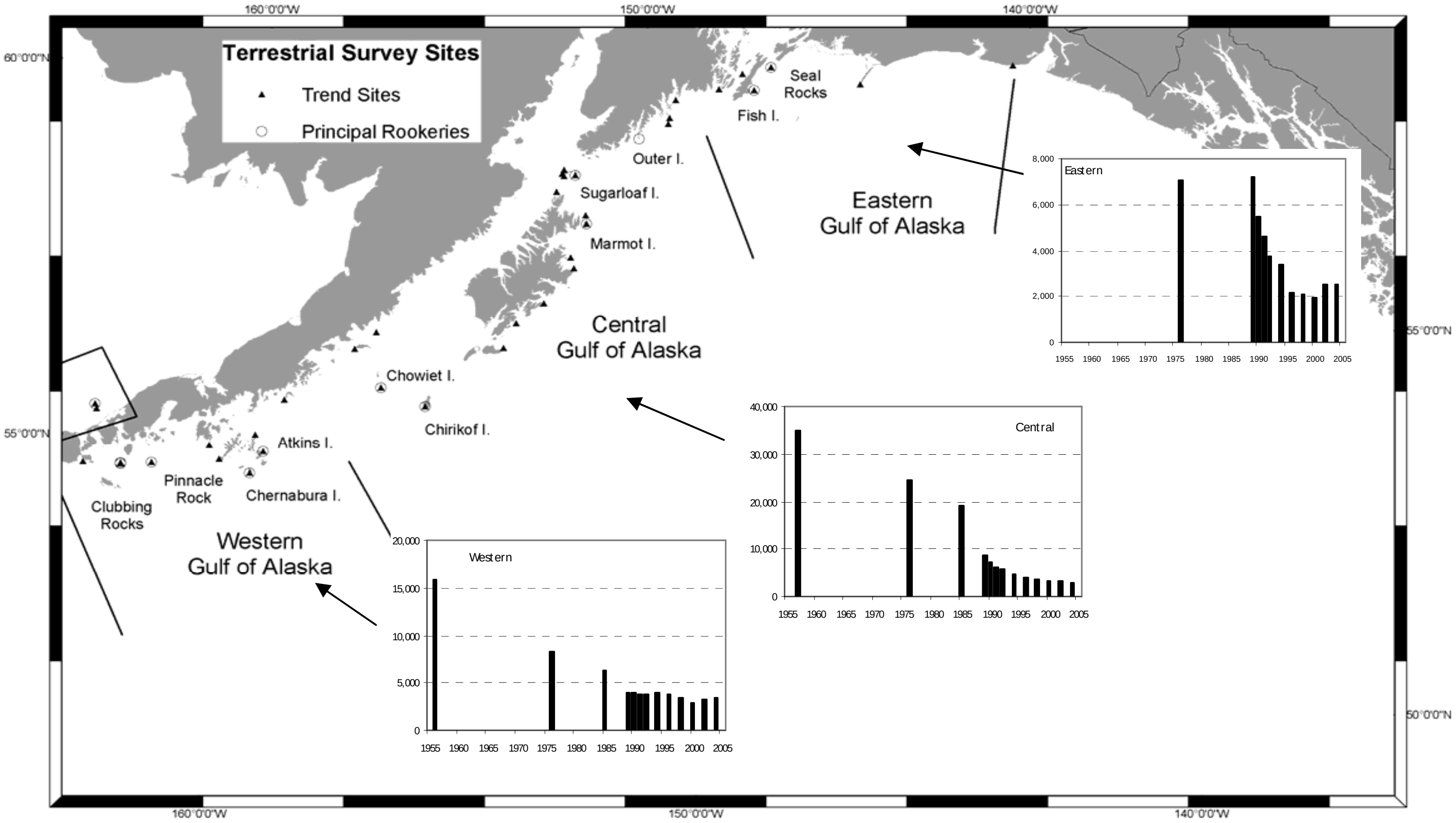


Figure 3.3. Counts of adult and juvenile Steller sea lions on western DPS trend sites in three sub-areas of the Gulf of Alaska, 1950s through 2004. Principal rookeries (named) and major terrestrial haul-out trend sites are shown (NMFS 1992; Fritz and Stinchcomb 2005).

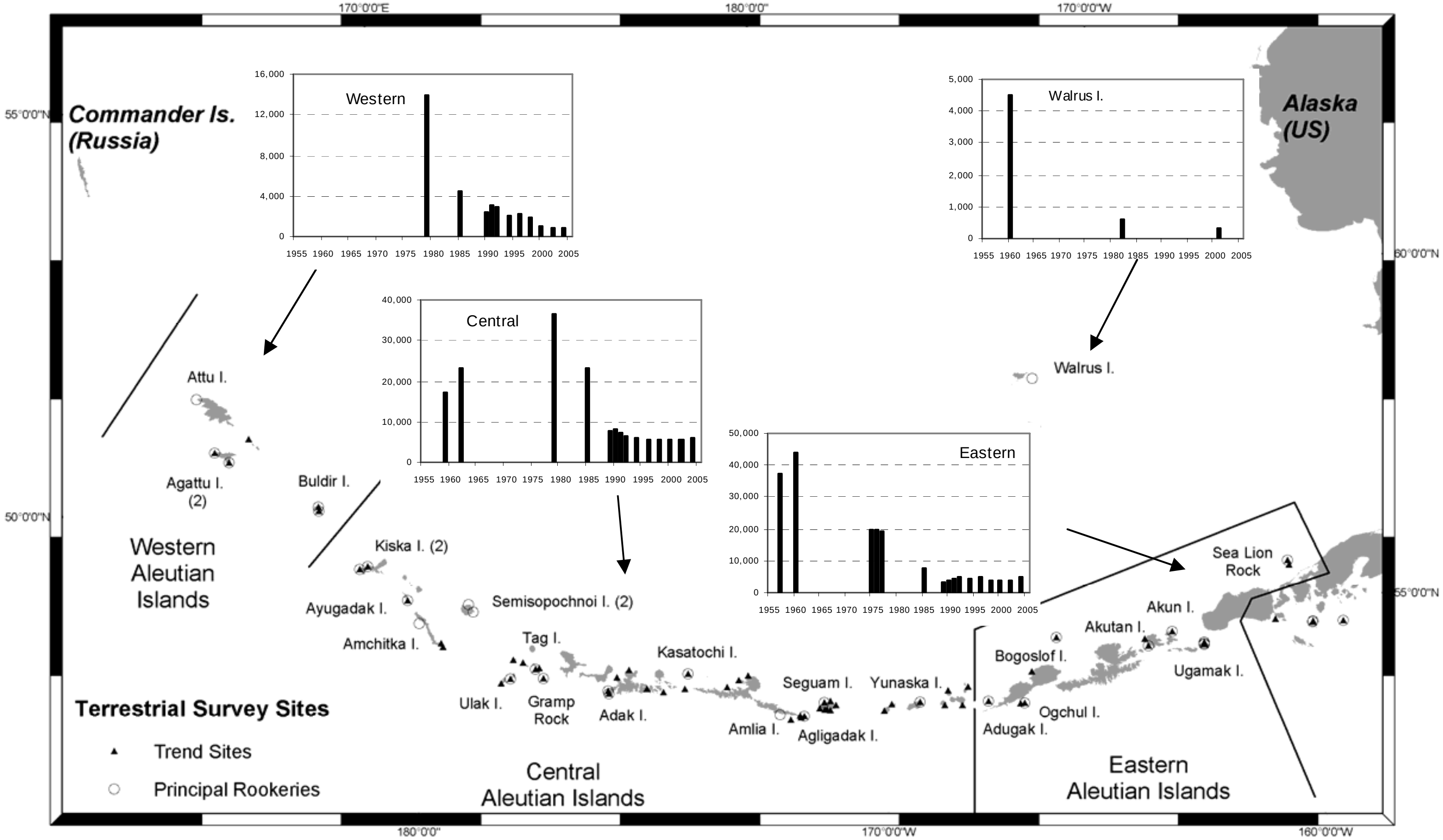


Figure 3.4. Counts of adult and juvenile Steller sea lions on western DPS trend sites in three sub-areas of the Aleutian Islands, 1950s through 2004. Counts on Walrus Island in the eastern Bering Sea are also shown, as are the location of principal rookeries (named) and major terrestrial haulout trend sites (NMFS 1992; Fritz and

Figure 3.5. Counts of non-pups in the western population.

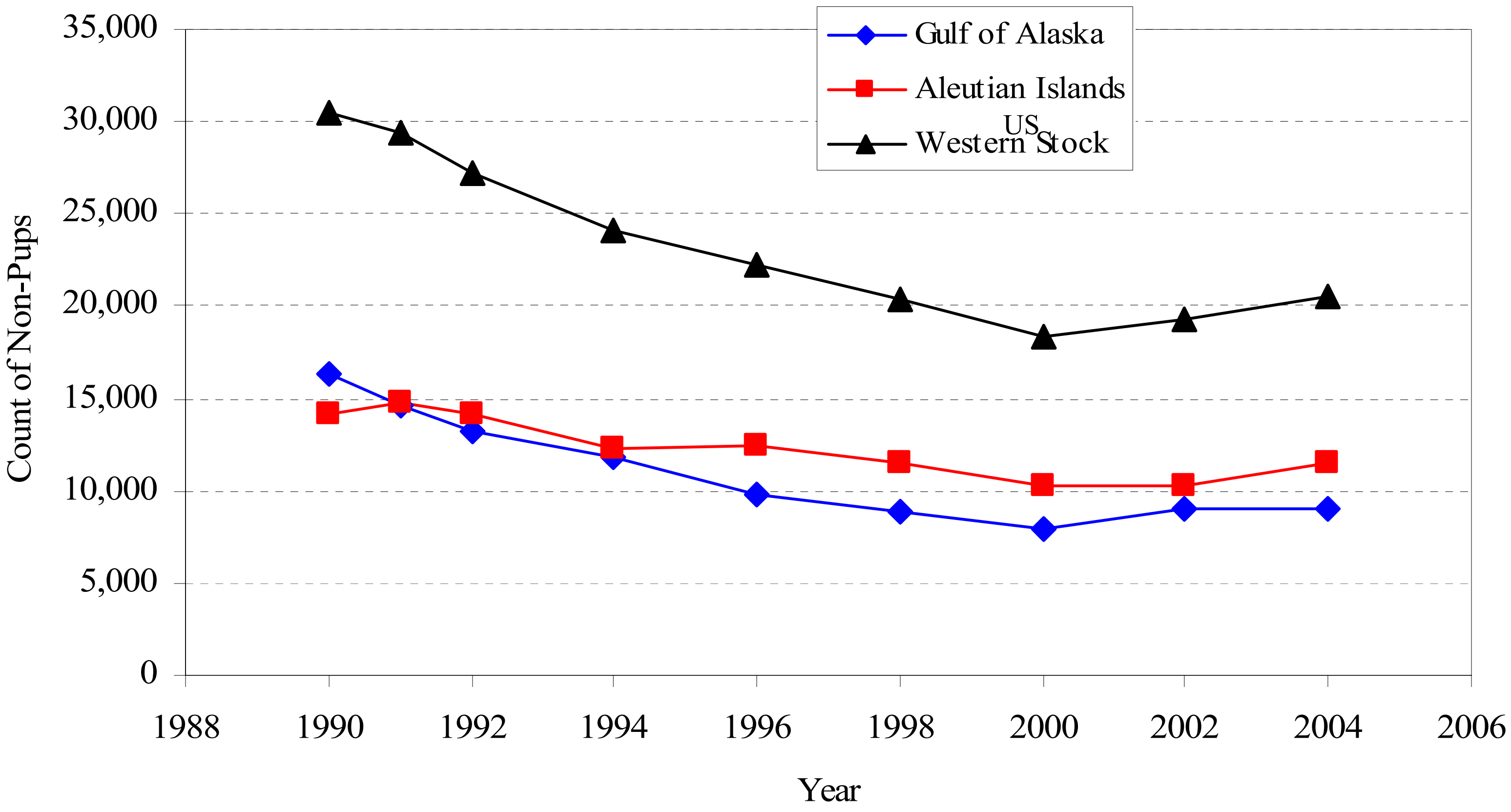


Figure 3.6. Steller sea lion pup counts at trend rookeries in the range of the western stock in Alaska by region from the late 1980s to 2005 in the Gulf of Alaska (A) and Aleutian Islands (B). Percent change in counts between 1990/92 and 2001/02 (C) and 2001/02 and 2005 (D) are also shown (data from Table 2).

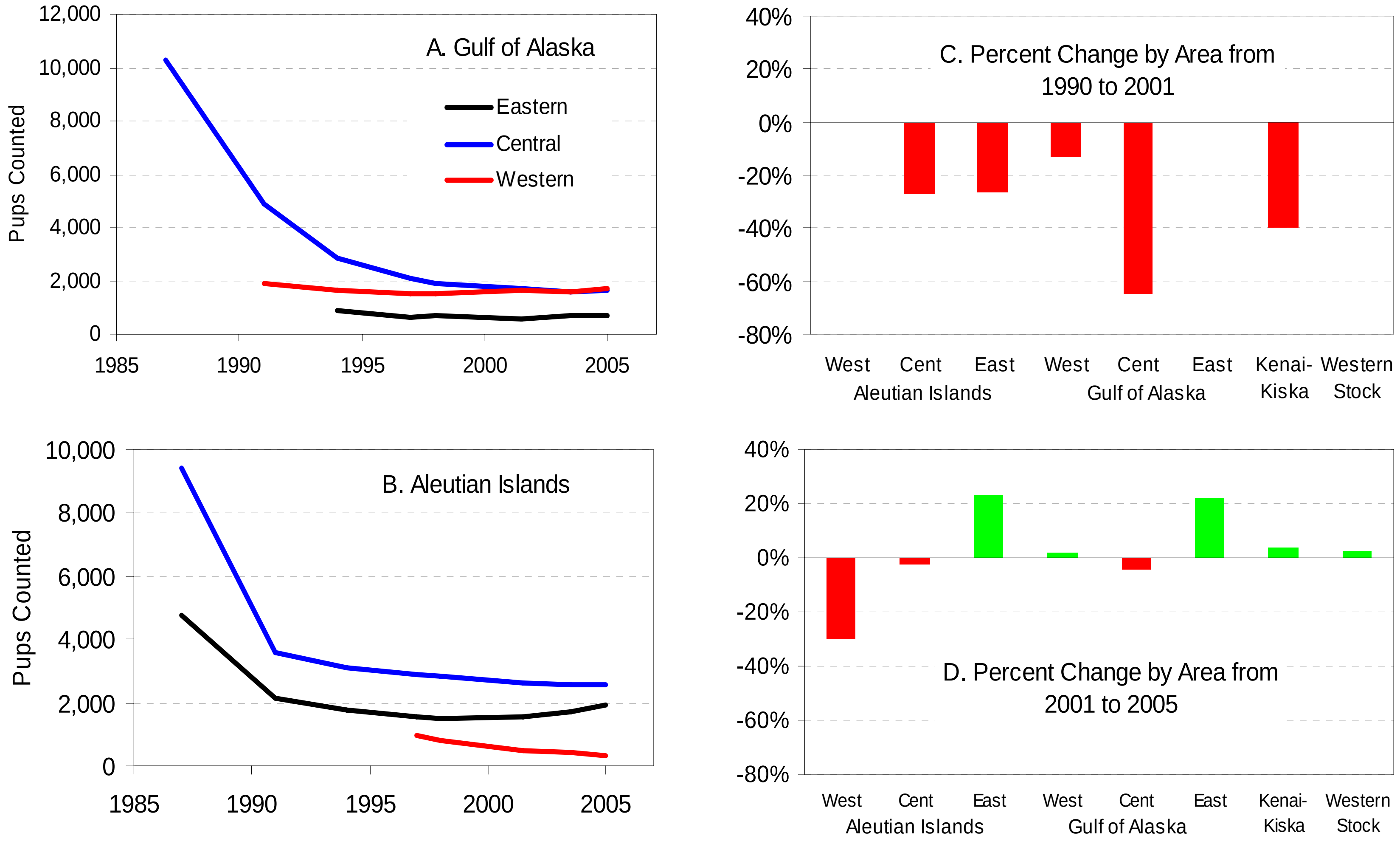
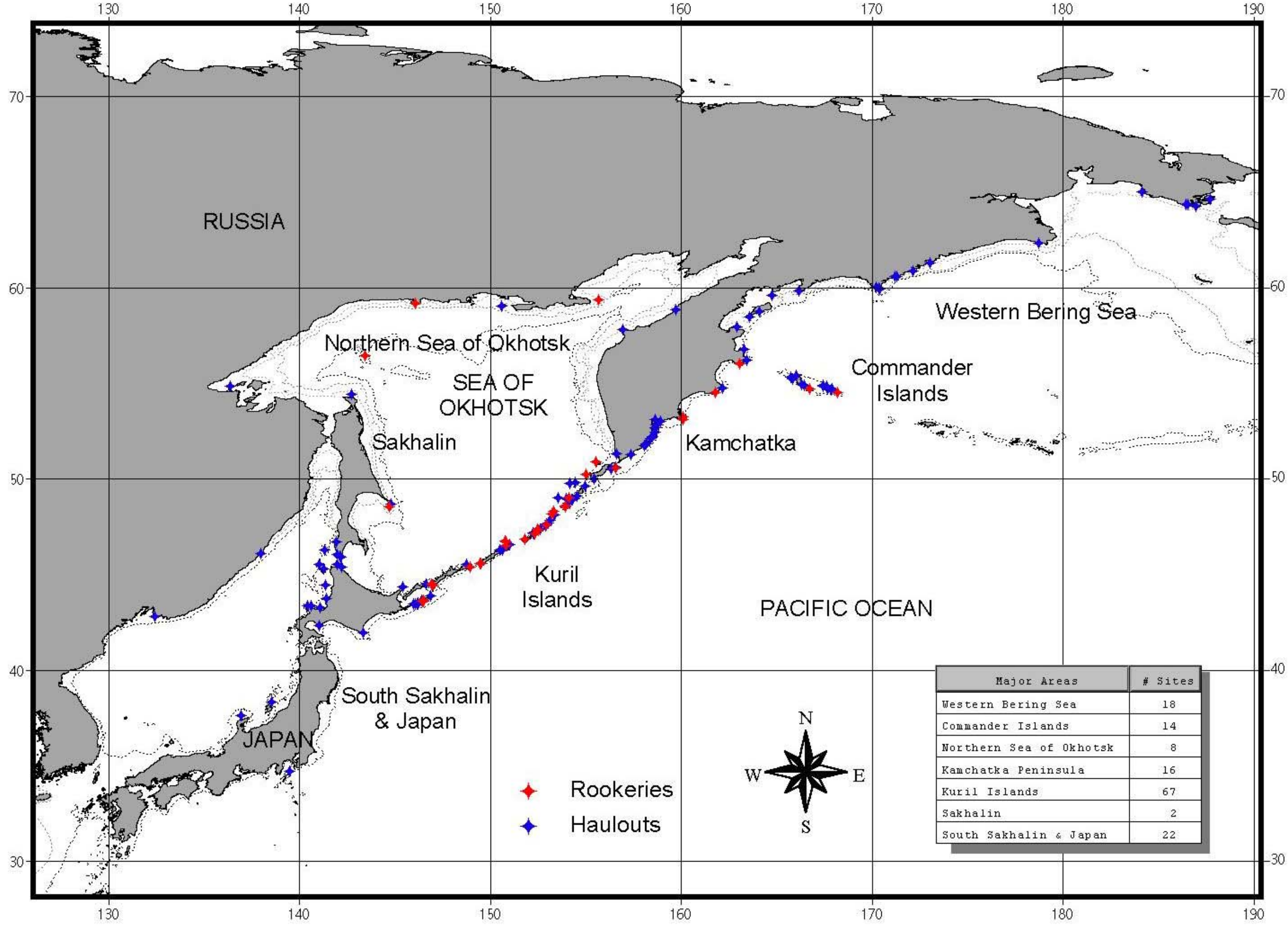


Figure 3.7. Locations of Steller sea lion rookeries (red) and haulout sites in Asia (Russia and Japan).



