Endangered Species Act

Section 7 Consultation - Biological Opinion

Agency:	National Marine Fisheries Service
Activities Considered:	Authorization of BSAI groundfish fisheries based on TAC specifications recommended by the North Pacific Fishery Management Council for 2000; Authorization of GOA groundfish fisheries based on TAC specifications recommended by the North Pacific Fishery Management Council for 2000; and Authorization of both BSAI and GOA groundfish fisheries based on statutes, regulations, and management measures to implement the American Fisheries Act of 1998.
Consultation By:	NMFS - Alaska Region

Issued: ____

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1.0 PURPOSE AND CONSULTATION HISTORY

Section 7(a)(2) of the Endangered Species Act, 16 U.S.C. § 1531 et seq., 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 result in the destruction or adverse modification of 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 (FWS), depending upon the protected species that may be affected. For the actions described in this document, the action agency is NMFS’s Sustainable Fisheries Division. Due to the protected species involved, the consulting agency is also within NMFS; i.e., NMFS’s Office of Protected Resources. Section 7(b) of the Act requires that the consultation be summarized in a biological opinion detailing how the action may affect protected species.

The purpose of this opinion is to fulfill the section 7 requirements for consultation on (1) authorization of groundfish fisheries in 2000 under the Bering Sea and Aleutian Islands (BSAI) groundfish fishery management plan and based on 2000 TAC specifications, (2) authorization of groundfish fisheries in 2000 under the Gulf of Alaska (GOA) groundfish fishery management plan and based on 2000 TAC specifications, and (3) authorization of both BSAI and GOA groundfish fisheries based on the American Fisheries Act of 1998 (AFA). Section 7 regulations allow a formal consultation to encompass a number of similar actions within a given geographic area or a segment of a comprehensive plan (50 CFR 402.14). Consistent with this regulatory provision and for purposes of efficiency, these three actions are being summarized in a single biological opinion. Much of this opinion focuses on the potential effects of these fisheries on the endangered western population of Steller sea lions (*Eumetopias jubatus*).

The Steller sea lion was listed as threatened in 1990. After the Steller sea lions was originally listed, NMFS issued two biological opinions on the groundfish fisheries off Alaska. The first examined the effects of the Fishery Management Plan (FMP) for the BSAI Management Area, and the second examined the effects of the FMP for the GOA groundfish fisheries. Both concluded that the fisheries were not likely to jeopardize the continued existence and recovery of the Steller sea lion. Between 1991 and 1996, NMFS evaluated the effects of various changes to both the BSAI and GOA groundfish fisheries (Table 1), and collected additional data on the fisheries. In 1995, NMFS reinitiated formal consultation on the effects of the BSAI and the GOA groundfish fisheries as managed under the FMPs, and the proposed 1996 Total Allowable Catch (TAC) specifications on the Steller sea lion. Consultation was reinitiated because of (1) new information on the fisheries and their management, and (2) continued decline of the sea lion. On January 26, 1996, NMFS issued two new biological opinions, both of which concluded that the respective FMPs, the fisheries, and the 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.

On January 17, 1997, NMFS issued a Decision Memorandum on the 1997 BSAI and GOA TAC specifications and the need for section 7 consultation. NMFS determined that the groundfish fisheries were not likely to affect Steller sea lions in a way or to an extent not already considered in previous section 7 consultations on this fishery and reinitiation of formal consultation was not required. On September 10, 1997, NMFS issued an environmental assessment/regulatory impact review (EA/RIR) on a proposed action to remove blue and black rockfish species from the GOA FMP (amendment 46) and allow the State of Alaska to assume management of these species. NMFS also determined that this action (1) was not likely to adversely affect those threatened and endangered species under its jurisdiction, and (2) was also not likely to result in the adverse modification of any designated critical habitats of these species.