Major Areas	# Sites
Western Bering Sea	18
Commander Islands	14
Northern Sea of Okhotsk	8
Kamchatka Peninsula	16
Kuril Islands	67
Sakhalin	2
South Sakhalin & Japan	22

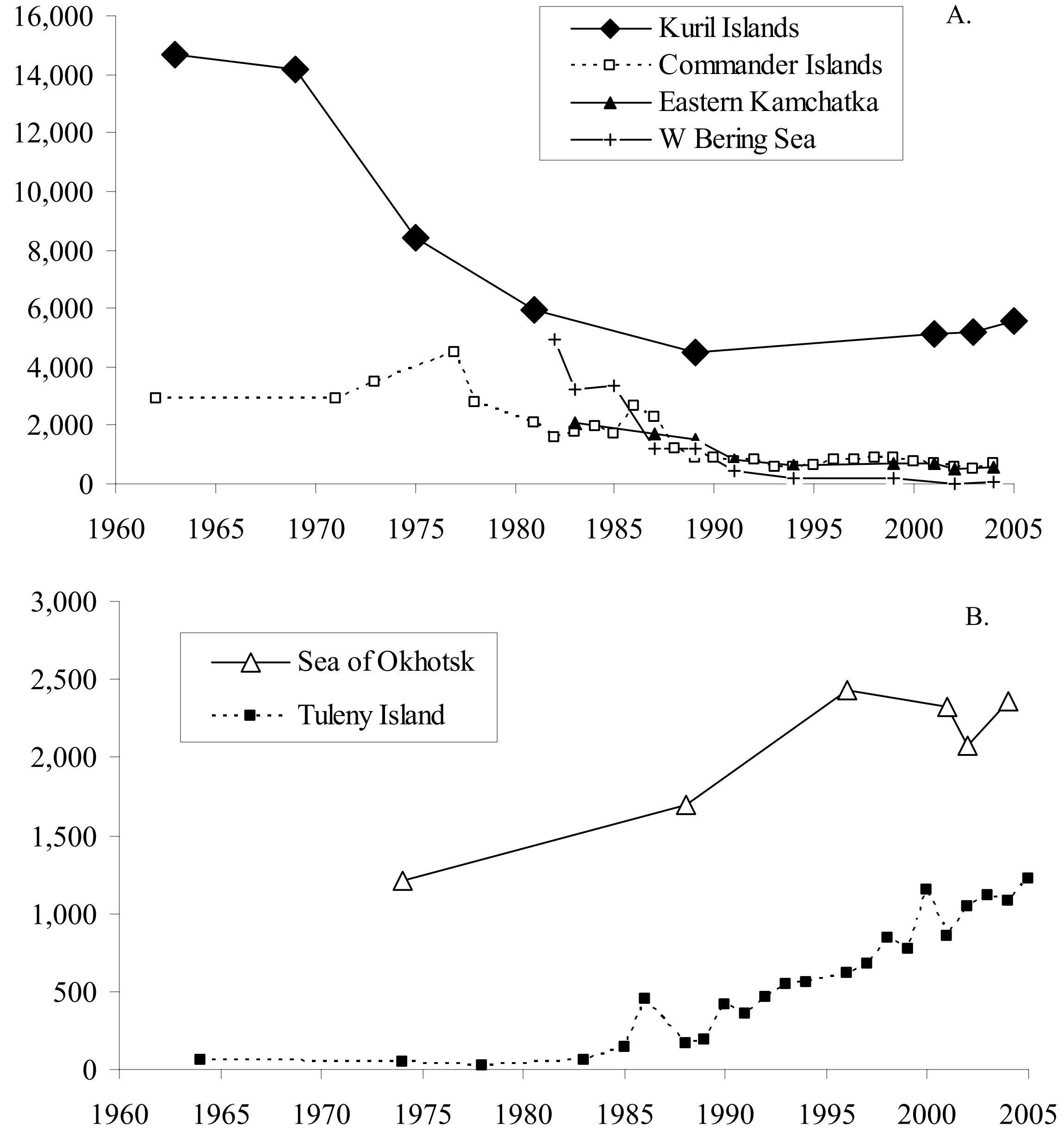
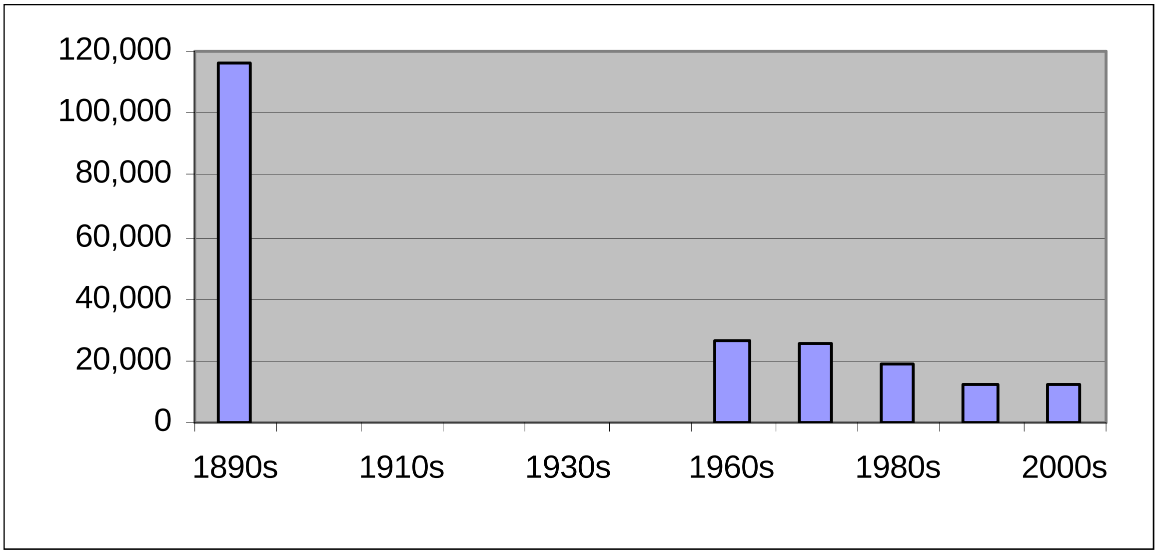


Figure 3.8. Counts of non-pup Steller sea lions in Russia at trend haul-out and rookey sites by sub-area. A. Kuril Islands, eastern Kamchatka Peninsula, western Bering Sea (no rookeries) and the Commander Islands. B. Sea of Okhotsk and Tuleny Island near Sakhalin Island (only rookeries).

Figure 3.9 Counts of non-pup Steller sea lions in Russia.



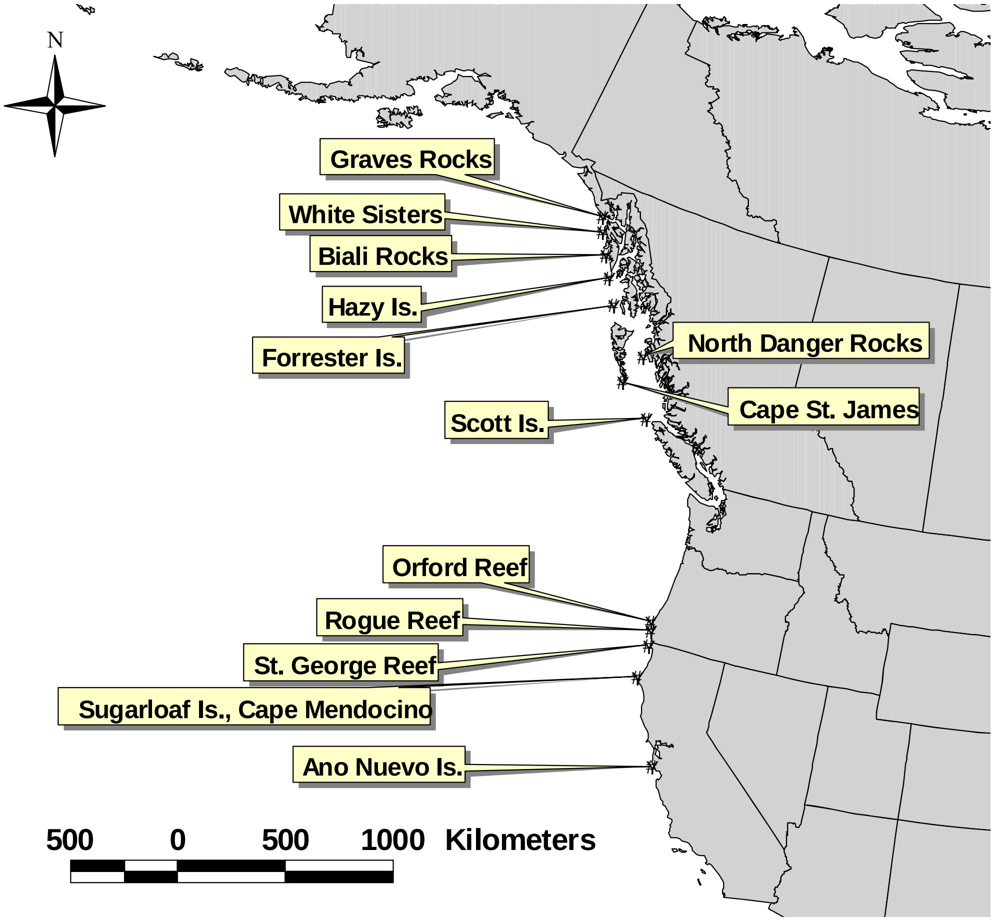


Figure 3.10 Geographic range of the eastern DPS of Steller sea lion showing locations of current rookeries (sites where > 50 pups were born).

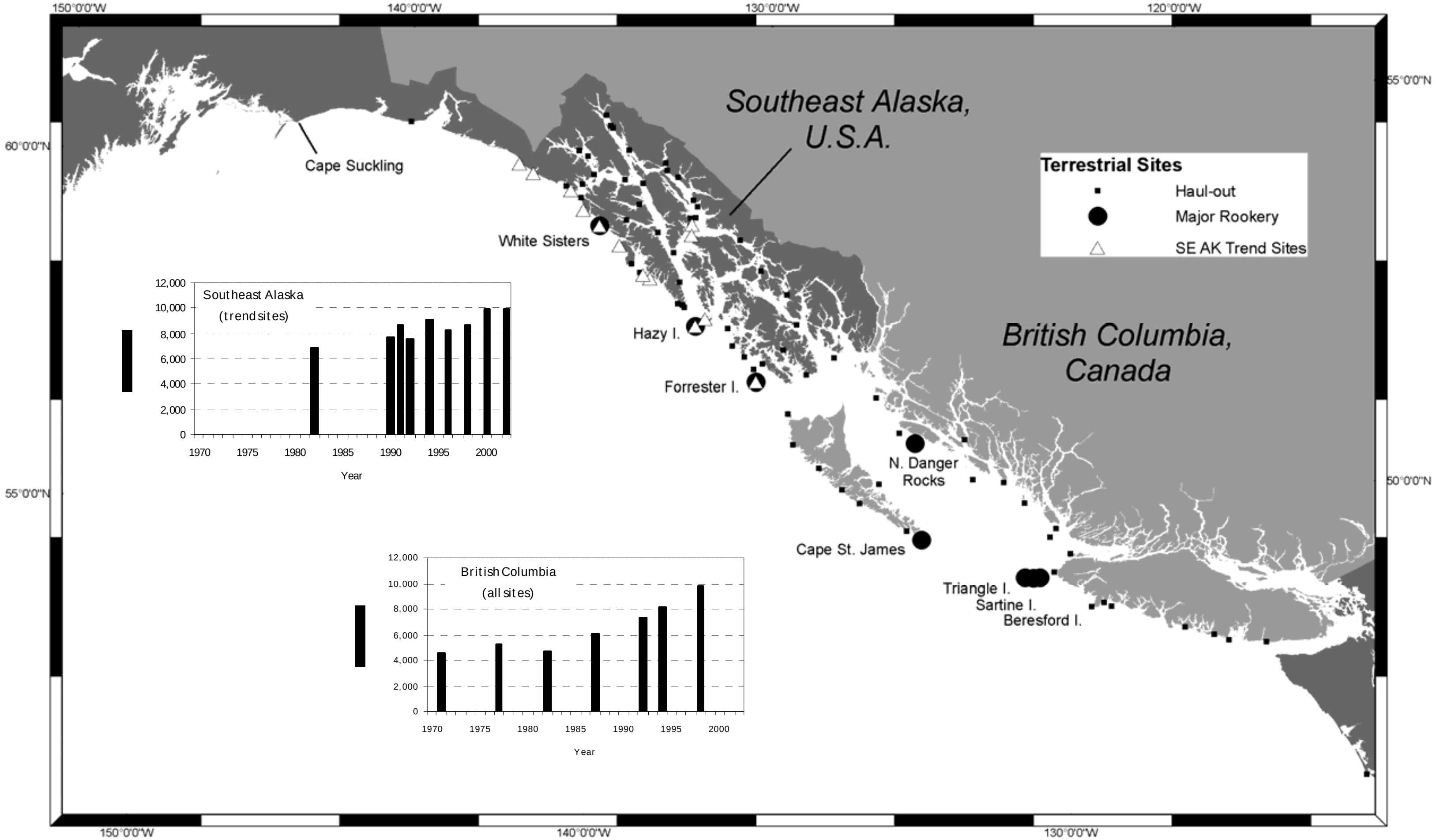


Figure 3.11 Counts of adult and juvenile Steller sea lions (non-pups) on eastern DPS terrestrial sites in Southeast Alaska (SE AK; trend sites) and British Columbia (all sites), 1971-2002. Major rookeries are named in both sub-areas (Olesiuk et al. ADF&G references), as is the boundary between the eastern and western distinct population segments (Cape Suckling).

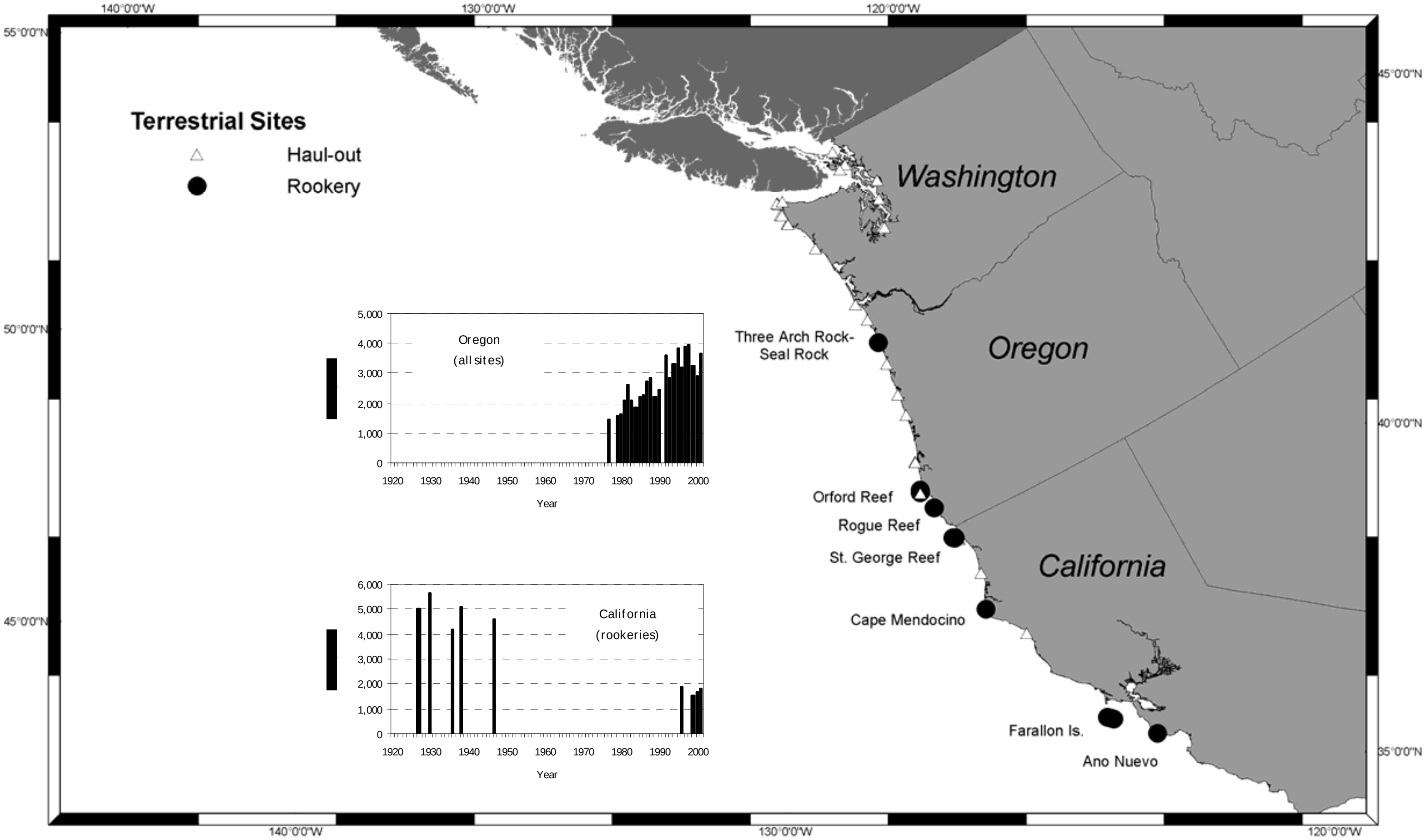
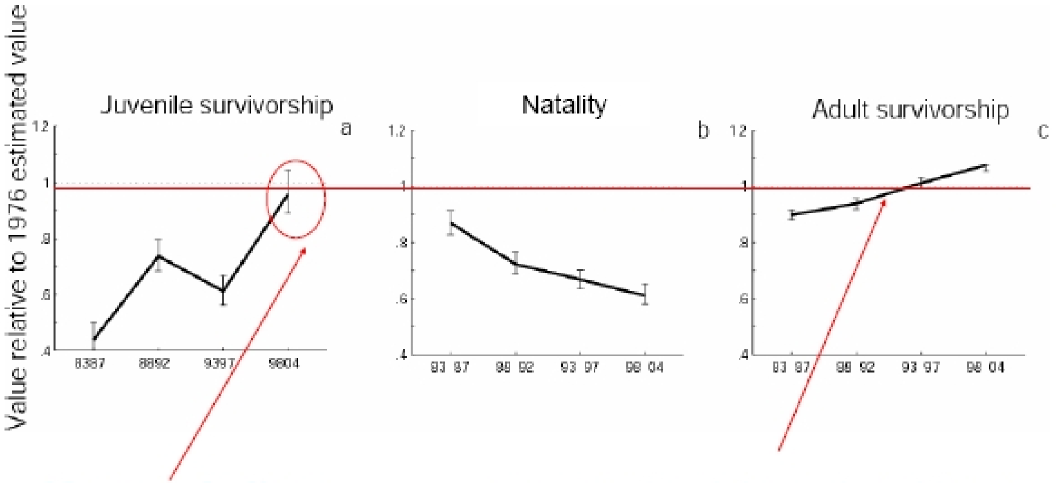


Figure 3.12 Counts of adult and juvenile Steller sea lions (non-pups) on eastern DPS terrestrial sites in Oregon (all sites) and California (rookeries), 1927-2001. Major rookeries are named in Oregon and California; there are no rookeries in Washington.

Figure 3.13 (A) Estimates of juvenile and adult survivorship and natality rates for the CGOA within the western DPS (from: Holmes *et al.* in review; available from presentation at http://faculty.washington.edu/eeholmes/talks.shtml). (B) Cumulative survival for female (top) and male (bottom) survival by region and branding effort (NMFS unpublished data; NMFS 2006b). Estimates from Marmot animals branded in 1987 and 1988, as well as estimates for Forrester Island are from Pendleton *et al.* (in review).

(A)



Near pre-decline survivorship

Increases in adult survivorship are outpacing those of juvenile survivorship a bit.

(B)

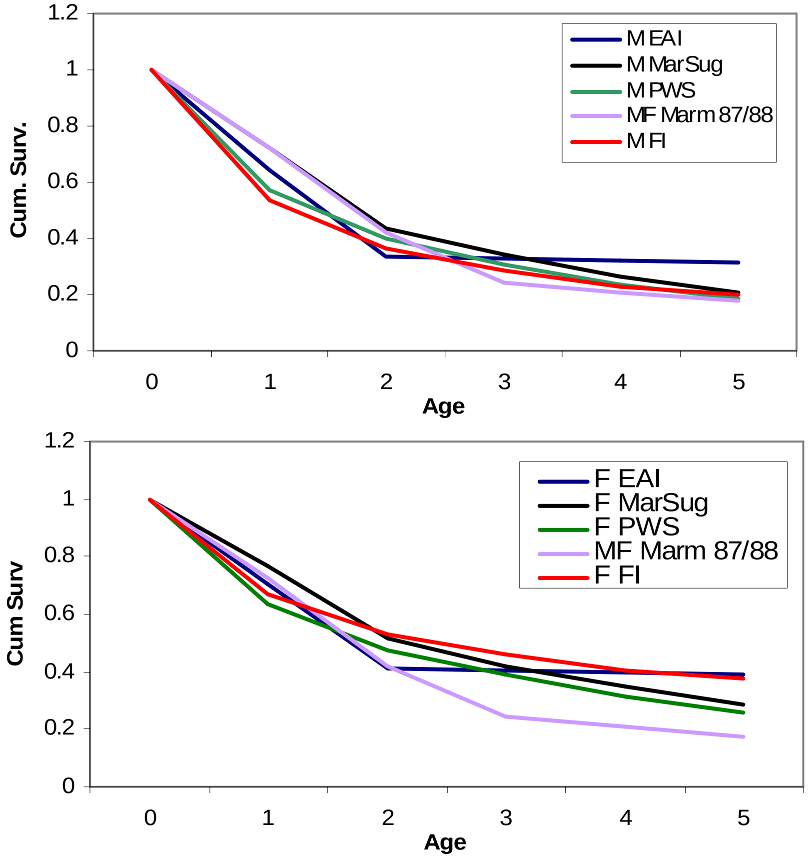
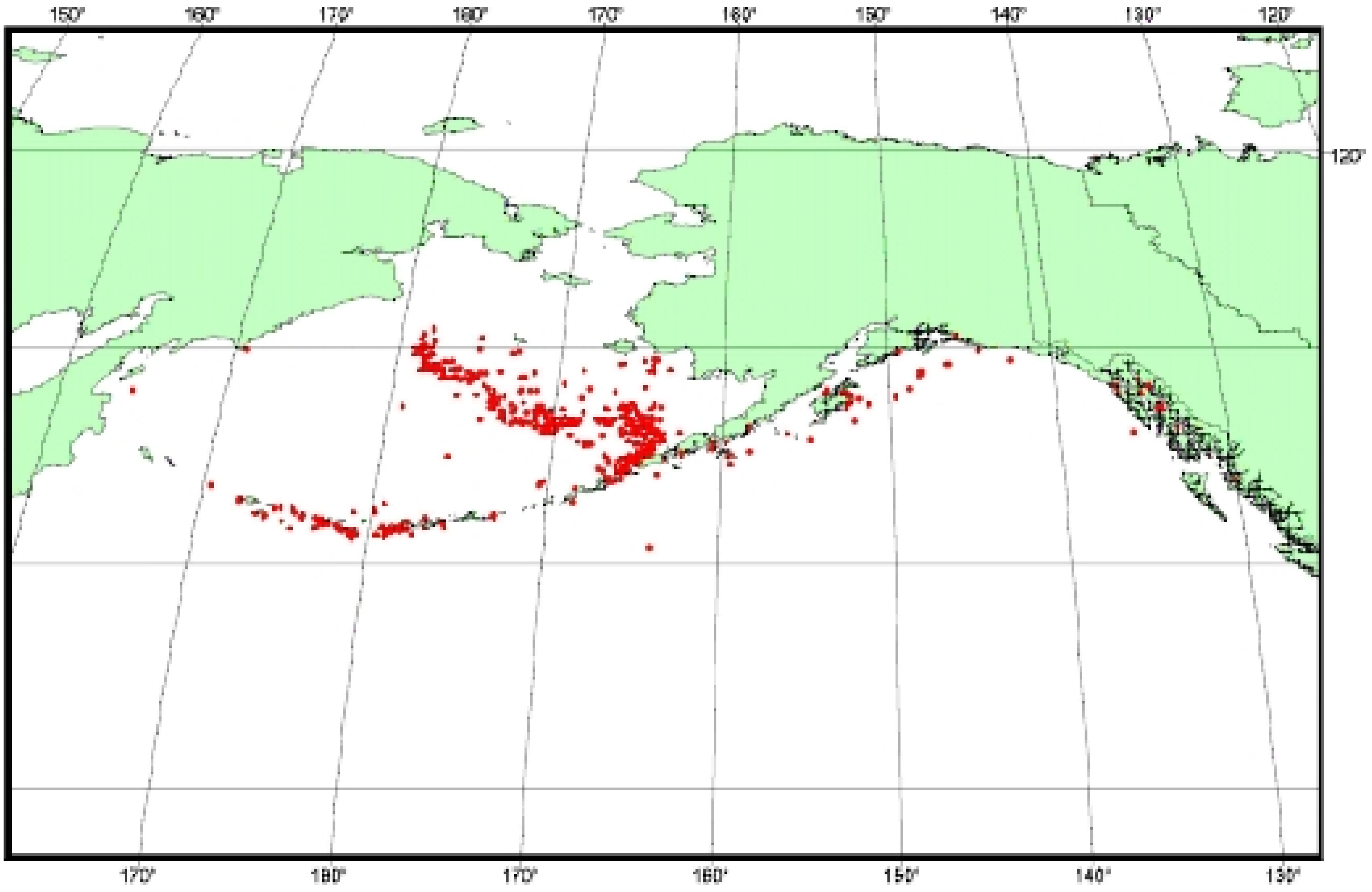


Figure 3.14 Sighting locations for Steller sea lions in the BSAI and GOA based on data from the Platforms-of-Opportunity Program, 1958-1997.

Steller Sea Lion Sightings, 1991 - 1997
POP database



Data source: NMML POP database, 1991-1997
Prepared by SAM, 22 Nov 2000

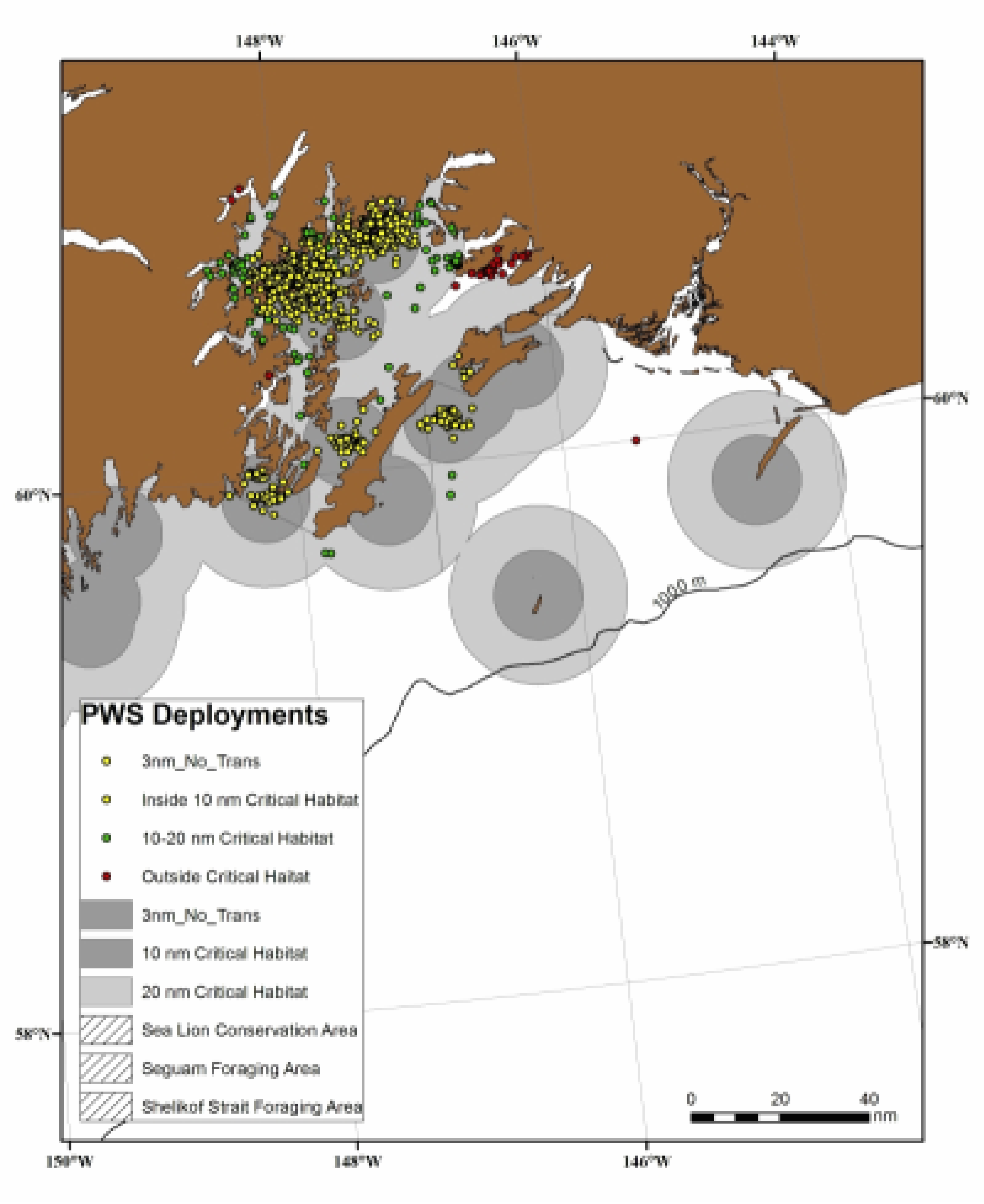


Figure 3.15 Locations associated with diving to >4 m for juvenile Steller sea lions instrumented in Prince William Sound during 2000-2002. Colors indicate distance zone of location based on nearest listed rookery or haulout.

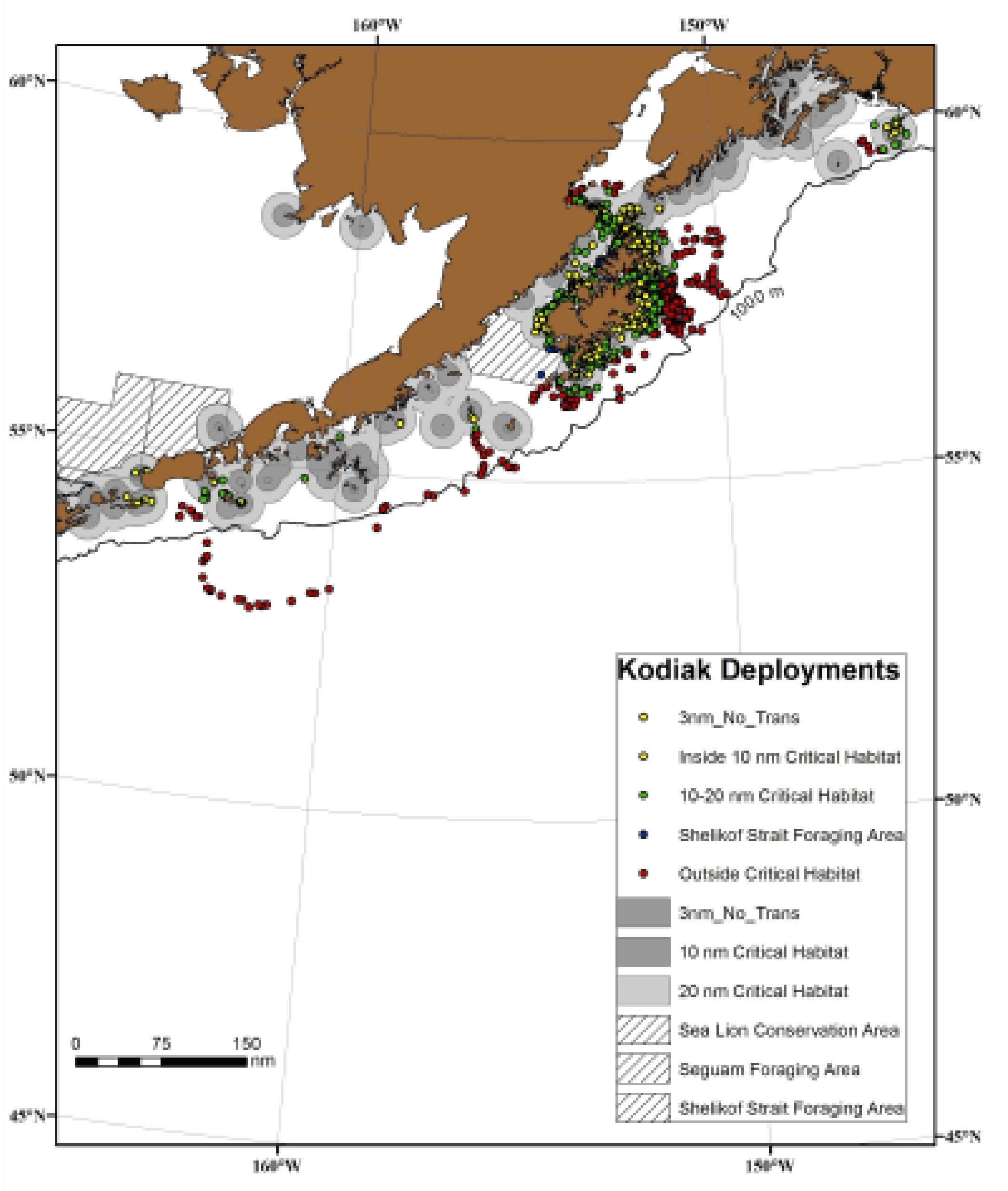


Figure 3.16 Locations associated with diving to >4 m for juvenile Steller sea lions instrumented near Kodiak Island during 2000-2005. Colors indicate distance zone of location based on nearest listed rookery or haulout.

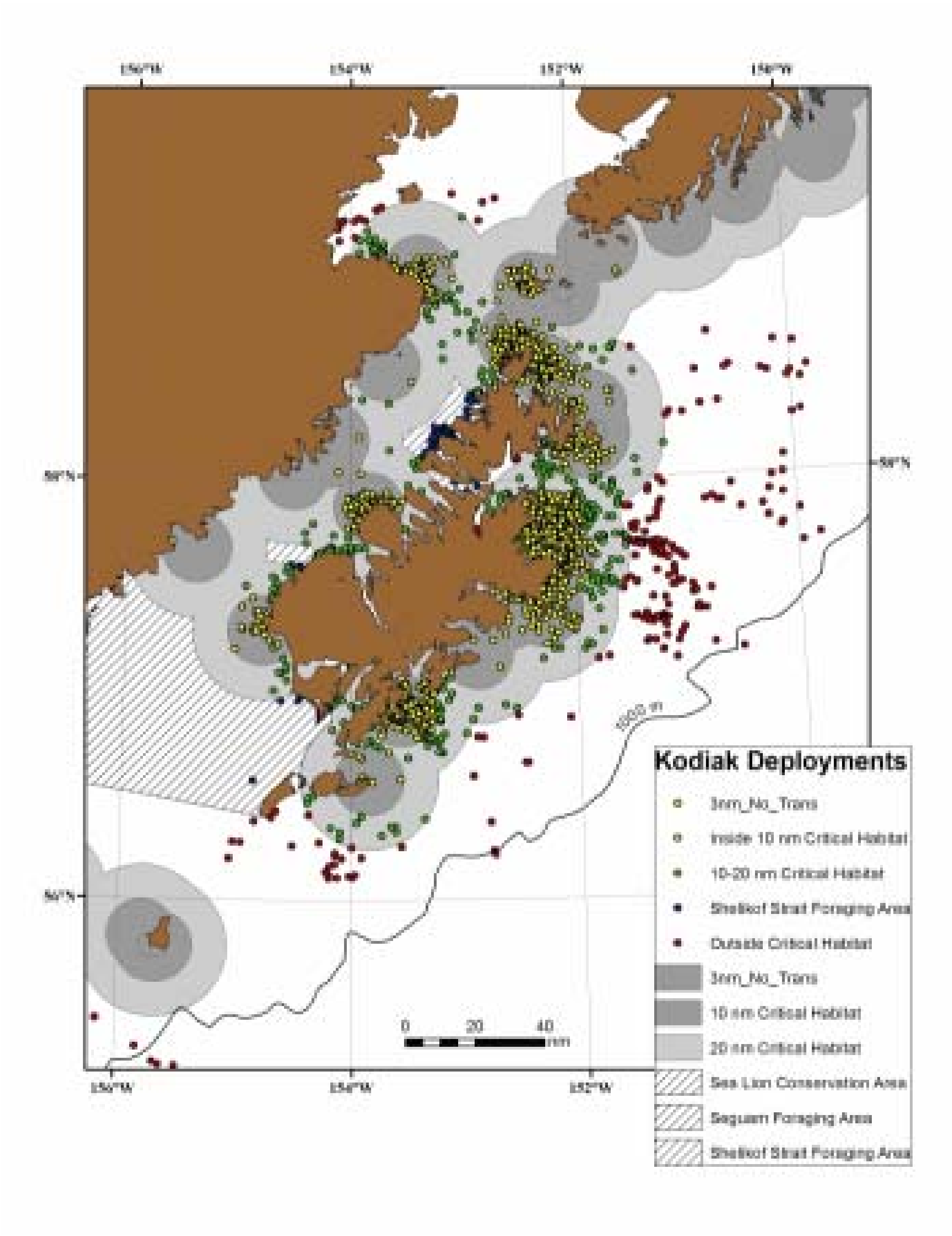


Figure 3.17 Locations associated with diving to >4 m for juvenile Steller sea lions in the Kodiak Island area during 2000-2005. Colors indicate distance zone of location based on nearest listed rookery or haulout.

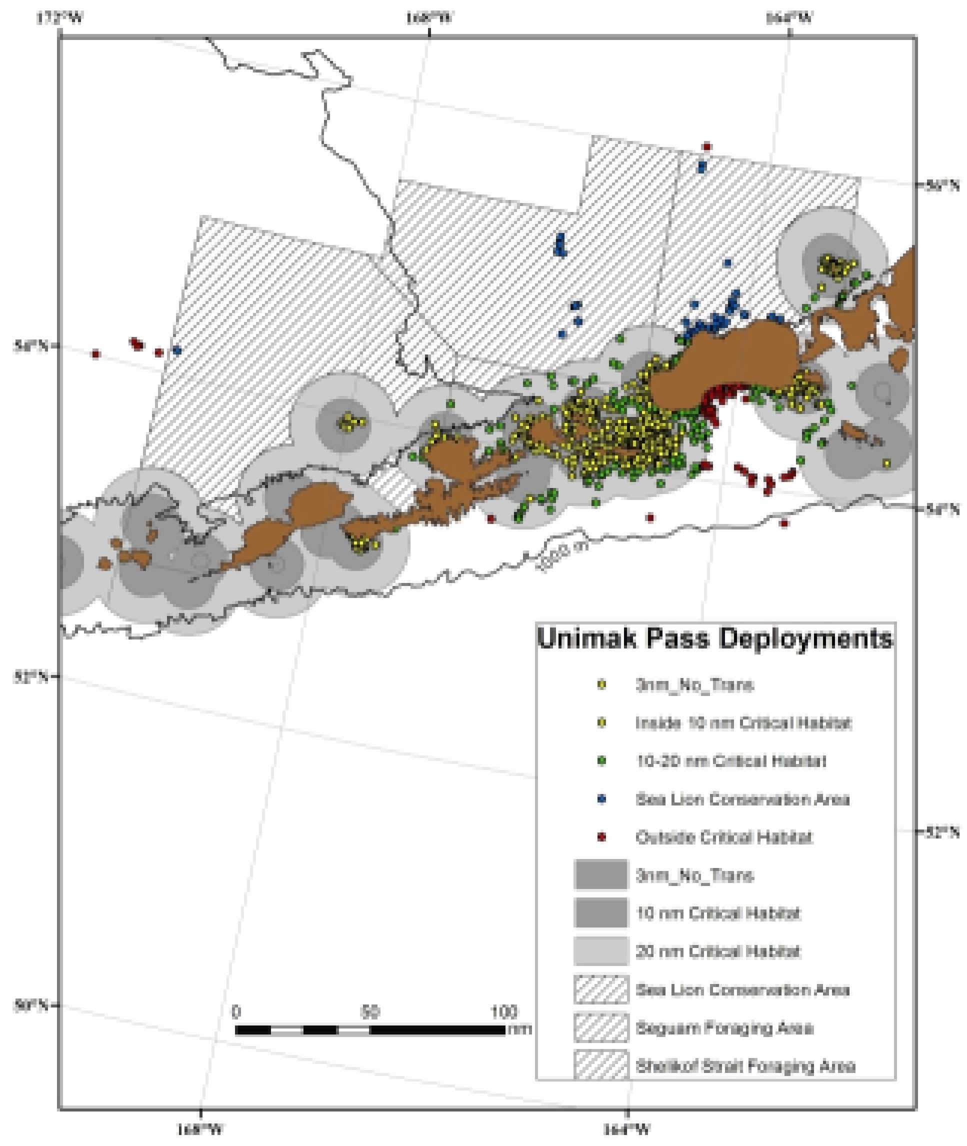


Figure 3.18 Locations associated with diving to >4 m for juvenile Steller sea lions in the Eastern Aleutian Islands area during 2000-2005. Colors indicate distance zone of location based on nearest listed rookery or haulout.

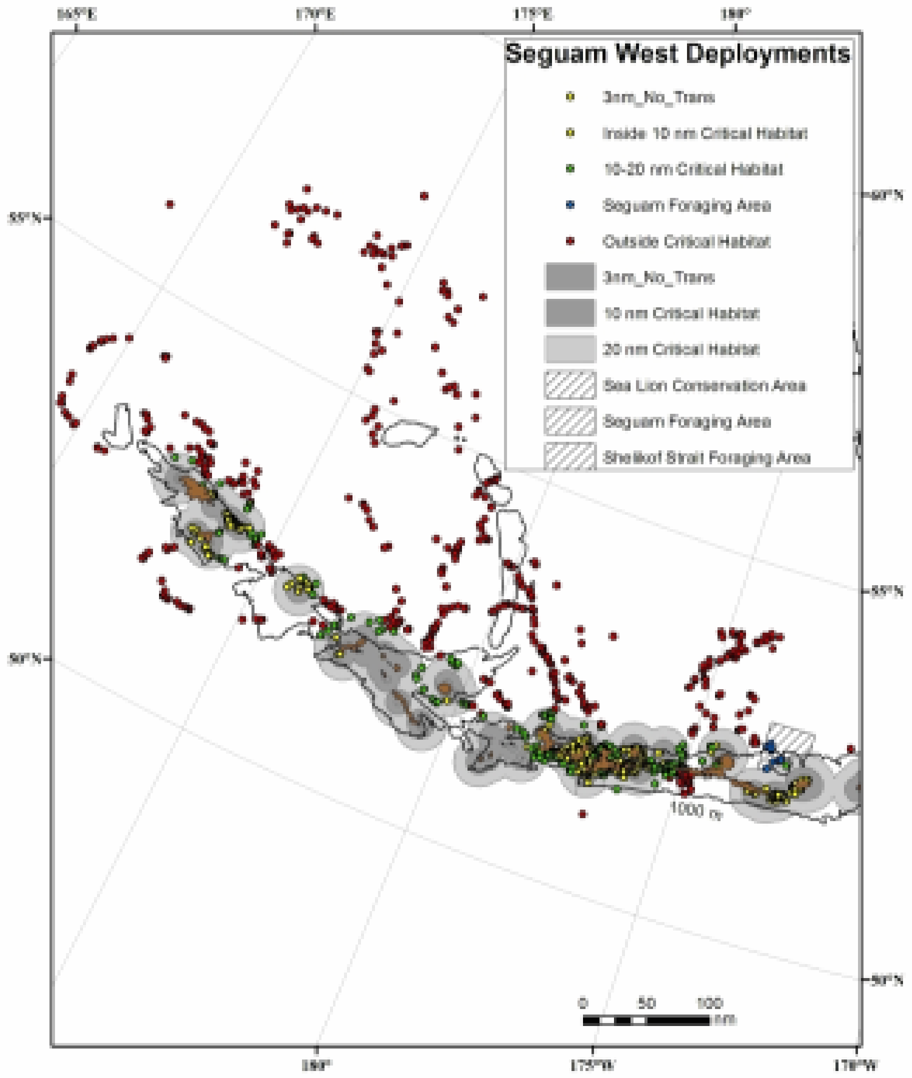


Figure 3.19 Locations associated with diving to >4 m for juvenile Steller sea lions in the Central-Western Aleutian Islands area during 2000-2005. Colors indicate distance zone of location based on nearest listed rookery or haulout.

Figure 3.20 Percent frequency of occurrence of prey occurring in Steller sea lion scats collected from 1999 to 2005 (NMFS 2006b).

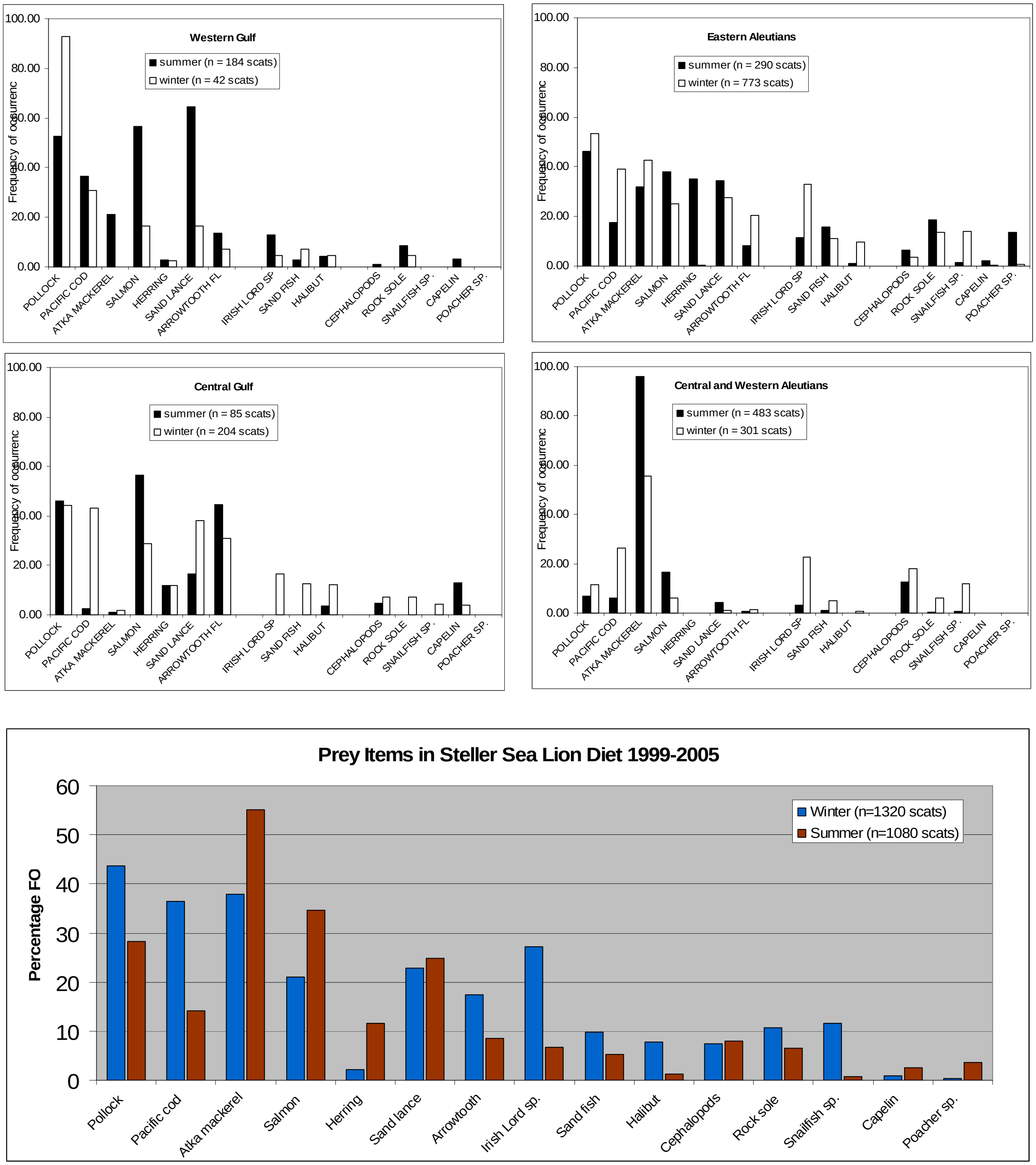


Figure 3.21 Relative frequency histograms of the estimated fork length of walleye pollock and Atka mackerel consumed by Steller sea lions compared with relative frequency histograms of fish caught by the walleye pollock and Atka mackerel commercial trawl fishery (1998-2000)(from Zeppelin *et al.* 2004).