On February 26, 1998, NMFS determined that the 1996 biological opinion on the effects of the BSAI groundfish fishery on Steller sea lions remained valid for the 1998 BSAI groundfish fishery. On March 2, 1998, NMFS issued a biological opinion that concluded that the 1998 GOA groundfish fishery was not likely to jeopardize the continued existence and recovery of Steller sea lions or to adversely modify critical habitat. This opinion only addressed the 1998 fishery, not the continued implementation of the GOA FMP beyond 1998. In June 1998, the North Pacific Fishery Management Council (Council) adopted a precautionary approach in approving a regulatory amendment to reduce the probability of localized depletion of Atka mackerel in critical habitat for Steller sea lions. The amendment would allocate the Atka mackerel TAC on a seasonal basis and shift the spatial allocation of the TAC over the next four years until 40% is taken within critical habitat and 60% is taken outside of critical habitat. In June 1998, the Council also approved an FMP amendment to alter the allocation of BSAI pollock to inshore and offshore sectors of the fishery from 35%:65% (respectively) to 39%:61% (respectively). On October 21, 1998, the President signed into law the American Fisheries Act (AFA), which changed the allocation scheme for pollock in the BSAI beginning in 1999.

On December 3, 1998, NMFS completed a biological opinion on the BSAI Atka mackerel fishery and the BSAI and GOA pollock fisheries. This opinion concluded that the pollock fisheries were likely to jeopardize the continued existence of the endangered western population of Steller sea lions and adversely modify its designated critical habitat. On December 13, 1998, the Council recommended a set of management measures for the pollock fisheries to avoid jeopardy and adverse modification. On December 16, those measures were incorporated (with some modification) into the December 3rd opinion and, on January 22, 1999, the measures were published in an emergency rule for the 1999 pollock fisheries. The emergency rule extended only until July 19, 1999. Therefore, at its June 1999 meeting, the Council made further recommendations for the later half of 1999 (extension of the emergency rule) and for 2000 and beyond (permanent rule). The December 3, 1998 opinion (as modified on December 16, 1998) was challenged in the United States District Court for the Western District of Washington.[1] On July 9, 1999, the Court upheld the findings of jeopardy for the pollock fisheries, but found the reasonable and prudent alternatives in the opinion to be "arbitrary and capricious" for lack of sufficient explanation. The Court remanded the opinion back to NMFS for preparation of Revised Final Reasonable and Prudent Alternatives (RFRPAs) with appropriate analysis and explanation. On November 8, 1999, both plaintiffs and intervenors filed notice with the Court of further claims against the RFRPAs.

In addition to the December 3, 1998, biological opinion on the pollock and Atka mackerel fisheries, a second opinion was completed December 22, 1998 on authorization of the BSAI and GOA groundfish fisheries based on the 1999 TAC specifications for those fisheries. That opinion concluded that the authorization did not jeopardize the continued existence of any listed species or destroy or adversely modify designated critical habitat. The conclusion was based, in part, on the implementation of reasonable and prudent alternatives for the BSAI and GOA pollock fisheries. The plaintiffs have filed a claim in Court challenging this conclusion.

[1] Plaintiffs are Greenpeace, the American Oceans Campaign, and the Sierra Club. Intervenors are the Aleutians East Borough, Westward Seafoods, Inc., Wards Cove Packaging Company, North Pacific Processors Inc., Nelbro Packaging Company, Unisea Inc., Peter Pan Seafoods Inc., Kodiak Salmon Packers Inc., Alyeska Seafoods Inc., Western Alaska Fisheries Inc., Kanaway Seafoods Inc., Royal Viking Inc., Morning Star LP, Great Pacific Limited Partnership, Alaskan Command Company, Pacific Knight LLC, the city of Unalaska, United Catcher Boats, and At-Sea Processors Association.

2.0 DESCRIPTION OF THE PROPOSED ACTIONS

The purpose of this section is to describe the proposed actions that are the subject of this consultation and opinion and thereby provide the background information needed to analyze their potential effects on protected species and, in particular, the western population of Steller sea lions. The three actions being considered in this Biological Opinion are:

- *Authorization of Bering Sea/Aleutian Islands (BSAI) groundfish fisheries based on total allowable catch (TAC) specifications* recommended by the North Pacific Fishery Management Council (Council) for 2000. Consultation on these fisheries because of new information on TAC specifications.