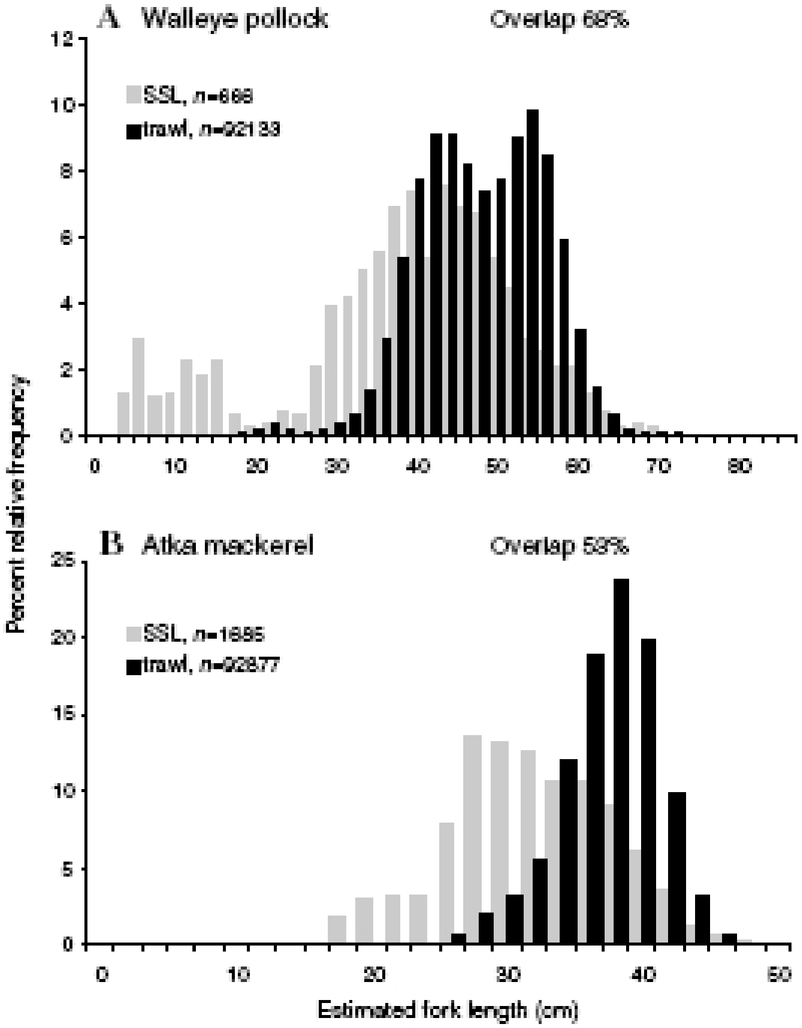


Figure 3.22 Schematic of the Steller sea lion life-cycle, with an emphasis on reproduction.

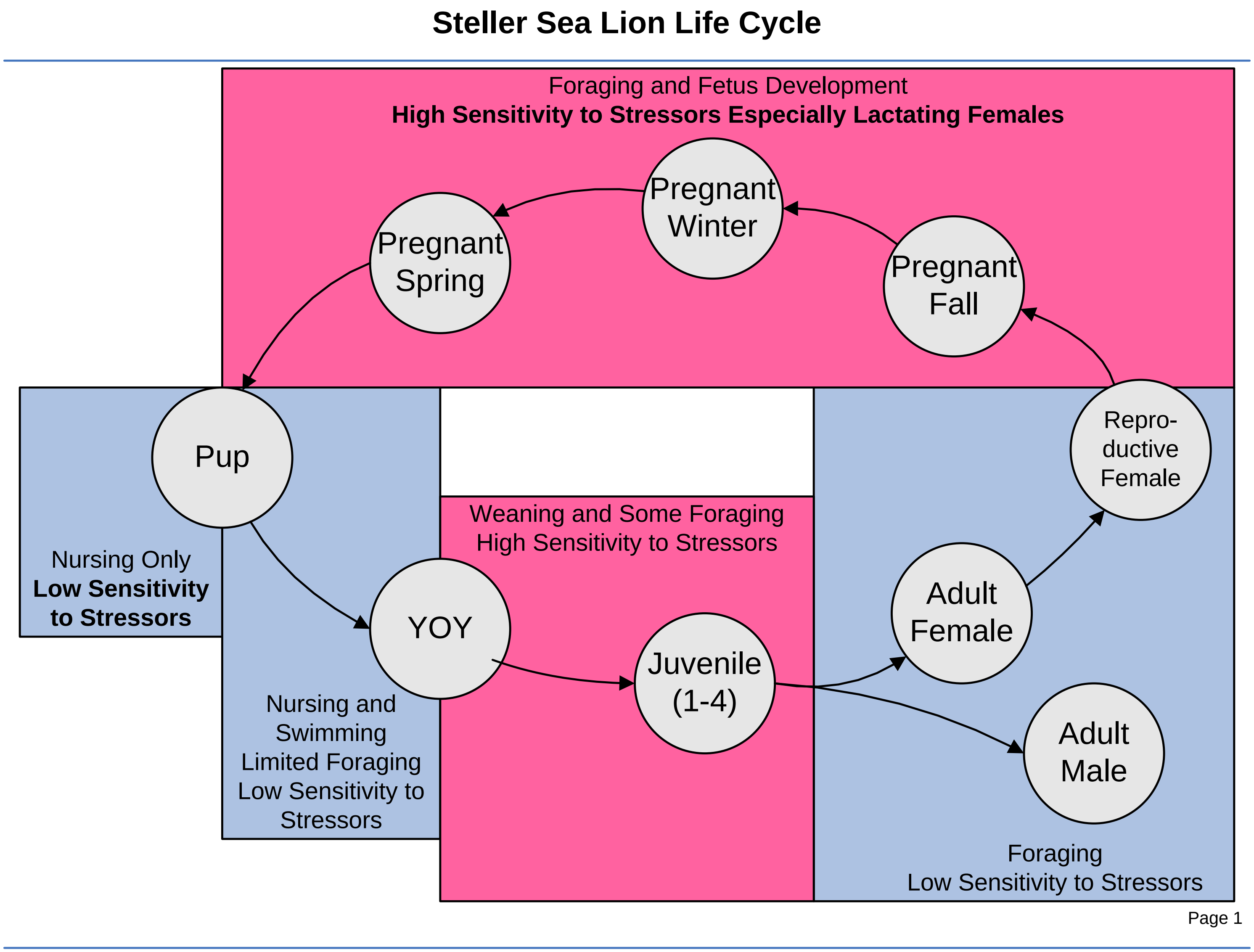
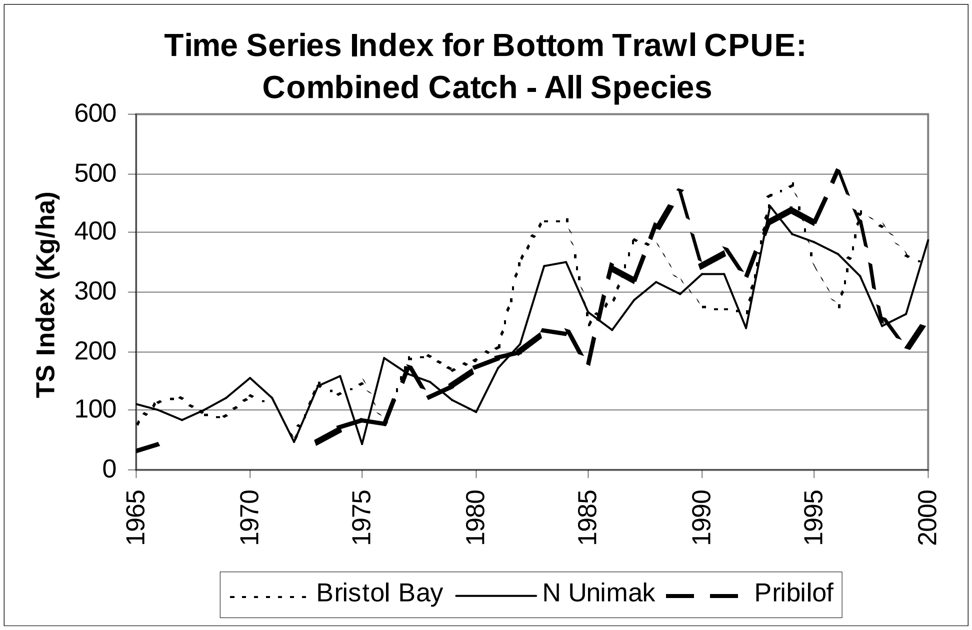


Figure 4.1 Time series index of bottom trawl catch for all species, including fish and invertebrates, at three sites in the southeast Bering Sea. Index units are CPUE in Kg/ha. (from Conners *et al.* 2002, NMFS 2006b).



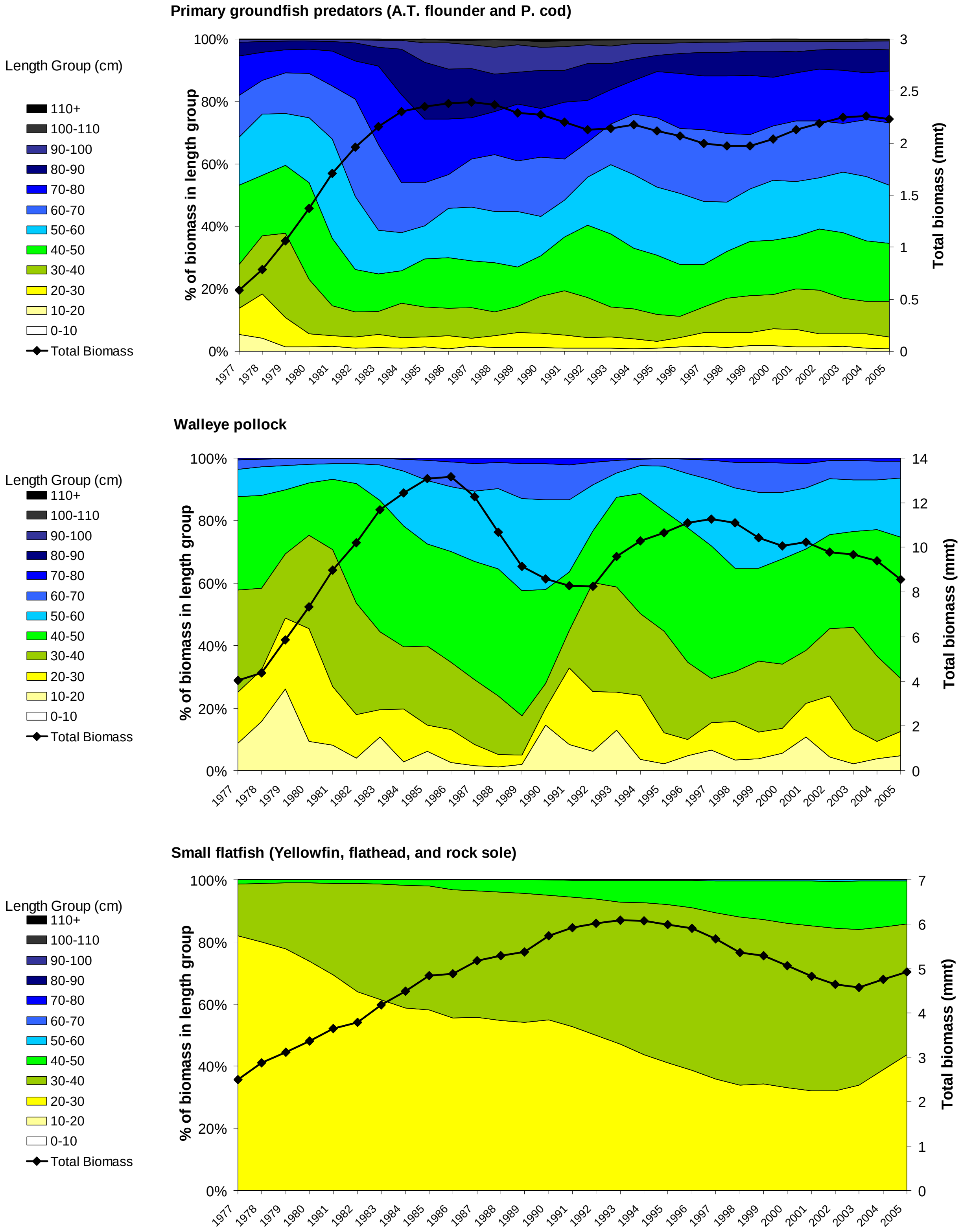


Figure 4.2 Total stock assessment biomass (mmt) and percentage of biomass by length class for major groundfish predators (top), walleye pollock (middle), and small flatfish (bottom). Biomass values come from age-structured stock assessment models as published in NPFMC (2005).

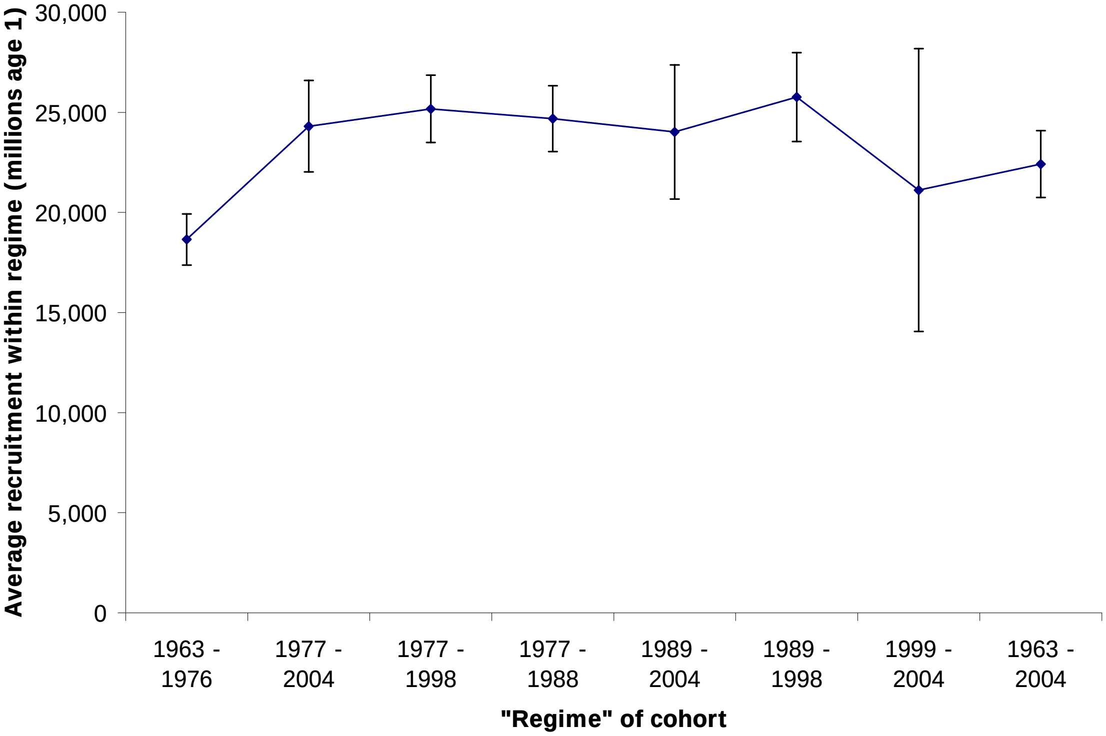


Figure 4.3 Average recruitment of EBS pollock at age 1 under different "regimes" based on estimates computed from within the stock assessment model. Vertical lines represent ± two standard deviations.

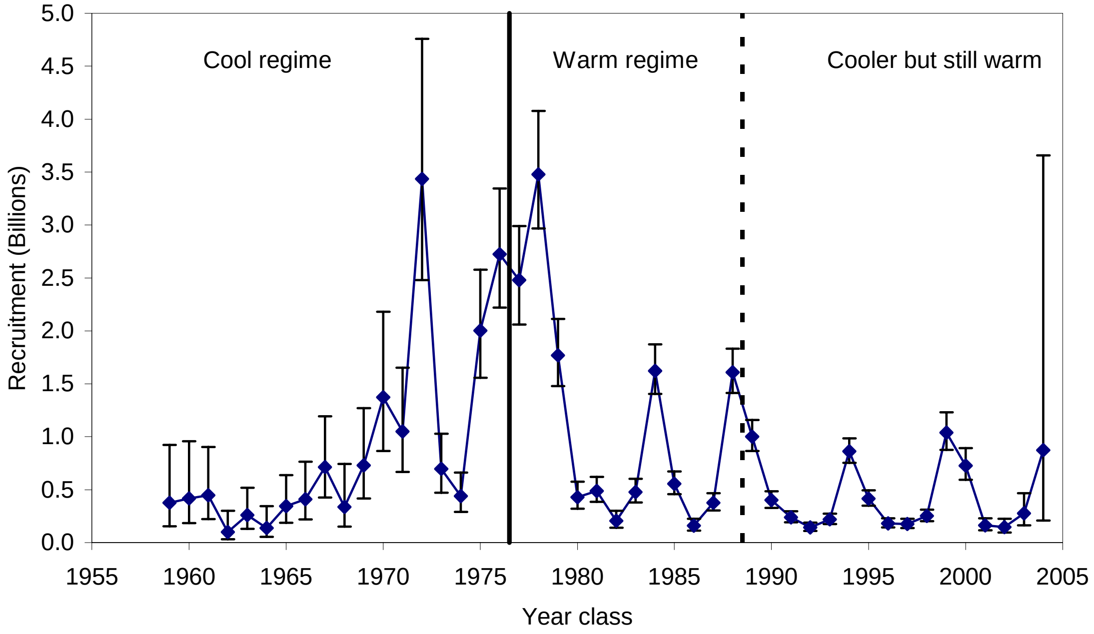


Figure 4.4 Estimated year class abundance for Gulf of Alaska pollock from Dorn et al. (2005). Vertical lines separate climate regimes with stong (solid line) and moderate (dashed line) signal strength (modified from Fritz and Hinckley 2005).

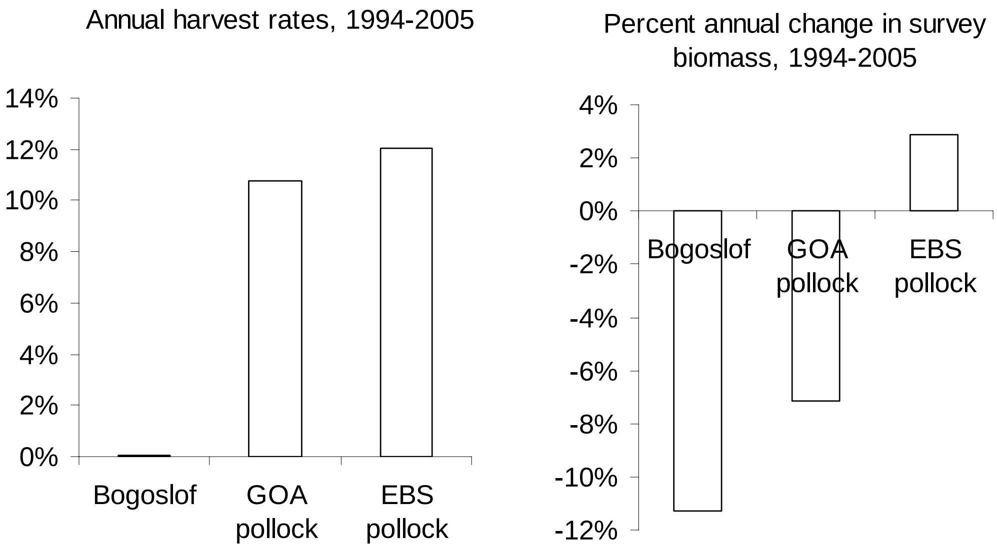


Figure 4.5 Annual harvest rates for pollock in 1994-2005 in the Bogoslof area, Gulf of Alaska, and eastern Bering Sea (left), and percent annual change in survey biomass during the same period (right).

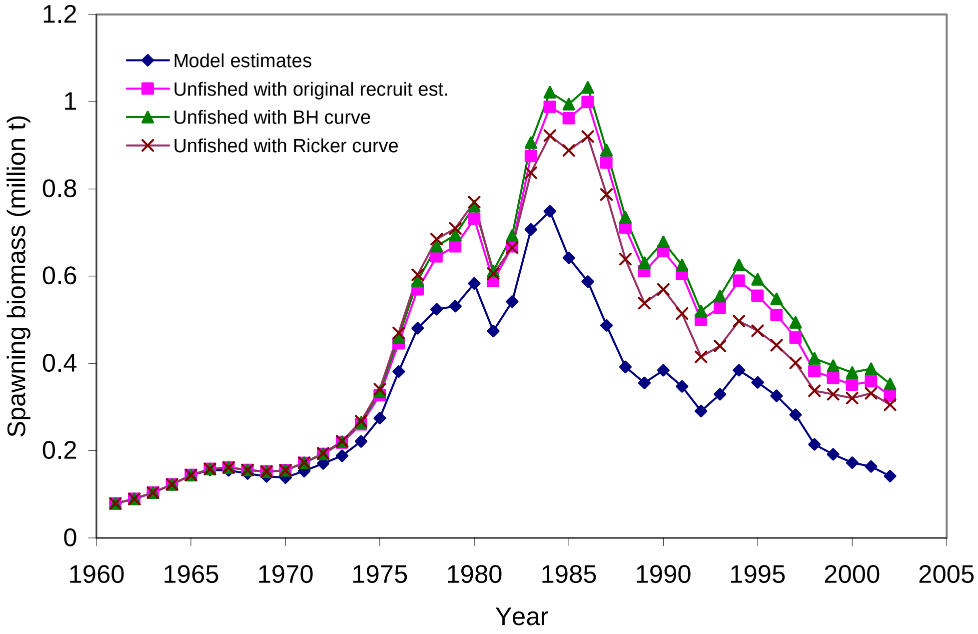


Figure 4.6 Spawning biomass trajectories for simulated unfished populations of Gulf of Alaska pollock compared to stock assessment model estimates.

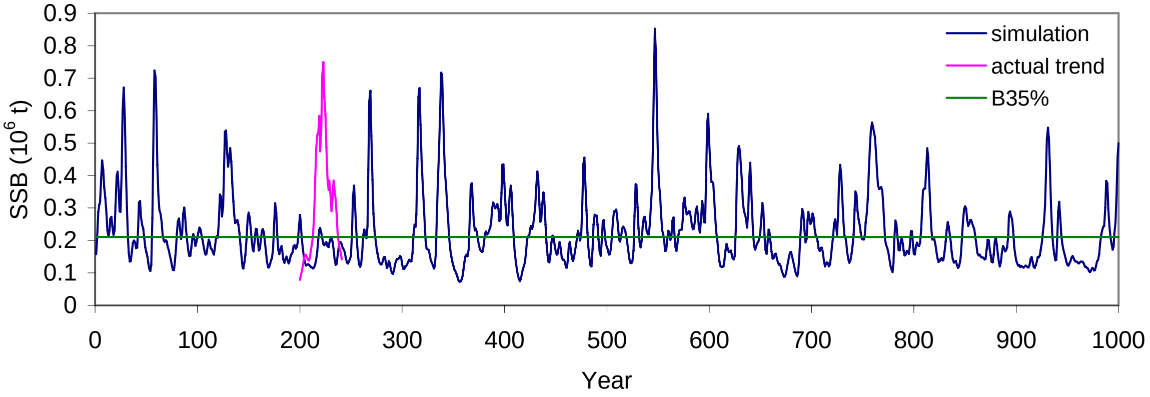


Figure 4.7 Example 1000-year simulation of spawning stock dynamics under current Gulf of Alaska pollock harvest control rule. Random recruitments were drawn from a lognormal distribution with the same variance and autocorrelation as the historical recruitment time series. The estimated 42-year trend from the assessment model is shown beginning in year 200 of the simulation.

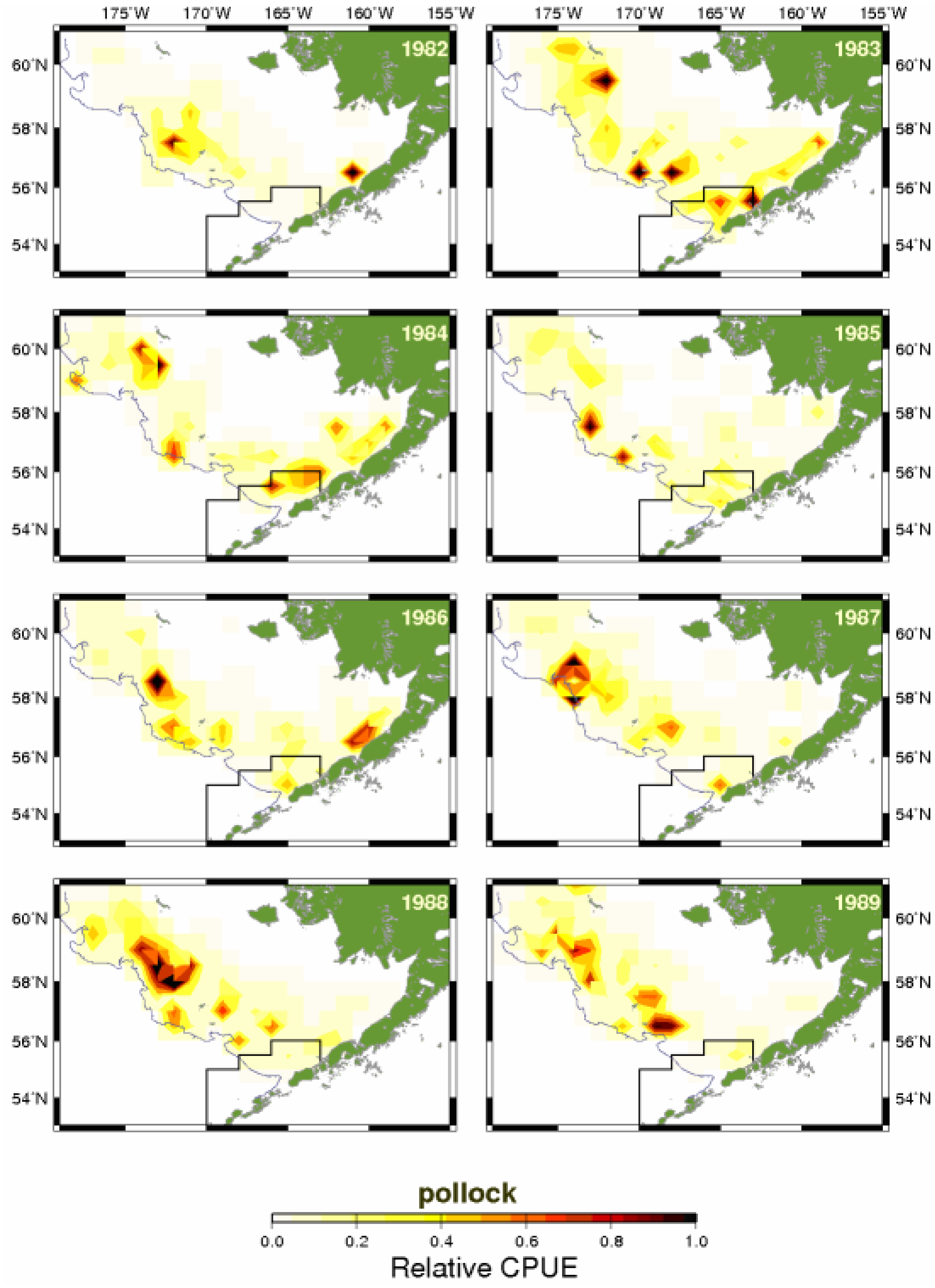


Figure 4.8 NMFS summer trawl survey gridded CPUE means by year for pollock, 1982-1989. The Steller sea lion critical habitat area is indicated by the line.

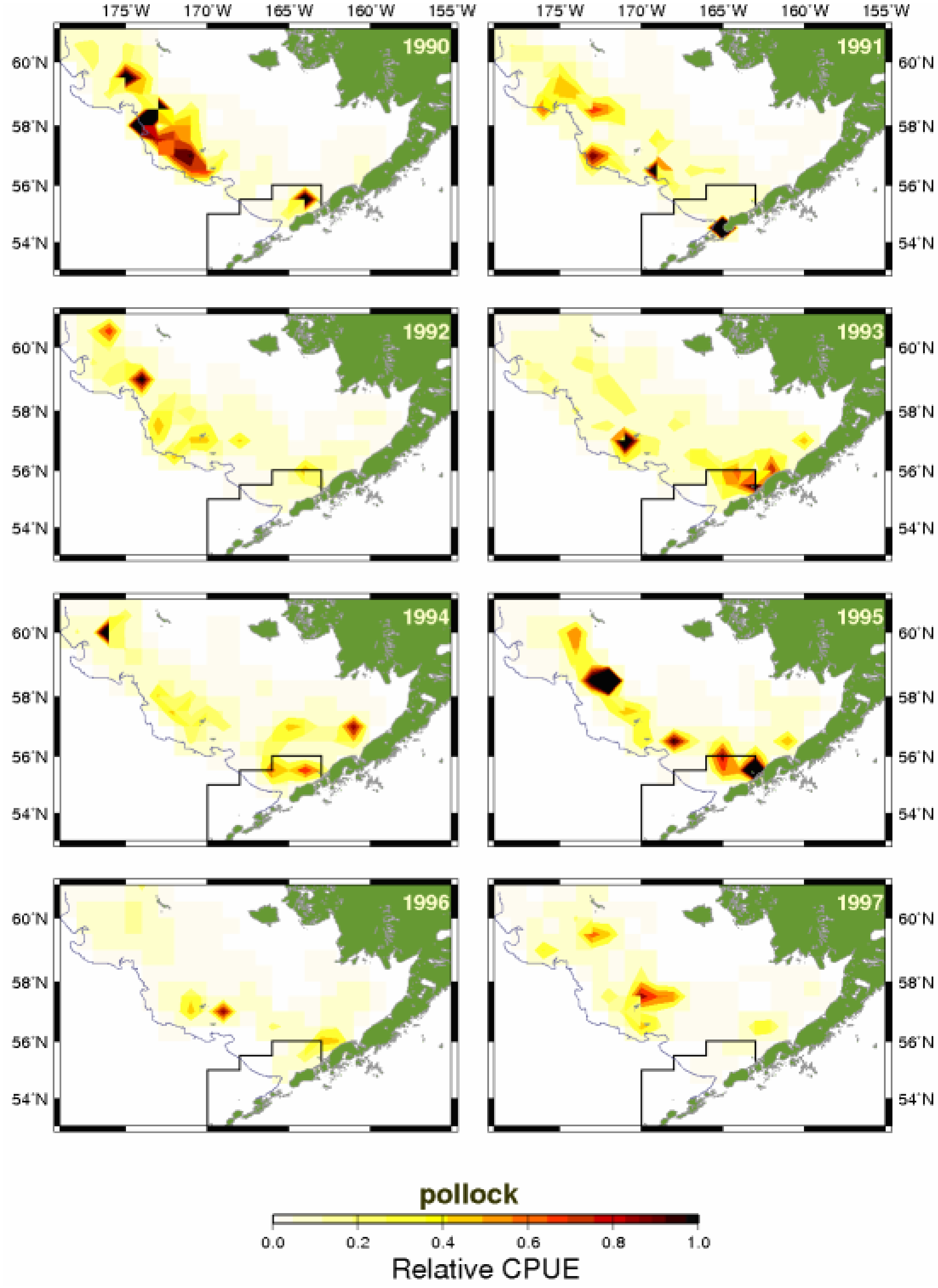


Figure 4.9 NMFS summer trawl survey gridded CPUE means by year for pollock, 1990-1997. The Steller sea lion critical habitat area is indicated by the line.

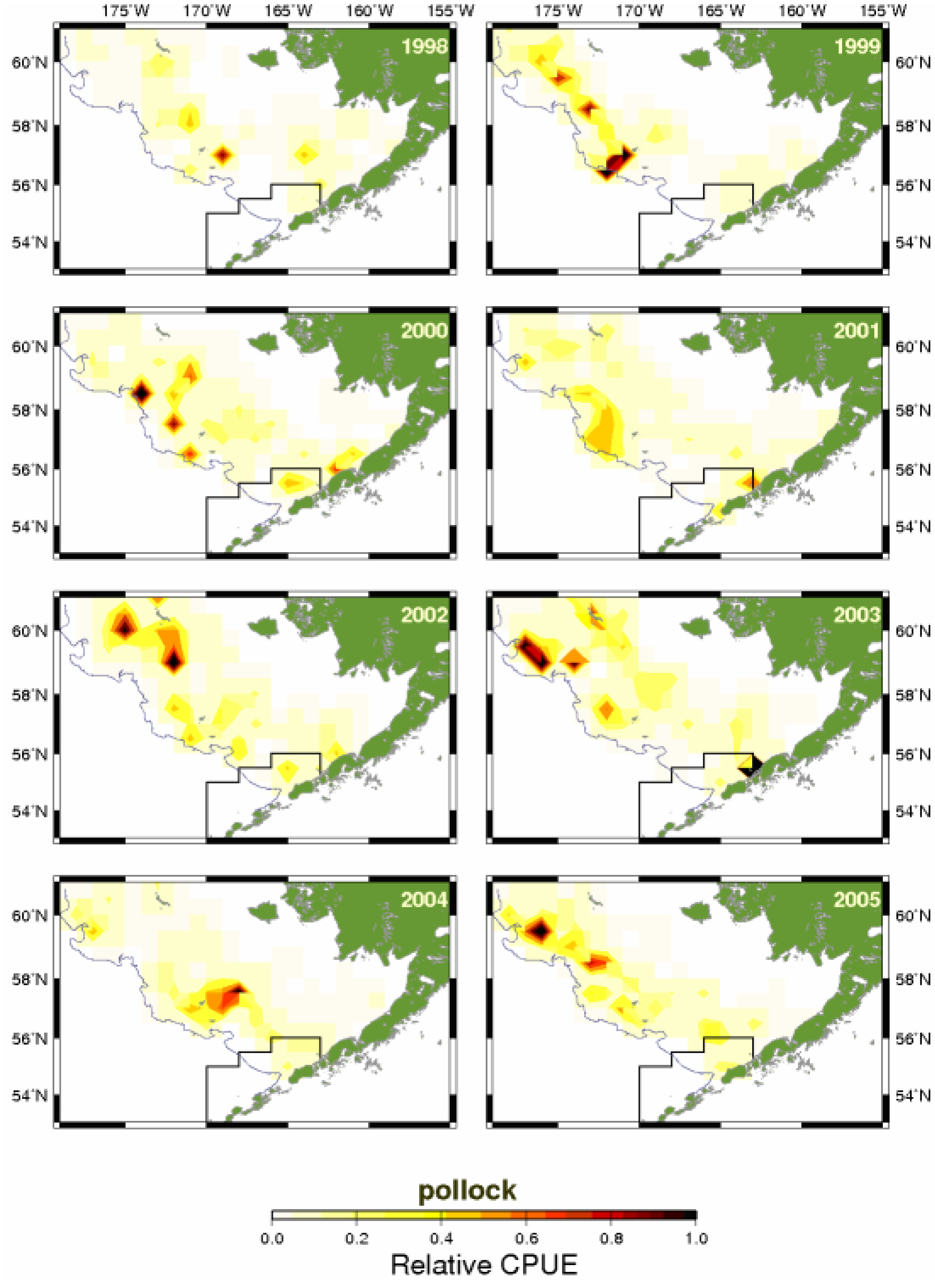


Figure 4.10 NMFS summer trawl survey gridded CPUE means by year for pollock, 1998-2005. The Steller sea lion critical habitat area is indicated by the line.

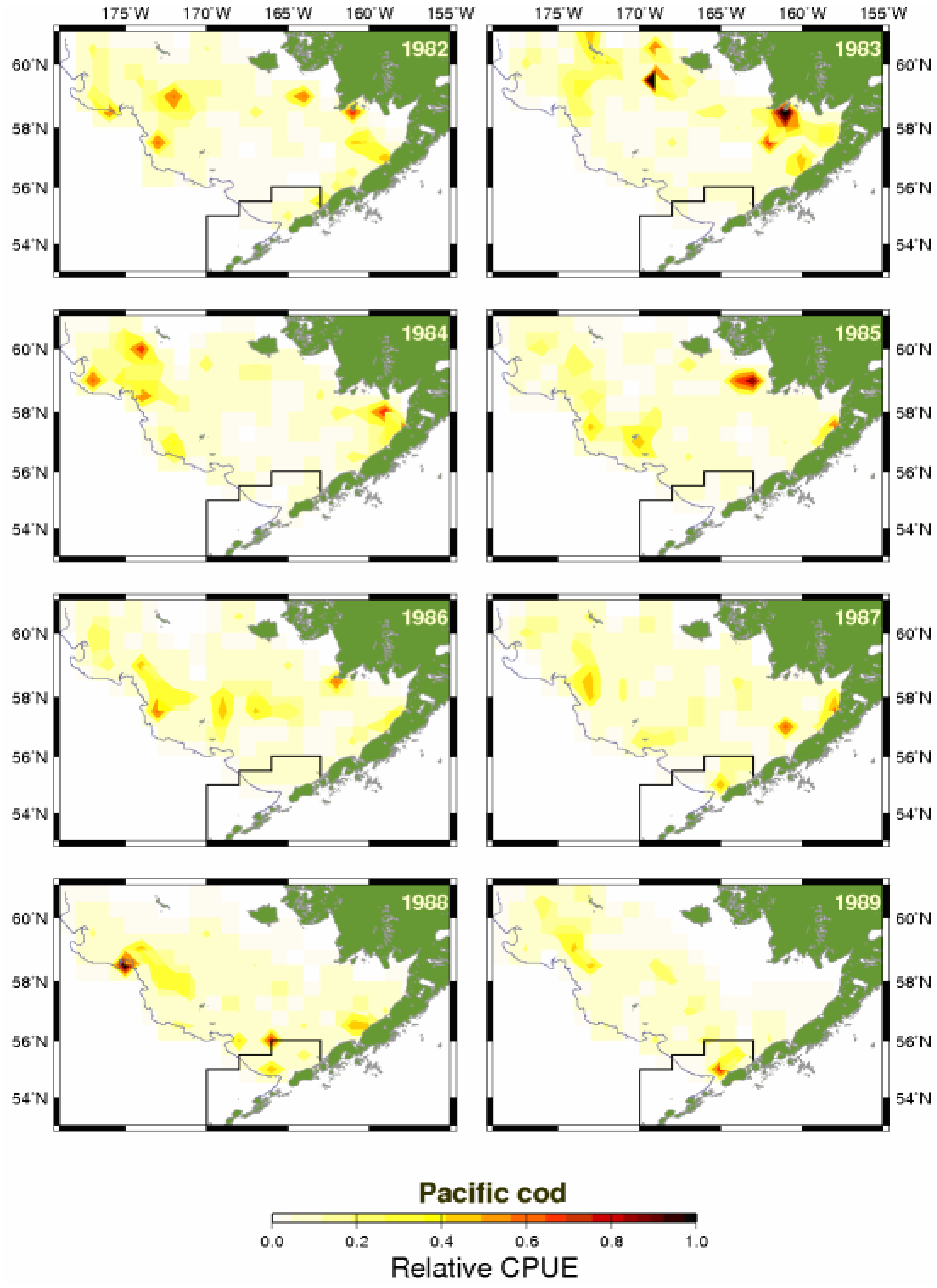


Figure 4.11 NMFS summer trawl survey gridded CPUE means by year for Pacific cod, 1982-1989. The Steller sea lion critical habitat area is indicated by the line.

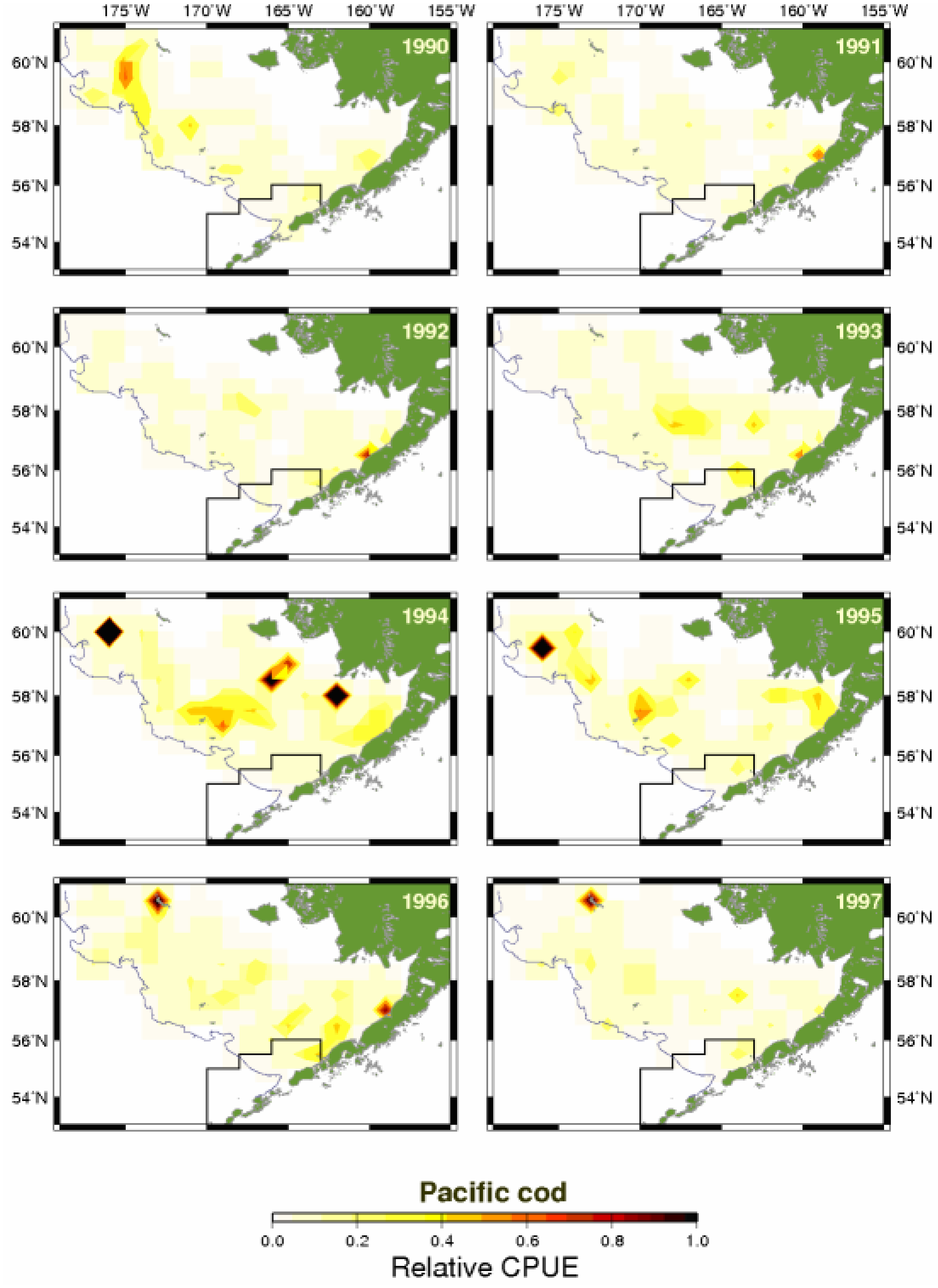


Figure 4.12 NMFS summer trawl survey gridded CPUE means by year for Pacific cod, 1990-1997. The Steller sea lion critical habitat area is indicated by the line.