- *Authorization of Gulf of Alaska (GOA) groundfish fisheries based on TAC specifications* recommended by the Council for 2000. Consultation on these fisheries because of new information on TAC specifications.

- *Authorization of BSAI and GOA groundfish fisheries based on implementation of the American Fisheries Act (AFA) of 1998.* Consultation was reinitiated because of changes in fisheries management occurring or predicted to occur through implementation of the provisions of this act.

These two actions are separate actions that would be taken by NMFS and are each separately subject to consultation pursuant to section 7 of the ESA. They have been grouped into this single Biological Opinion for efficiency and in compliance with the regulatory language of section 7, which allows NMFS to group a number of similar, individual actions within a given geographic area or segment of a comprehensive plan (50 CFR 402.14(b)).

2.1 Derivation of TAC specifications

Groundfish target species fall under the umbrella of Federal fisheries management or, by omission, not under management according to the approved Fishery Management Plans (FMPs) and amendments thereto (North Pacific Fishery Management Council 1994, 1995). For groundfish fisheries managed under the BSAI and GOA FMPs, the Council may split or combine target species groups for purposes of establishing individual TAC specifications based on commercial importance of a species or species group and the sufficiency of available biological information to manage a species or species group on its own biological merits.

The status of each species or species group is assessed annually based upon the best available scientific information. Assessments are prepared by NMFS scientists, and compiled by the plan teams into annual Stock Assessment and Fishery Evaluation (SAFE) reports. The SAFE reports contain information on historical catch trends, biomass estimates, preliminary estimates of Acceptable Biological Catch (ABC), assessments of harvest impacts and alternative harvesting strategies. Most of the assessments are based primarily on trawl and longline surveys conducted by NMFS. Data are also collected from commercial fisheries through the observer program. In addition to determining total catch of each species, these data provide information on removal of fish by age and improve estimates of stock structure and year-class strength (Witherell and Ianelli 1997).

TAC specifications are developed as part of an overall process that sets the ABC and Overfishing Levels (OFL) for each fished stock, as described in the groundfish FMPs. These terms are defined as follows:

> Acceptable Biological Catch is 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 fishing mortality rate used to calculate ABC is capped by an Overfishing Level.

Overfishing is defined as any amount of fishing in excess of a prescribed maximum allowable rate. This maximum allowable rate is prescribed through a set of six tiers which are listed below in descending order of preference, corresponding to descending order of information availability. The Council's Scientific and Statistical Committee (SSC) has final authority for determining whether a given item of information is "reliable" for the purpose of this definition, and may use either objective or subjective criteria in making such determinations. 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 the SSC may establish a different value for a specific stock or stock complex as merited 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 per recruit (SPR) equal to X% of the equilibrium level of spawning per recruit in the absence of any fishing. If information to characterize the entire maturity schedule of a species is not available, sufficient, or reliable, then the SSC may choose to view SPR calculations based on a knife-edge maturity assumption. For tier (3), the term $B_{40\%}$ refers to the long-term average biomass that would be expected under average recruitment and $F=F_{40\%}$.