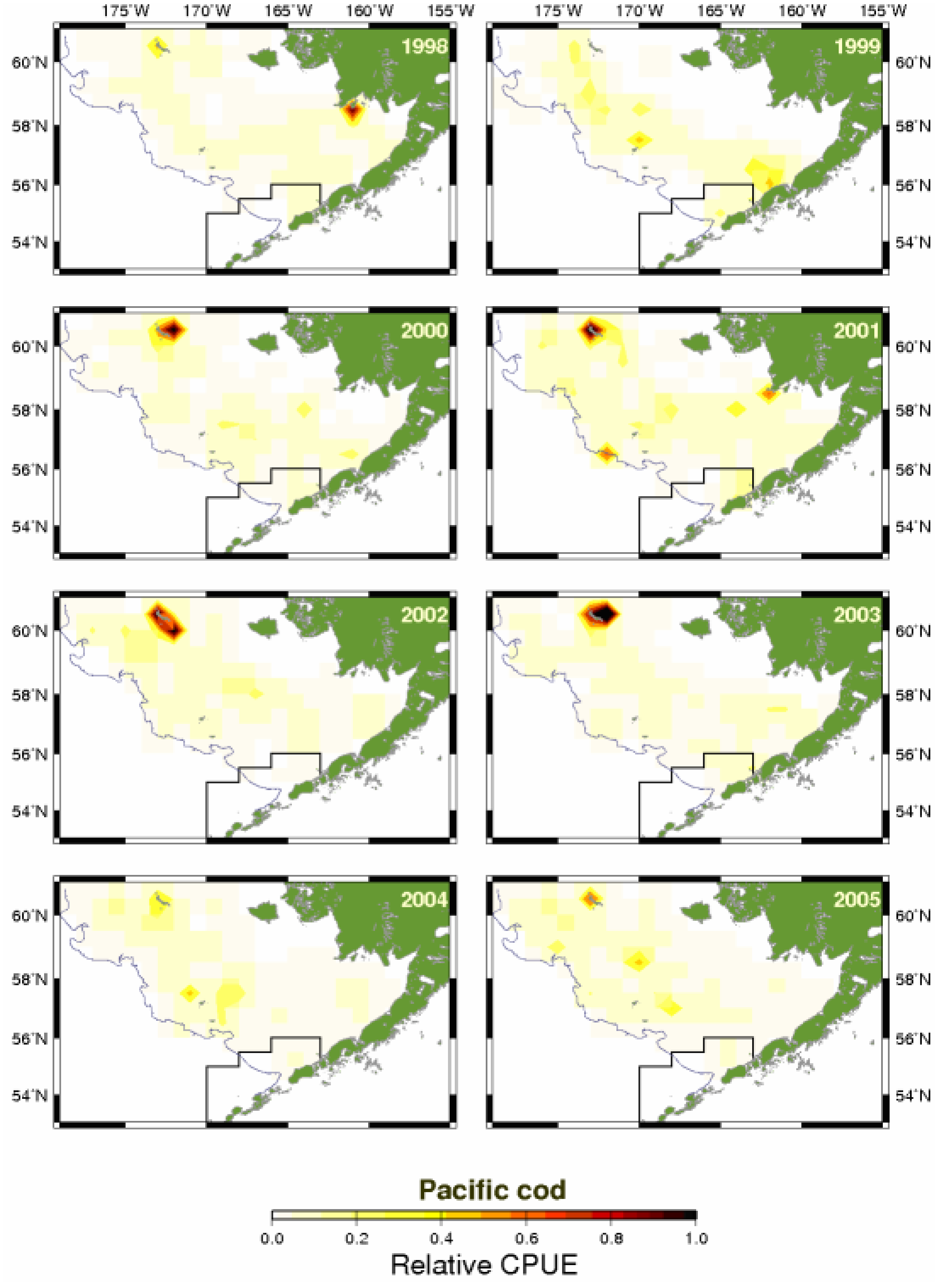


Figure 4.13 NMFS summer trawl survey gridded CPUE means by year for Pacific cod, 1996 - 2005. The Steller sea lion critical habitat area is indicated by the line.

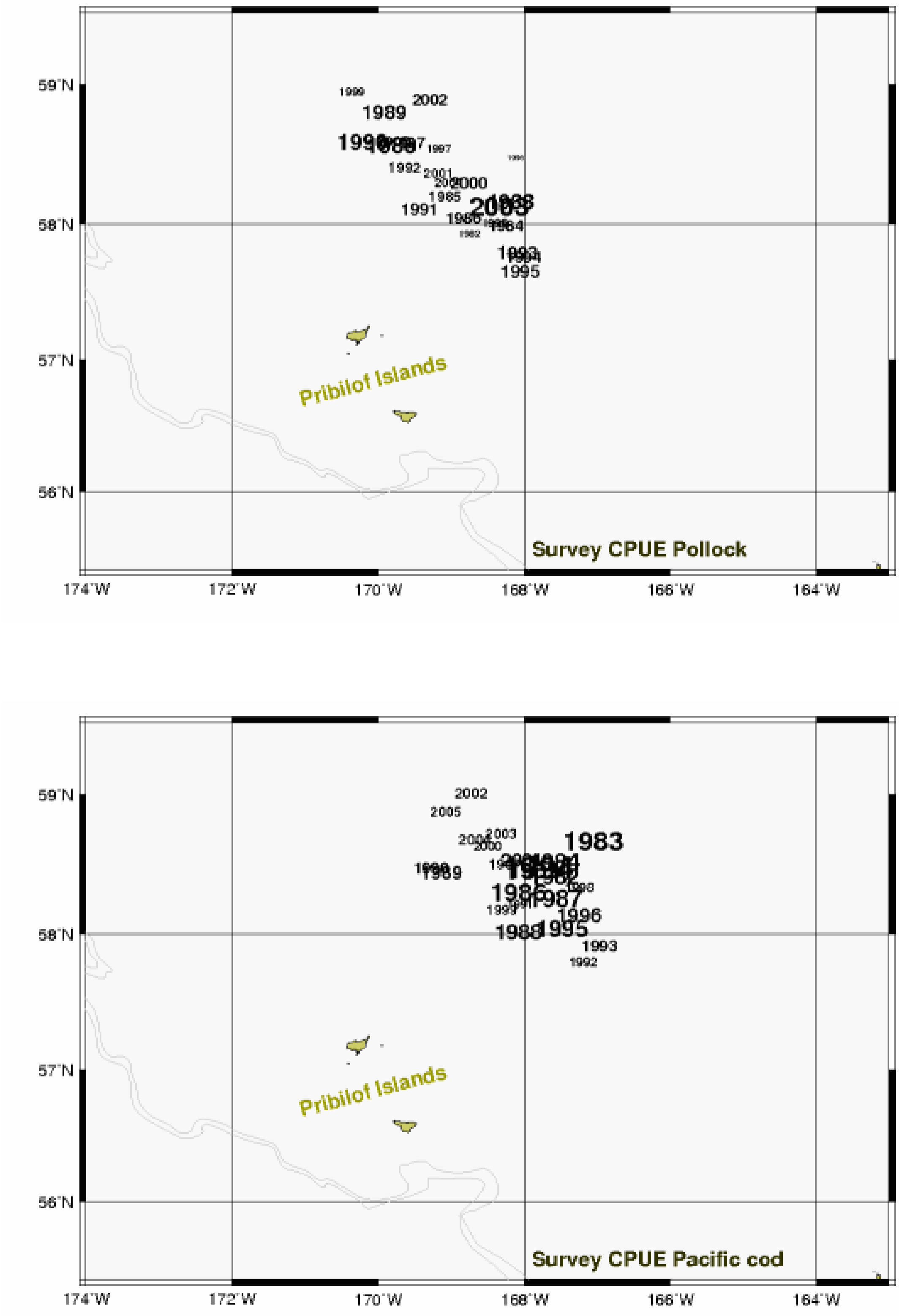


Figure 4.14 NMFS summer trawl survey mean CPUE weighted centers of abundance by year for pollock (top panel) and Pacific cod (bottom panel). The size of the year symbol is proportional to the mean CPUE for that year.

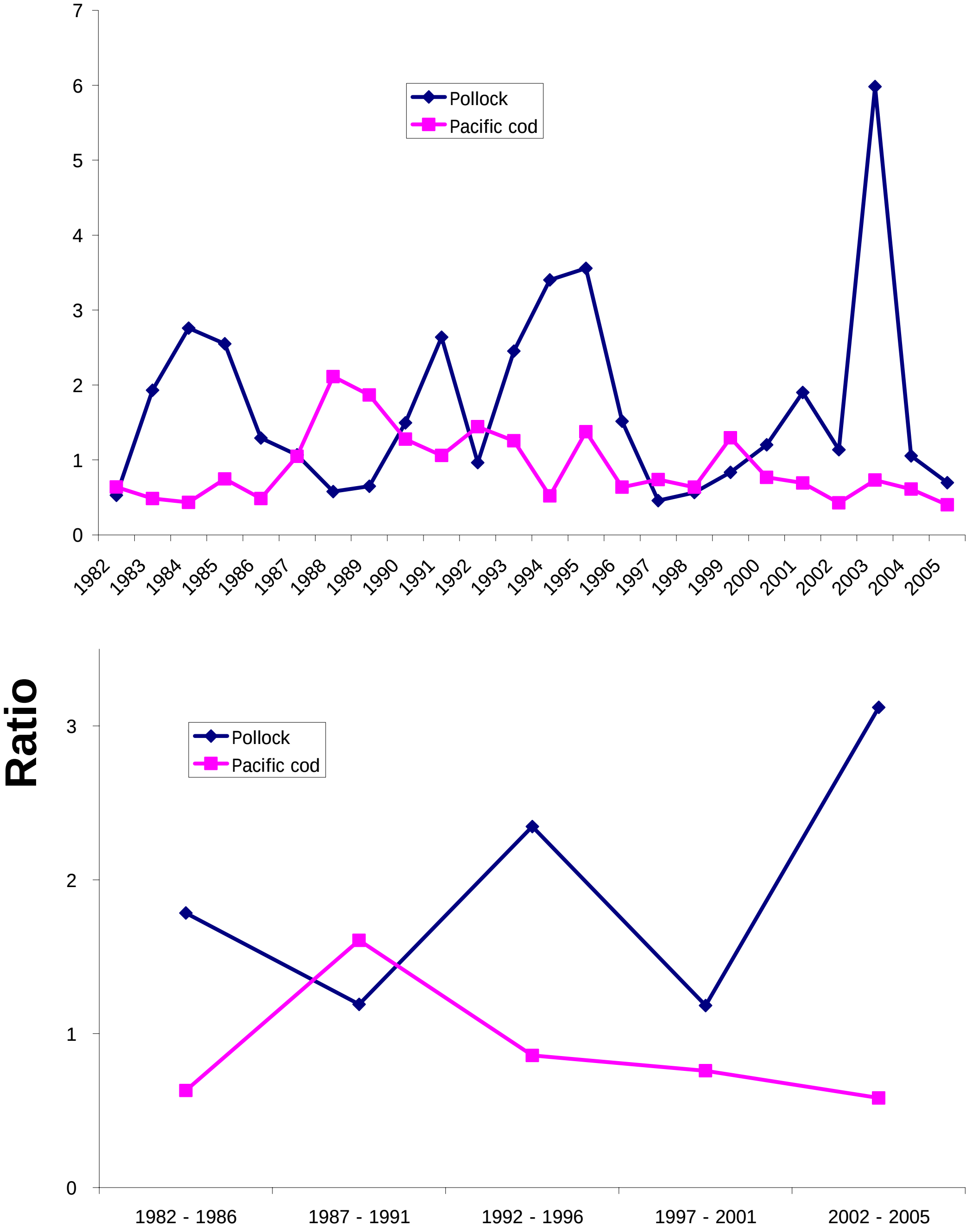


Figure 4.15 Ratio of average NMFS summer trawl survey CPUE **inside** Steller sea lion critical habitat over the average CPUE **outside** of critical habitat by year (top panel) and by 5-year periods (bottom panel) for pollock and Pacific cod.

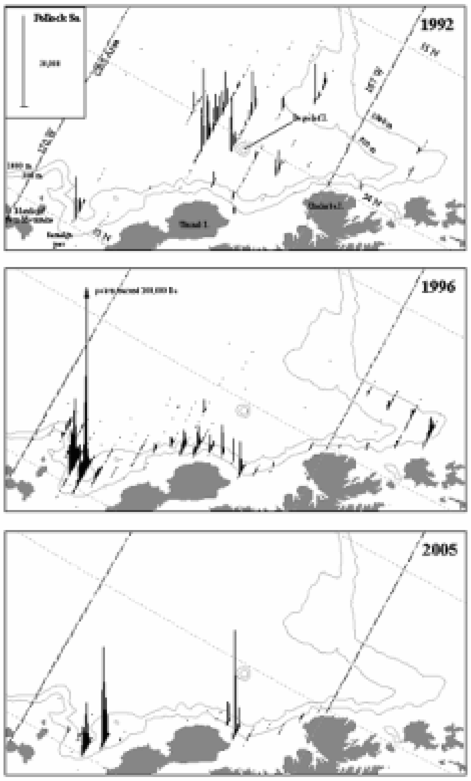


Figure 4.16 Bogoslof Island region pollock backscatter (sA) along tracklines during winter in three selected years. From Honkalehto *et al.* 2005.

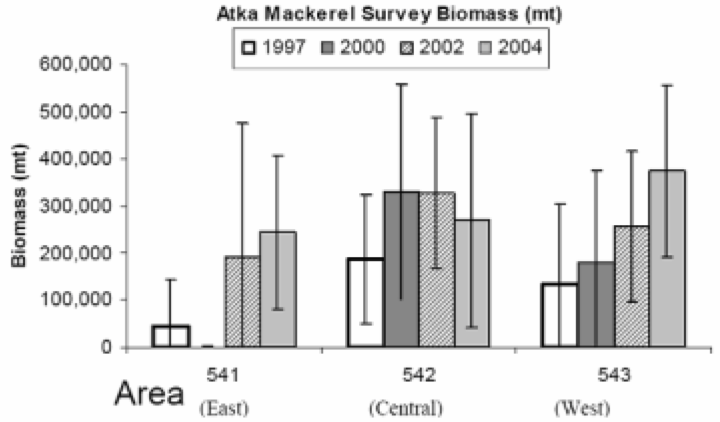


Figure 4.17 Atka mackerel Aleutian survey biomass estimates by area and survey year. Bars represent 95% confidence intervals based on sampling error (Lowe *et al.* 2005).

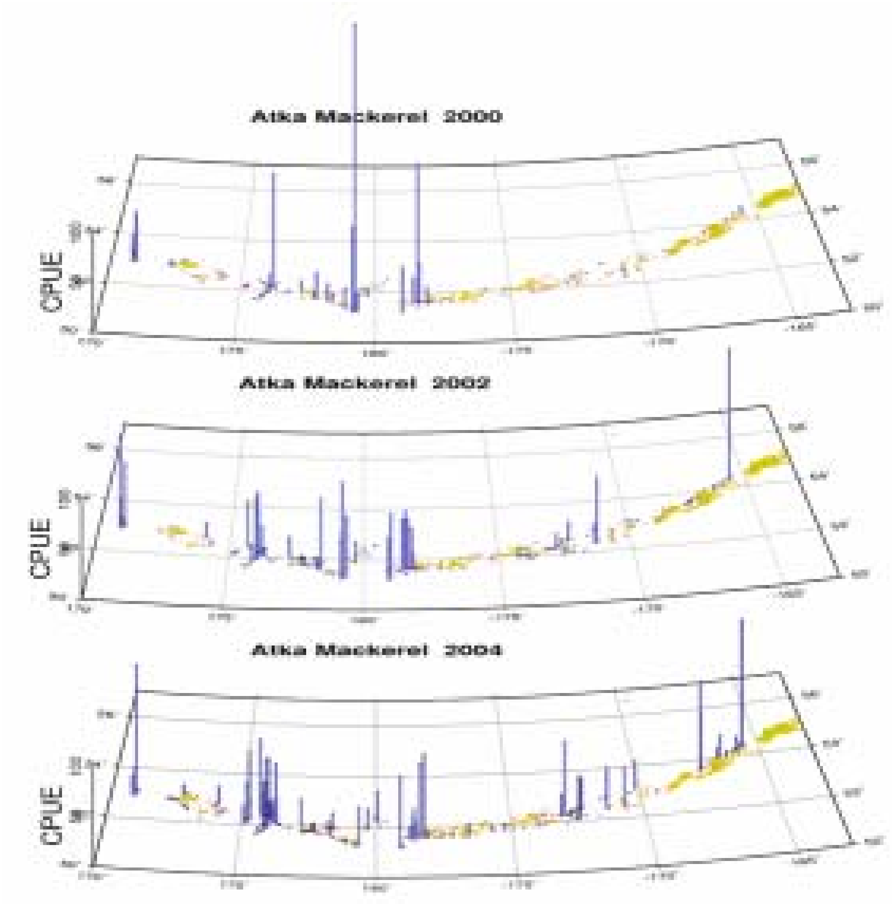


Figure 4.18 Atka mackerel Aleutian survey station CPUE (bar height), 2000-2004 (Lowe *et al.* 2005).

Figure 4.19 Pacific cod GOA survey station CPUE (bar height), 2001-2005.

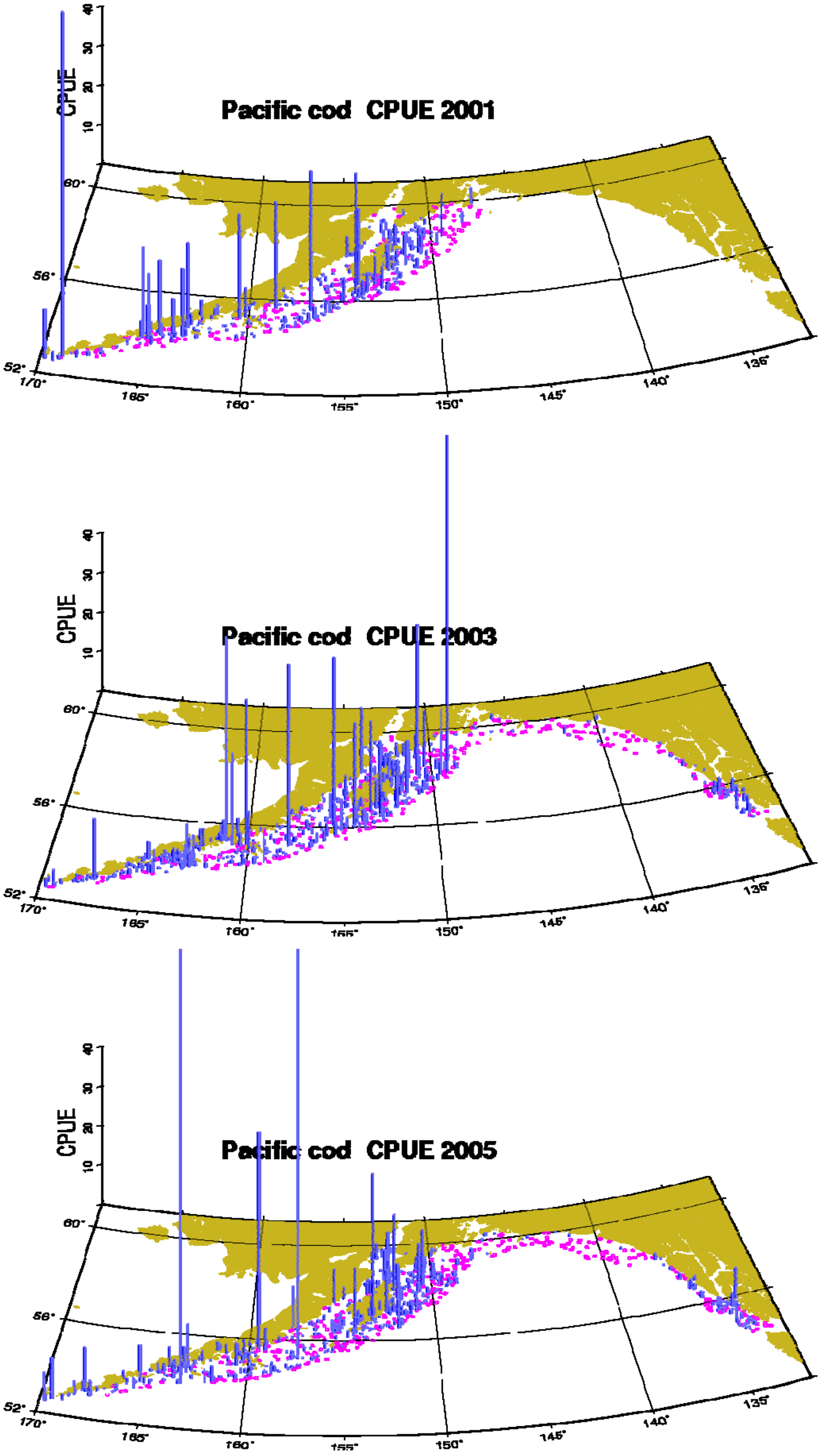
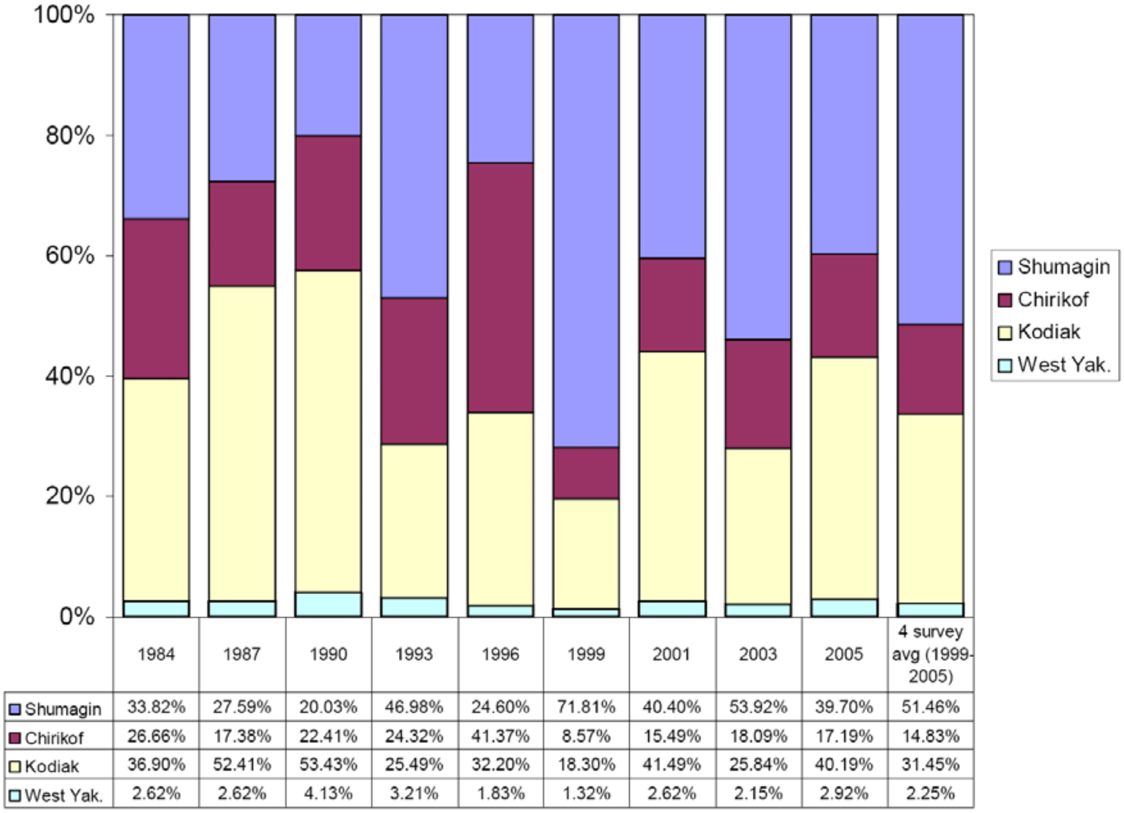


Figure 4.20 Percent distribution of Gulf of Alaska pollock biomass west of 140° W lon. in NMFS bottom trawl surveys in 1984-2005. The percent in West Yakutat in 1984, 1987, and 2001 was set equal to the mean percent in 1990-99 (from Dorn *et al.* 2005).