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} \# m_H , the harmonic mean of the pdf
   - 1b) Stock status: $a < B/B_{MSY}$ \# 1
     - $F_{OFL} = m_A \times (B/B_{MSY} - a)/(1 - a)$
     - F_{ABC} \# $m_H \times (B/B_{MSY} - a)/(1 - a)$
   - 1c) Stock status: B/B_{MSY} \# a
     - $F_{OFL} = 0$
     - $F_{ABC} = 0$
2) Information available: Reliable point estimates of B, B_{MSY} , F_{MSY} , $F_{30\%}$, and $F_{40\%}$.
   - 2a) Stock status: $B/B_{MSY} > 1$
     - $F_{OFL} = F_{MSY} \times (F_{30\%} / F_{40\%})$
     - F_{ABC} \# F_{MSY}
   - 2b) Stock status: $a < B/B_{MSY}$ \# 1
     - $F_{OFL} = F_{MSY} \times (F_{30\%} / F_{40\%}) \times (B/B_{MSY} - a)/(1 - a)$
     - F_{ABC} \# $F_{MSY} \times (B/B_{MSY} - a)/(1 - a)$
   - 2c) Stock status: B/B_{MSY} \# a
     - $F_{OFL} = 0$
     - $F_{ABC} = 0$
3) Information available: Reliable point estimates of B, $B_{40\%}$, $F_{30\%}$, and $F_{40\%}$.
   - 3a) Stock status: $B/B_{40\%} > 1$
     - $F_{OFL} = F_{30\%}$
     - F_{ABC} \# $F_{40\%}$
   - 3b) Stock status: $a < B/B_{40\%}$ \# 1
     - $F_{OFL} = F_{30\%} \times (B/B_{40\%} - a)/(1 - a)$
     - F_{ABC} \# $F_{40\%} \times (B/B_{40\%} - a)/(1 - a)$
   - 3c) Stock status: $B/B_{40\%}$ \# a
     - $F^{OFL} = 0$
     - $F_{ABC} = 0$
4) Information available: Reliable point estimates of B, $F_{30\%}$, and $F_{40\%}$.
     - $F_{OFL} = F_{30\%}$
     - F_{ABC} \# $F_{40\%}$

5) Information available: Reliable point estimates of B and natural mortality rate M.

F_{OFL} = M

F_{ABC} # 0.75 × M

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

If sufficient information is available and if the stock is healthy, then harvest recommendations are based on the exploitation rate corresponding to the fishing mortality rate that provides maximum sustainable yield (F_{MSY}). However, estimation of F_{MSY} is often difficult because it is influenced by unknown density-dependent mechanisms. In an age-structured assessment, for example, estimation of F_{MSY} requires a reliable estimate of the stock-recruitment relationship. Surrogate exploitation rates were developed with the intent of achieving the same practical effect as fishing at the F_{MSY} level, that is, providing a yield close to MSY with a low probability of reducing the stock to dangerously low levels (Clark 1991, 1993). The surrogate rates are determined entirely by life history parameters, and based upon levels of spawning biomass per recruit. Clark (1993) suggested that maintaining a target level of spawning biomass per recruit around 40% of the equilibrium unfished level substantially reduced the frequency of episodes of low spawning biomass (which he defined as less than 20% of the equilibrium unfished level), given the presence of random variation in recruitment. The fishing mortality rate that reduces the spawning biomass per recruit to about 40% of the equilibrium unfished level is denoted $F_{40\%}$ (Clark 1993).

The analysis from which the $F_{40\%}$ exploitation rate was derived was an expansion of an earlier analysis (Clark 1991) that considered a range of life history parameters typical of North Pacific groundfish stocks and a set of spawner-recruit relationships that encompassed a reasonable range of density dependence. Deterministic yield computations over the range of life history parameters and spawner-recruit relationships showed that fishing at the rate that reduced spawning biomass to 35% of the equilibrium unfished value ($F_{35\%}$) was a robust strategy. Results further showed that yield would be at least 75% of MSY. Clark (1993) showed through stochastic trials that, in the presence of random variation in recruitment, the target level of spawning biomass per recruit was slightly higher, around 40%. This was particularly evident when the recruitment deviations had a high degree of serial correlation. Clark (1993) notes that fishing at rates higher than $F_{35\%}$ runs the risk of fishing less resilient stocks down to very low levels and consequently low yields.