	1984	1987	1990	1993	1996	1999	2001	2003	2005	4 survey avg (1999-2005)
Shumagin	33.82%	27.59%	20.03%	46.98%	24.60%	71.81%	40.40%	53.92%	39.70%	51.46%
Chirikof	26.66%	17.38%	22.41%	24.32%	41.37%	8.57%	15.49%	18.09%	17.19%	14.83%
Kodiak	36.90%	52.41%	53.43%	25.49%	32.20%	18.30%	41.49%	25.84%	40.19%	31.45%
West Yak.	2.62%	2.62%	4.13%	3.21%	1.83%	1.32%	2.62%	2.15%	2.92%	2.25%

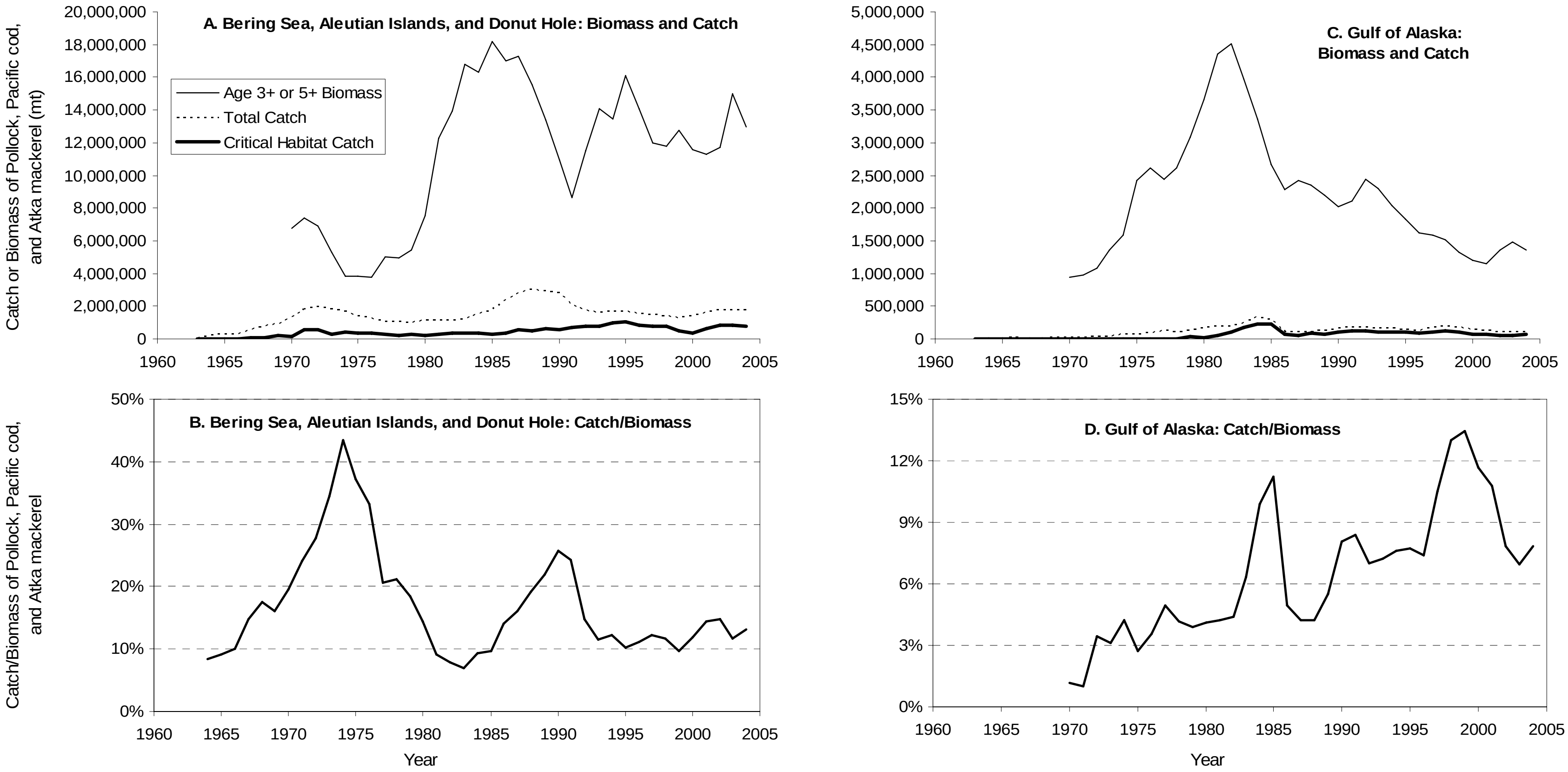
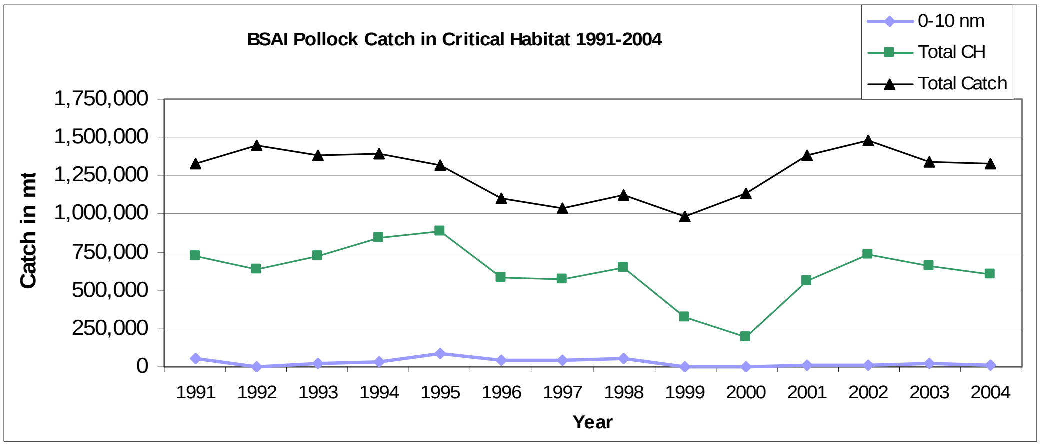
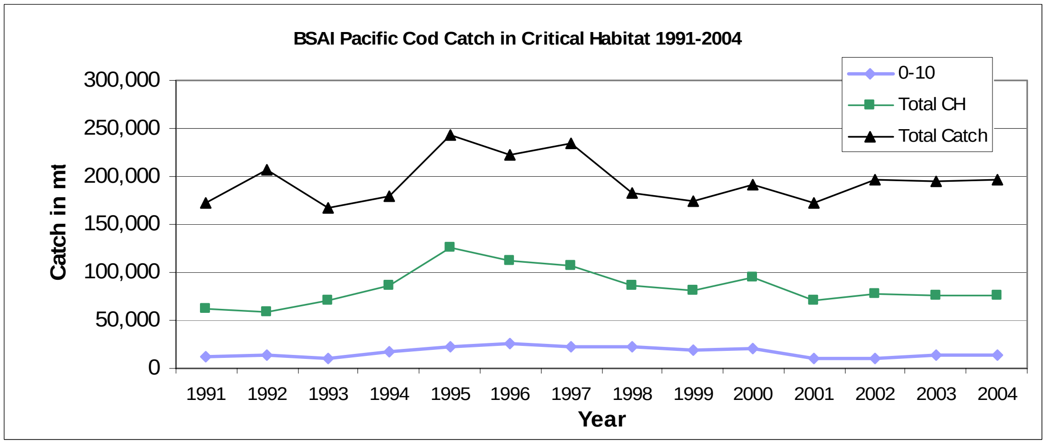


Figure 4.21 (A) Catch and estimated age 3+ biomass of walleye pollock, Pacific cod and Atka mackerel in the eastern Bering Sea, Aleutian Islands and "Donut Hole" (international waters of the central Bering Sea) from 1964-2004. Estimated biomass is from stock assessments and includes Bogoslof pollock biomass (Ianelli et al. 2005, Lowe et al. 2005, Thompson et al. 2005). (B) Annual harvest rates calculated from panel (A). (C). Catch and estimated age 3+ biomass of walleye pollock and Pacific cod in the Gulf of Alaska from 1964-2004. Estimated biomass is from stock assessments (Dorn et al. 2005, Thompson et al. 2005). Total catch as well as that portion removed from Steller sea lion critical habitat are shown. (D) Annual harvest rates for the GOA fisheries from panel (C).





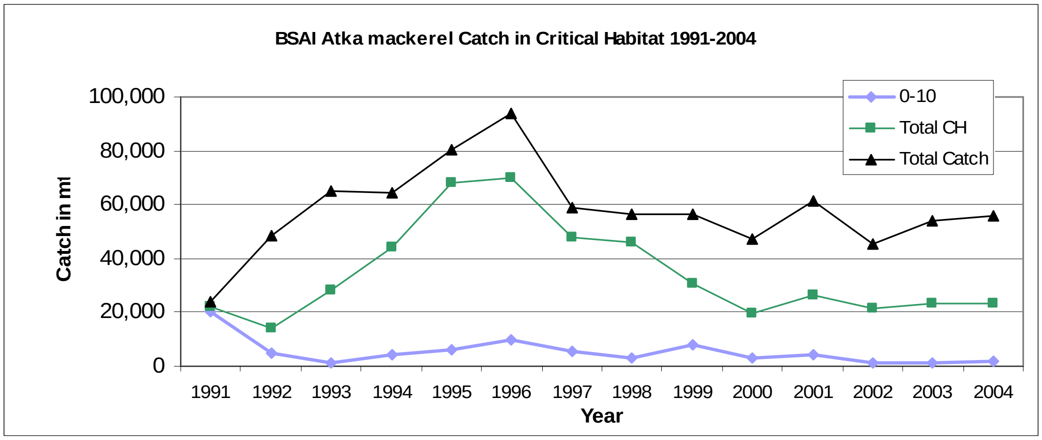
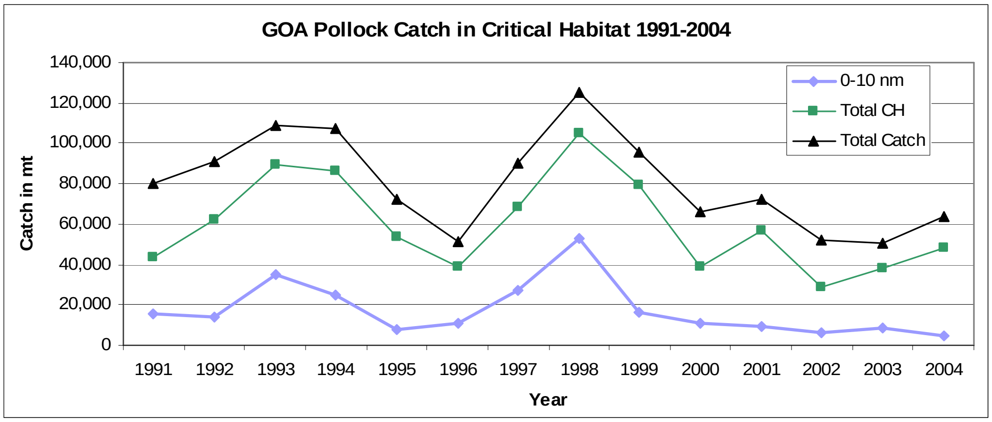


Figure 4.22 Catch of Pollock, Pacific cod, and Atka mackerel in critical habitat in the Bering Sea Aleutian Islands (BSAI) from 1991-2004.



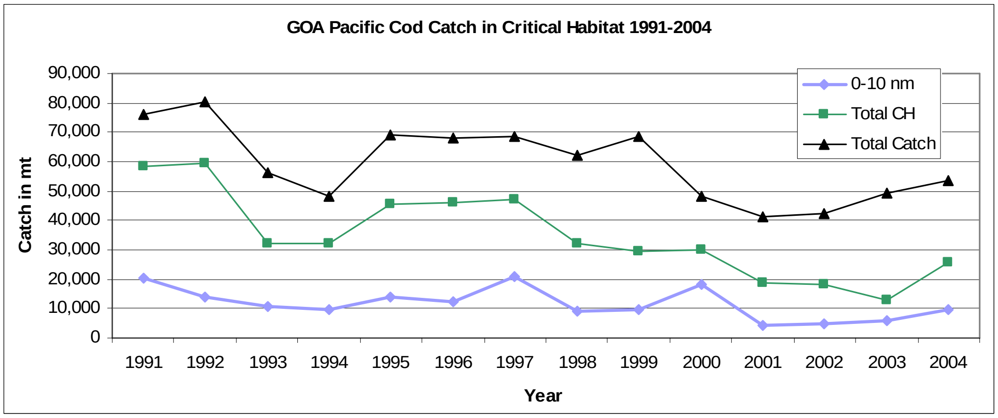
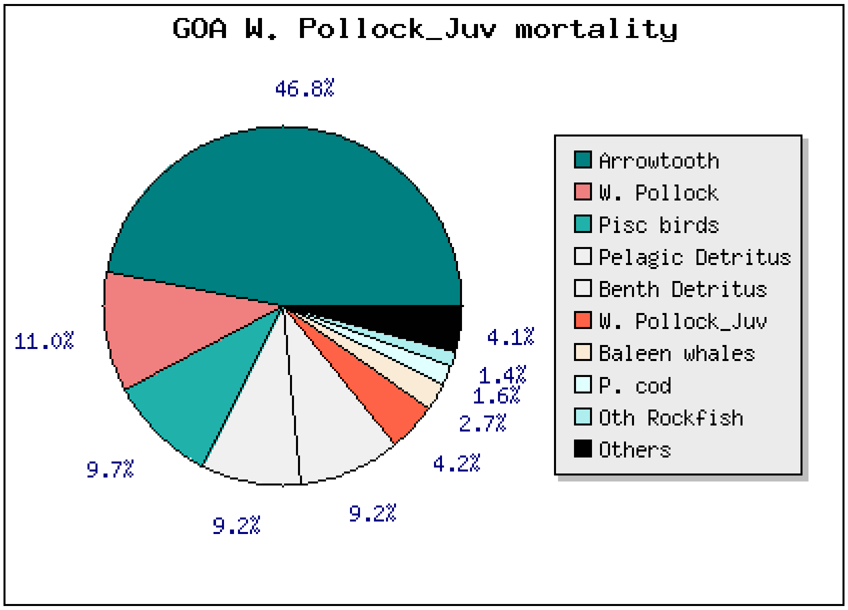
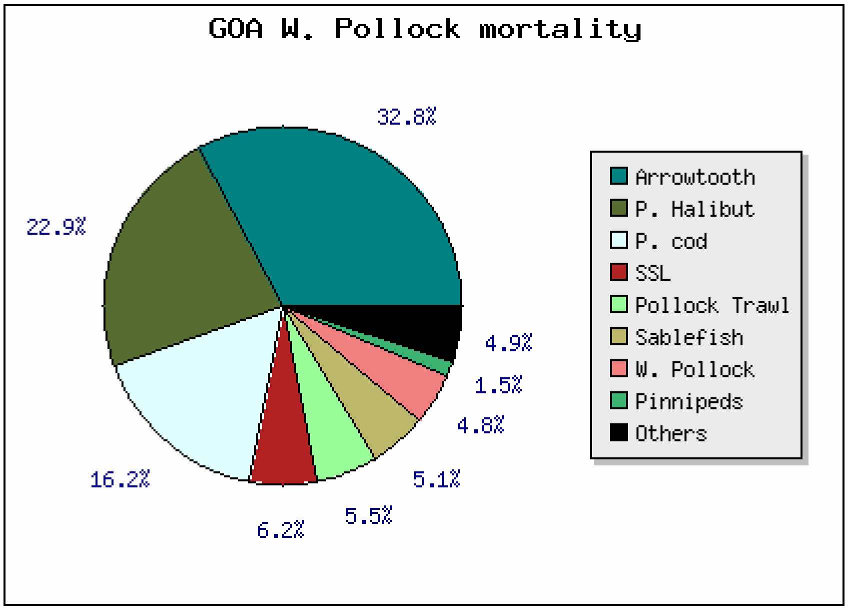


Figure 4.23 Catch of Pollock and Pacific cod in critical habitat in the Gulf of Alaska (GOA) from 1991-2004.

Figure 4.24 Sources of mortality for walleye pollock juveniles (top) and adults (bottom) from an ECOPATH model of the Gulf of Alaska. Pollock less than 20cm are considered juveniles.





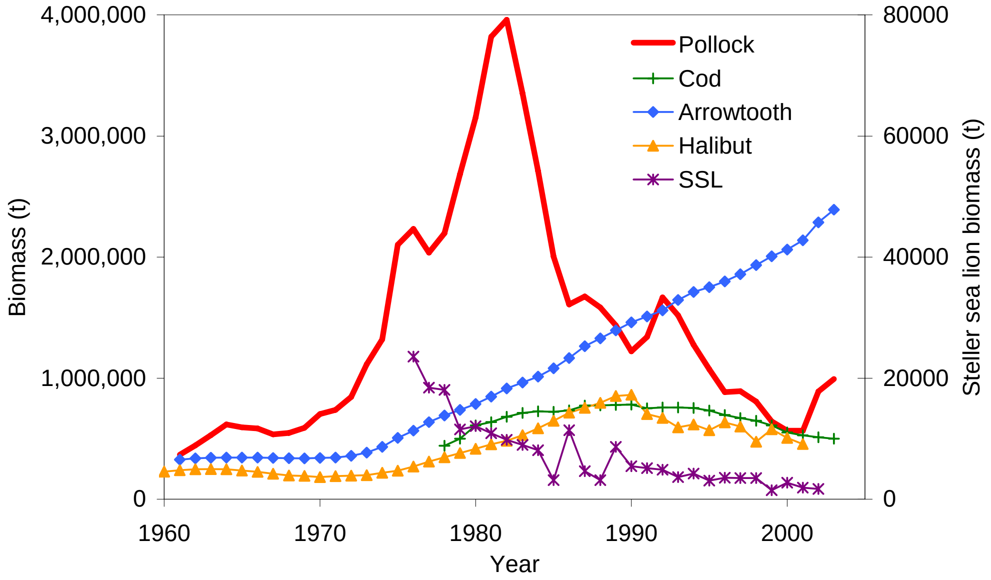


Figure 4.25 Historical trends in GOA walleye pollock, Pacific cod, Pacific halibut, arrowtooth flounder, and Steller Sea Lions, from stock assessment data.

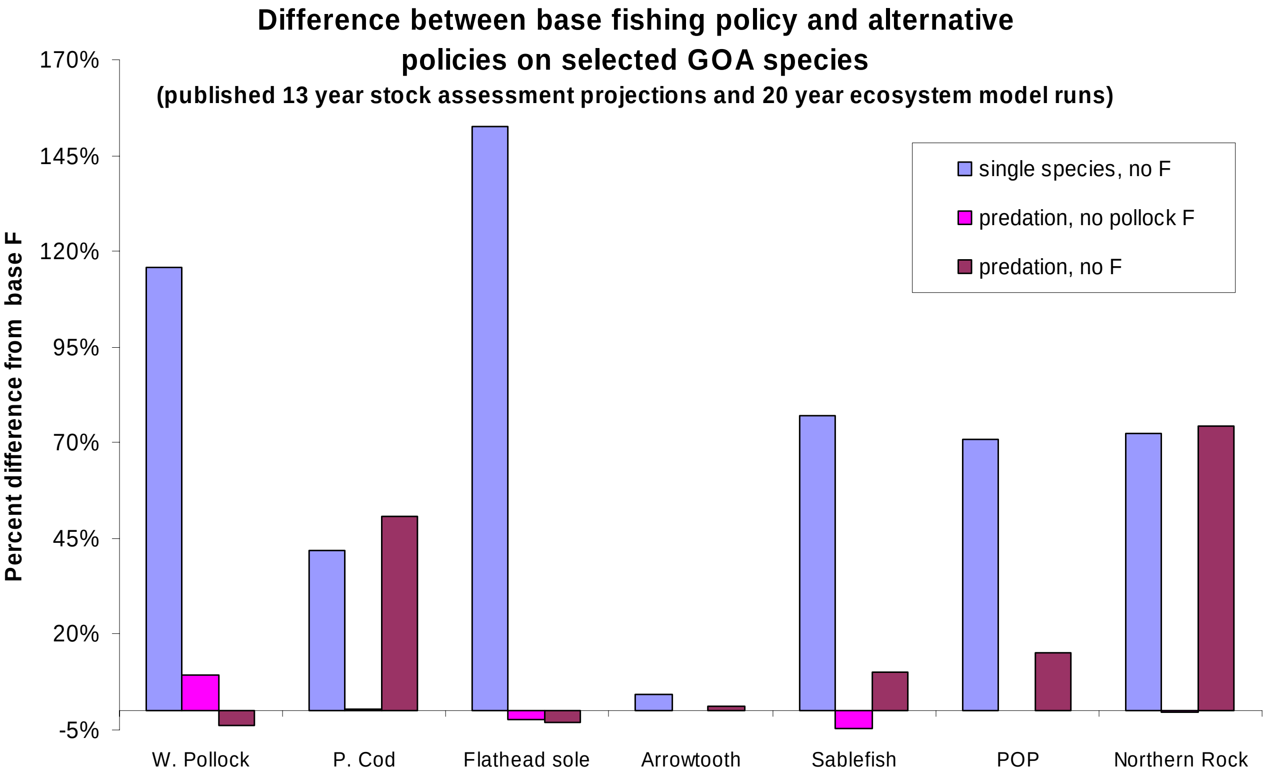


Figure 4.26 Comparison of potential outcomes of reducing or stopping pollock fishing on pollock biomass in the GOA given different assumptions of predation and which fisheries are stopped.