Tiers (1-2) also rely on estimation of F_{MSY} to determine the OFL. Thompson (1993) recommended 30% of the unfished level of spawning biomass per recruit ($F_{30\%}$) as a minimum sustainable level. In cases where insufficient information exists to estimate F_{MSY}, but sufficient life history information to estimate spawning biomass per recruit levels, $F_{30\%}$ is the OFL. In cases where information is even more limited (Tier 5), the fishing mortality rate corresponding to the OFL is equal to the natural mortality rate, and the maximum allowable FABC is 75% of the natural mortality rate. Deriso (1982) showed that M often exceeds F_{MSY}, and Thompson (1993) showed that M can exceed even $F_{30\%}$. According to Thompson (1993) capping the harvest rate at 75% of M should generally keep the fishing mortality level below $F_{30\%}$.

Annually at its September and December meetings, the Council, AP, and SSC review the Draft and Final SAFE reports, respectively. Based on the information contained in these reports, the Council makes both ABC and TAC recommendations. The NMFS packages the recommendations into specification documents and forwards them to the Secretary of Commerce for approval. Secretarial approval usually occurs by March for the subject fishing year. Because some of the fisheries are underway before approval, the Secretary implements one-fourth of the preliminary TAC specifications (based on the previous year) and apportionments thereof toward fisheries occurring in the first quarter of the calendar year (50 CFR 679.20(c)(2)). Upon approval, the new TAC specifications replace the preliminary TAC specifications (50 CFR 679.20(c)(3)).

The TAC specifications define upper harvest limits, or fishery removals, for the next fishing year. Catch specifications are made for each managed species or species group, and in some cases, by species and sub-area. The sum of the TAC specifications is important because the fishery management plans specify upper and lower ceilings for total TAC in each management area. In the BSAI, the lower limit is 1.4 million mt and upper limit is 2 million mt (50 CFR 679.20(a)(1)(I)). In the GOA the lower limit is 116,000 mt and the upper limit is 800,000 mt (50 CFR 679.20(a)(1)(ii)).

The entire TAC amount is available to the domestic fishery. Sub-allocations of TAC are made for biological and socio-economic reasons according to percentage formulas established through FMP amendments. For particular target fisheries, TAC specifications are further allocated within management areas, among management programs (open access or Community Development Quota program [CDQ]), processing components (inshore or offshore), specific gear types (trawl, non-trawl, hook-and-line, pot, jig), and seasons according to regulations 50 CFR 679.20, 679.23, and 679.31. The gear authorized in the Federally managed groundfish fisheries off Alaska includes trawl, hook-and-line, longline, pot, and jig (50 CFR 679.2).

Fishing areas correspond to the defined regulatory areas within the fishery management units. The BSAI is divided into nineteen reporting areas (Fig. 1), some of which are combined for the purpose of setting TAC specifications. A Steller Sea Lion Conservation Area will be established in 2000 as part of the RFRPAs for the (EBS) pollock fishery. This area consists of the southeastern Bering Sea special foraging area included in the designation of critical habitat for the Steller sea lion, and the eastern portion of the Catcher-Vessel-Operation-Area not falling within critical habitat. The Aleutian Islands group comprises regulatory Areas 541, 542, and 543. When the Aleutian Islands are referred to individually, 541 represents the eastern Aleutian Islands, 542 the central Aleutian Islands, and 543 the western Aleutian Islands. The GOA is divided into eight reporting areas (Fig. 2). The western GOA is Area 610, the central GOA includes Areas 620 and 630, and the eastern GOA includes Areas 640 and 650. State waters in Prince William Sound comprise Area 649. State waters in southeast Alaska comprise Area 659.

The fishing year coincides with the calendar year, January 1 to December 31 (50 CFR 679.2 and 679.23). Depending on the target species' spatial allocation (detailed below), additional specifications are made to particular seasons (quarters of the year or combinations of quarters) within the year. Fisheries are opened and closed by regulatory announcement. Closures are made when in-season information indicates the apportioned TAC or available prohibited species catch (PSC) has been or will soon be reached, or at the end of the specified season, if the particular TAC has not been taken.

Catch accounting in the U.S. groundfish fisheries is divided into species that must be discarded (50 CFR 679.20(d)(2) and 679.21(b)) and those that may be or are required to be retained (50 CFR 679.20(e) and (f) and 679.27). Of the total TAC, 10% of the allowable catch for all species is first allocated to the CDQ program in the BSAI (50 CFR 679.31(a) and (b)(1)(iii)). The rest of the TAC is then apportioned to directed fishery or bycatch reserve according to spatial and temporal management measures that apply. These measures are detailed below, beginning with the BSAI and noting differences in the GOA, if any. Unless specified otherwise, in both FMP areas, trawl gear may only fish from January 20 though December 31 (50 CFR 679.23(c)). The remaining gear types may start fishing January 1 (50 CFR 679.23 (a)).

2.2 Interim and proposed TAC specifications for 2000

Interim and recommended final TAC specifications for the BSAI and GOA groundfish fisheries in 2000 are provided in Tables 2 and 3, respectively.

2.3 The American Fisheries Act of 1998

On October 21, 1998, the President signed into law the American Fisheries Act (AFA), which will have major effects on the BSAI and GOA groundfish fisheries in 2000. The AFA:

(1) Established a new allocation scheme for BSAI pollock that allocates 10 percent of the BSAI pollock TAC to the CDQ Program, and after allowance for incidental catch of pollock in other fisheries, allocates the remaining TAC as follows: 50 percent to vessels harvesting pollock for processing by inshore processors, 40 percent to vessels harvesting pollock for processing by catcher/processors, and 10 percent to vessels harvesting pollock for processing by motherships.

(2) Provided for the buyout and scrapping of nine pollock catcher/processors through a combination of $20 million in Federal appropriations and $75 million in direct loan obligations. The AFA also established a fee of six-tenths (0.6) of one cent for each pound round weight of pollock harvested by catcher vessels delivering to inshore processors for the purpose of repaying the $75 million direct loan obligation.

(3) Listed by name and/or provided qualifying criteria for those vessels and processors eligible to participate in the non-CDQ portion of the BSAI pollock fishery. The AFA increases the U.S. ownership requirement to 75% for vessels with US fisheries endorsements and prohibited new fisheries endorsements for vessels greater than 165 ft, LOA, greater than 750 gross registered tons, or with engines capable of producing greater than 3,000 shaft horsepower.

(4) Increased observer coverage and scale requirements for AFA catcher/processors.

(5) Established limitations for the creation of fishery cooperatives in the catcher/processor, mothership, and inshore industry sectors.

(6) Required that NMFS grant individual allocations of the inshore BSAI pollock TAC to inshore catcher vessel cooperatives which form around a specific inshore processor and agree to deliver the bulk of their catch to that processor.

(7) Required harvesting and processing restrictions (commonly known as "sideboards") on fishermen and processors who have received exclusive harvesting or processing privileges under the AFA to protect the interests of fishermen and processors who have not directly benefitted from the AFA.

(8) Established excessive share harvesting caps for BSAI pollock and directed the Council to develop excessive share caps for BSAI pollock processing and for the harvesting and processing of other groundfish.

Since the passage of the AFA in October 1998, the Council and NMFS have developed extensive management measures to achieve the provisions of the AFA. While some of the resulting regulations were in place for the 1999 fisheries, the majority of the regulations will be implemented for the 2000 fisheries. NMFS is currently in the process of preparing proposed rules including those regulations. For example, a proposed rule to implement the major provisions of the AFA contains regulations for allocation of pollock TAC among fishery sectors (and within sectors where necessary), among fishery areas, and among fishing seasons. The rule also establishes harvest restrictions or "sideboards" on the participation of unrestricted AFA catcher/processors in other BSAI groundfish fisheries and completely prohibits AFA catcher/processors fishing in the GOA.

In a separate proposed rule, NMFS is proposing management measures to temporally and spatially disperse the BSAI pollock fishery to implement RFRPAs to protect endangered Steller sea lions. Both the sectoral allocations implemented through the AFA proposed rule, and changes to season dates and seasonal TAC apportionments implemented under the Steller sea lion proposed rule will be reflected in the interim and final harvest specifications for BSAI pollock fishery.