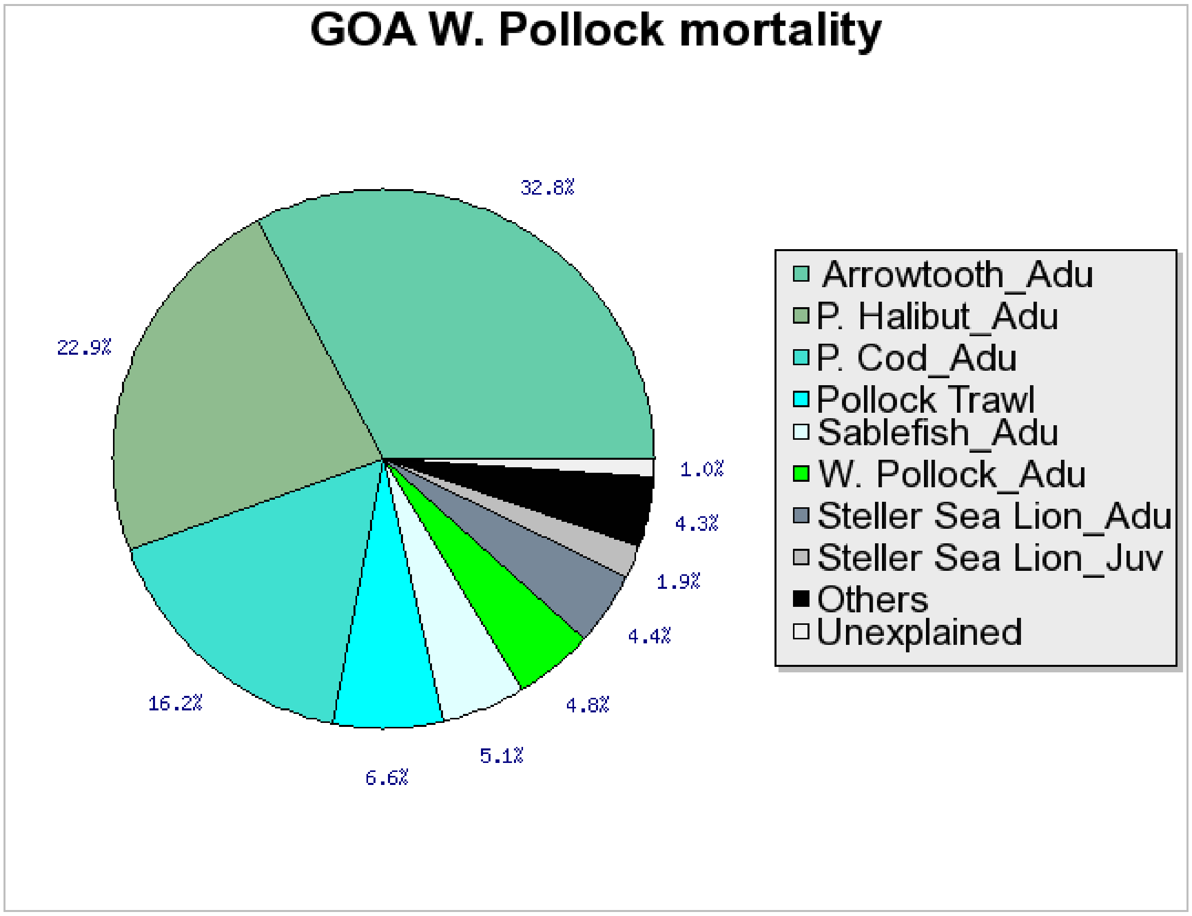


Figure 4.27 Pollock mortality sources as estimated by the GOA mass balance food web model (Gaichas 2006).

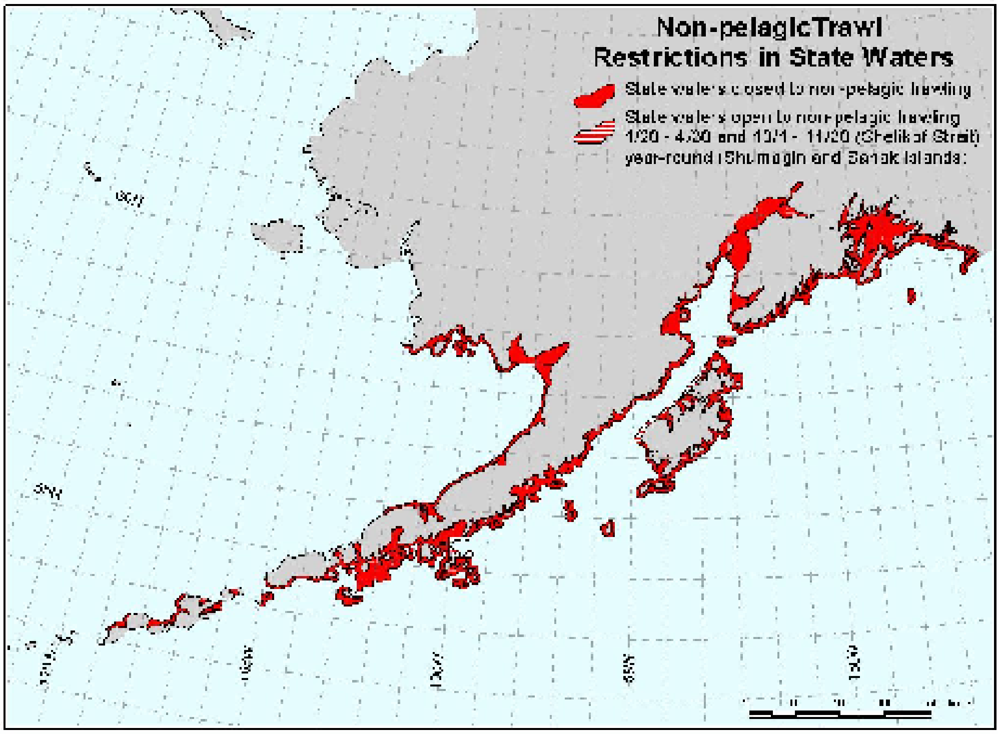


Figure 4.28 Non-pelagic trawl restrictions in state waters west of 144W.

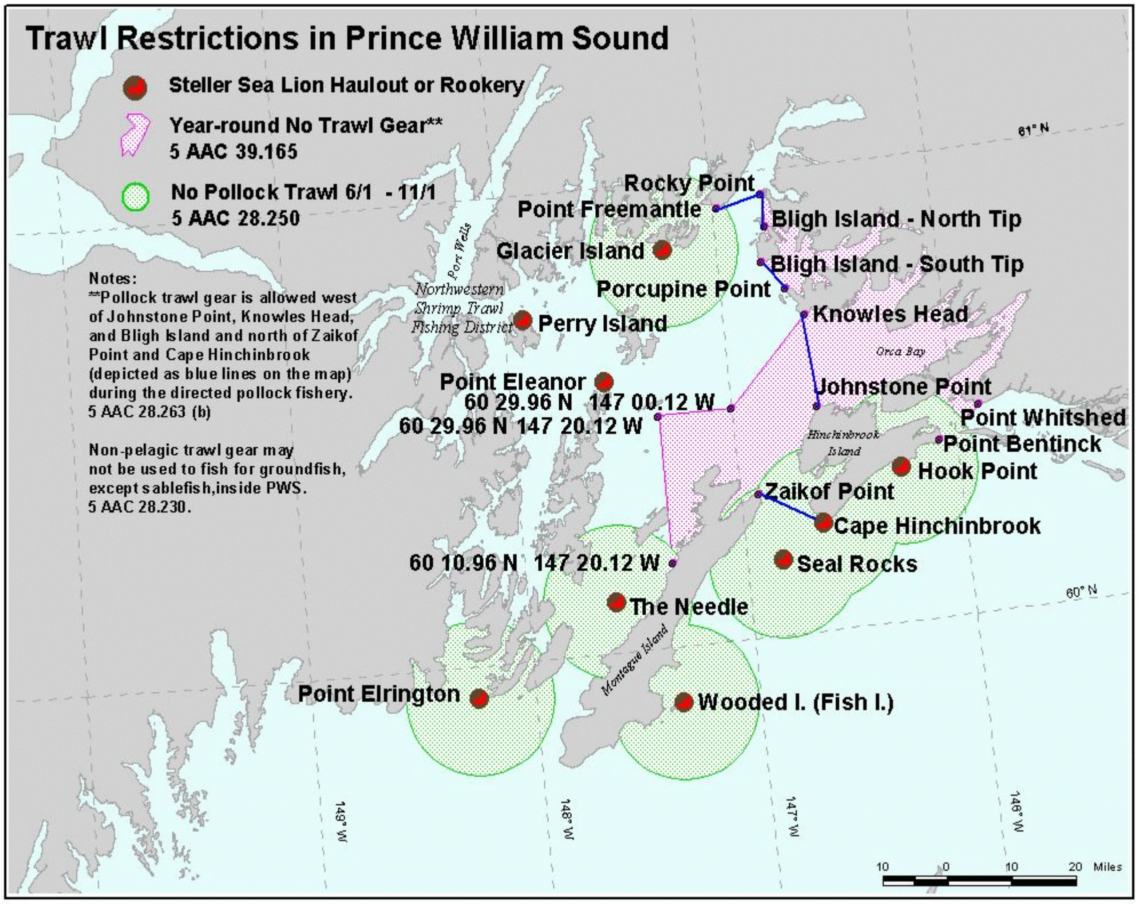


Figure 4.29 Year-round and seasonal trawl restrictions in Prince William Sound.

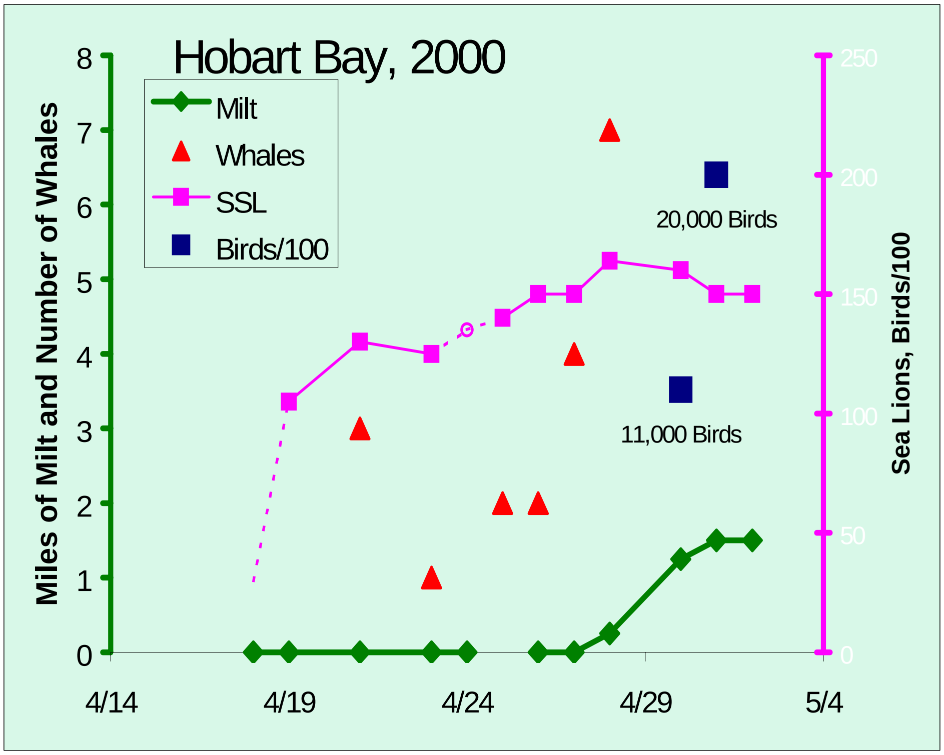


Figure 4.30 Response of marine mammals to herring in Hobart Bay, 2000.

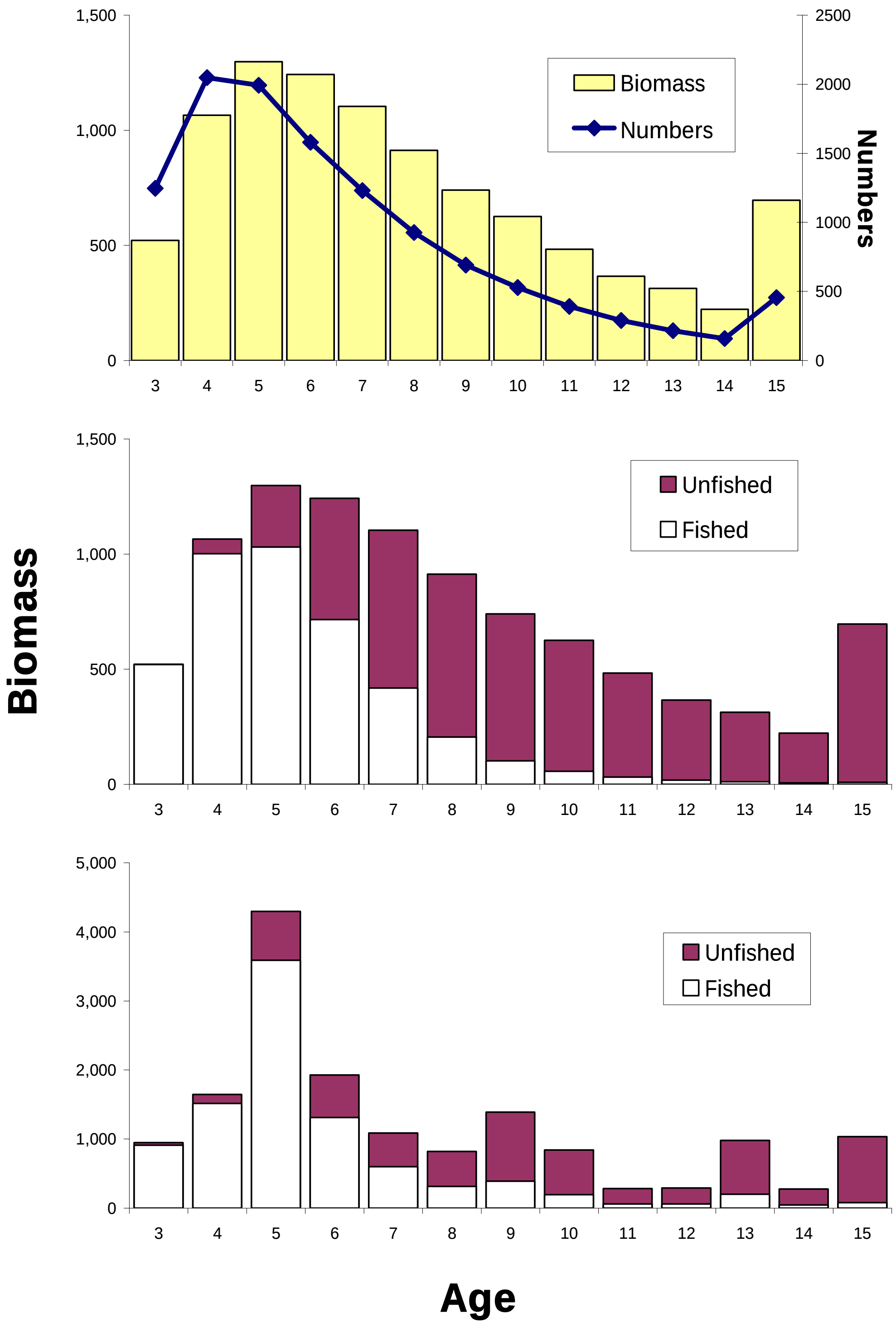


Figure 4.31 Theoretical unfished spawning biomass and numbers at age (top panel) based on EBS pollock stock dynamics. Theoretical spawning biomass at age under no fishing compared to expected spawning biomass at age under fishing at $F_{40\%}$ (middle panel). The bottom panel represents the 2005 spawning biomass at age (in white) compared to what would be expected had no fishing occurred (dark bars).

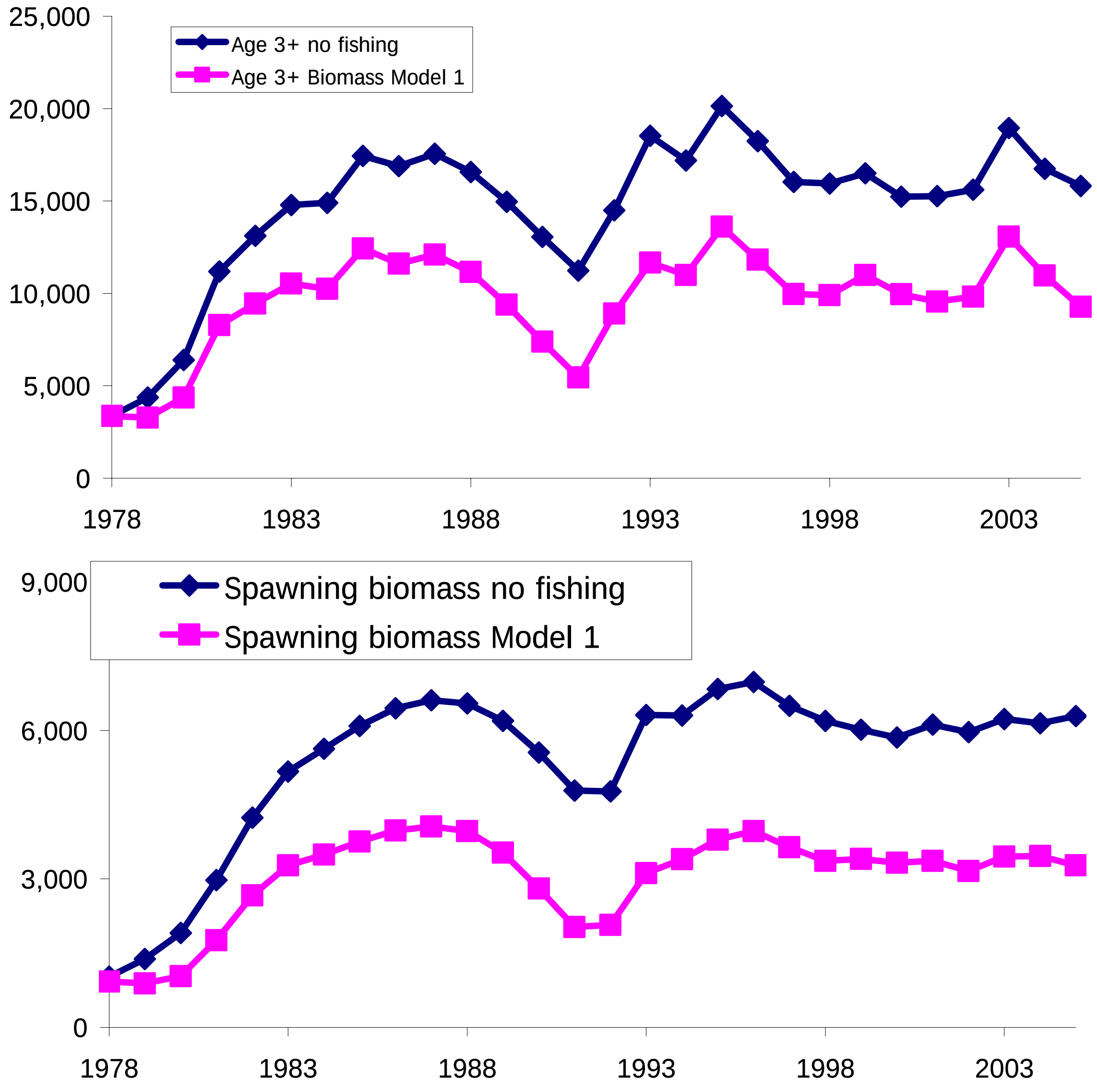
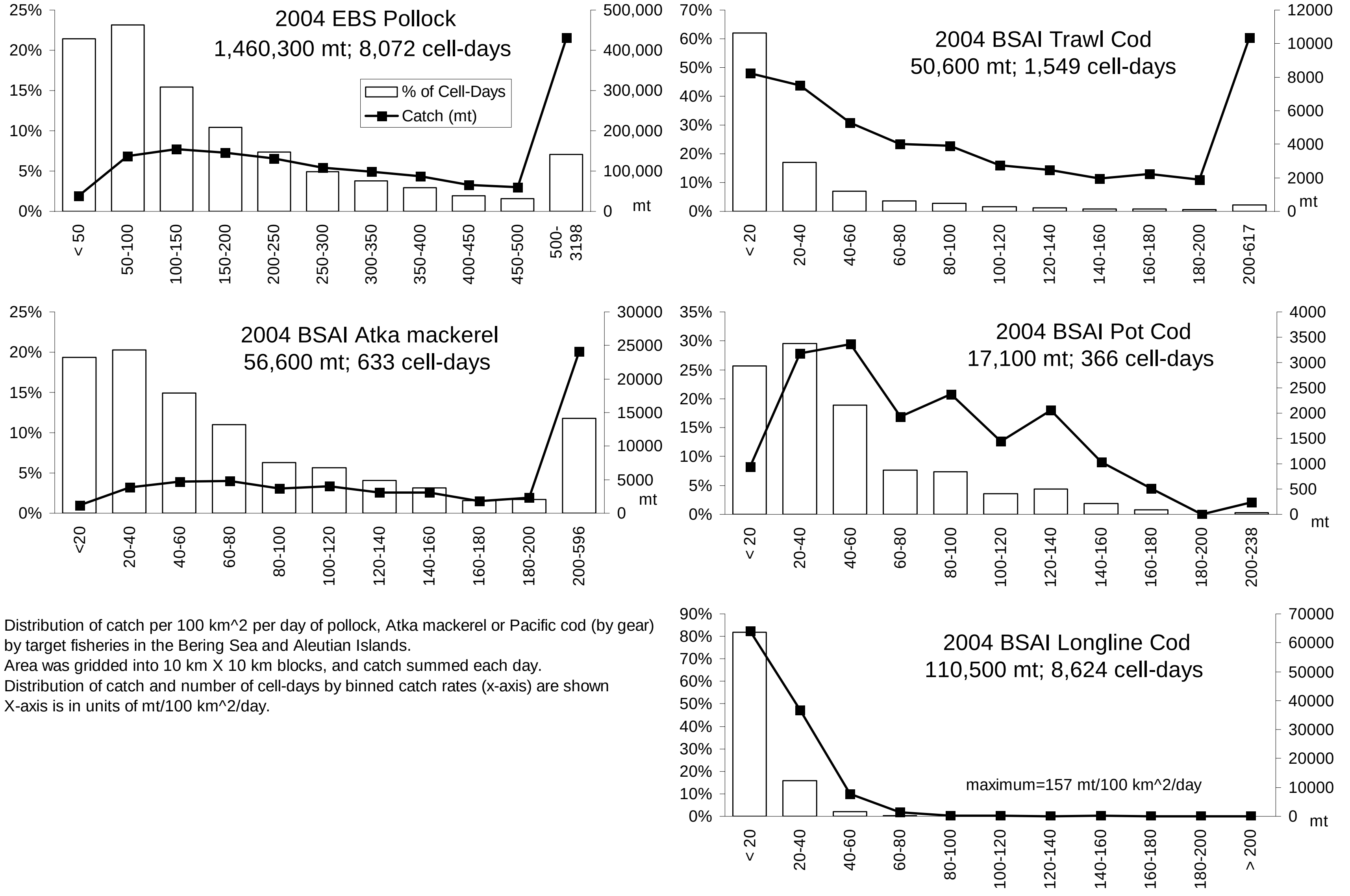


Figure 4.32 EBS pollock stock biomass estimates from Ianelli et al. (2005) compared to values had no fishing occurred during this period. Total age 3+ begin year biomass is shown in the top figure while the bottom shows female spawning biomass. The unfished stock size calculations assume the same natural mortality, mean weights-at-age, and estimates of numbers at age one as used in the assessment.

Table 4.33 Distribution of catch rates by gear type and cell.



Distribution of catch per 100 km^2 per day of pollock, Atka mackerel or Pacific cod (by gear) by target fisheries in the Bering Sea and Aleutian Islands.
Area was gridded into 10 km X 10 km blocks, and catch summed each day.
Distribution of catch and number of cell-days by binned catch rates (x-axis) are shown
X-axis is in units of mt/100 km^2/day.

Figure 4.34 Trends in western DPS Steller sea lion in Alaska overlayed with changes in vital rates and changes in conservation measures.