2.4 Target species

This section provides summary descriptive information on the major target species of the fisheries, including important life history traits, trophic interactions, fisheries, stock assessments, and recommended catch levels. These species and the respective fisheries are described in greater detail in the Stock Assessment and Fishery Evaluation (SAFE) reports completed by stock assessment authors from the Alaska Fisheries Science Center (AFSC), and reviewed at various levels throughout the Council process. By reference, those SAFE reports are incorporated in this document in their entirety.

2.4.1 Walleye pollock

Stock Description and Life History

Walleye pollock (*Theragra chalcogramma*, hereafter referred to as pollock) is the most abundant species within the EBS and the second most abundant groundfish stock in the GOA. Pollock is widely distributed throughout the North Pacific in temperate and subarctic waters (Wolotira *et al.* 1993). Pollock is a semidemersal schooling fish, which becomes increasingly demersal (i.e., associated with the ocean bottom) with age. Approximately 50% of female pollock reach maturity at age four at a length of approximately 40 cm (Ianelli et al. 1999). Pollock spawning is pelagic and takes place in the early spring on the outer continental shelf. In the EBS the largest concentrations occur in the southeastern portion of the EBS (north of Unimak Pass). In the GOA, the largest spawning concentrations in Shelikof Strait and the Shumagin Islands (Kendall *et al.* 1996). Juvenile pollock are pelagic and feed primarily on copepods and euphausiids. As they age, pollock become increasingly piscivorous and can be highly cannibalistic, with smaller pollock being a major food item (Livingston 1991b). Pollock are comparatively short-lived, with fairly high natural mortality rate (for all ages) assumed to be 0.3 (Dorn *et al.* 1999, Wespestad and Terry 1984) and maximum recorded age of around 22 years.

Although stock structure of Bering Sea pollock is not well defined (Wespestad 1993), three stocks of pollock are recognized in the BSAI for management purposes; EBS, Aleutian Islands and Aleutian Basin (Ianelli *et al.* 1999). Pollock in the GOA are thought to be a single stock (Alton and Megrey 1986) originating from springtime spawning primarily in Shelikof Strait (Brodeur and Wilson 1996).

Trophic Interactions

The diet of EBS pollock has been studied extensively (Dwyer 1984, Lang and Livingston 1996, Livingston 1991b, Livingston and DeReynier 1996, Livingston *et al.* 1993). These studies have shown that juvenile pollock is the dominant fish prey in the EBS; other fish are also consumed by pollock including juveniles of Pacific herring, Pacific cod, arrowtooth flounder, flathead sole, rock sole, yellowfin sole, Greenland turbot, Pacific halibut and Alaska plaice. On the shelf area of the EBS, the contribution of these other fish prey to the diet of pollock tends to be very low (i.e., usually less than 2% by weight of the diet; Livingston 1991b, Livingston and DeReynier 1996, Livingston *et al.* 1993). However, in the deeper slope waters, deep-sea fish (myctophids and bathylagids) are a relatively important diet component (12% by weight), along with euphausiids, pollock, pandalid shrimp and squid (Lang and Livingston 1996).

The cannibalistic nature of pollock, particularly adults feeding on juveniles, is well-documented by field studies in the EBS (Bailey 1989, Dwyer *et al.* 1987, Livingston 1989b, 1991b, Livingston and DeReynier 1996, Livingston and Lang 1997, Livingston *et al.* 1993). Cannibalism by pollock in the Aleutian Islands region has not yet been documented (Yang 1996). Cannibalism rates in the EBS vary depending on year, season, area, and predator size (Dwyer *et al.* 1987, Livingston 1989b, Livingston and Lang 1997). Cannibalism rates are highest in autumn, next highest in summer, and lowest in spring. Cannibalism rates by pollock larger than 40 cm are higher than those by pollock less than 40 cm. Most pollock cannibalized are age-0 and age-1 fish, with most cannibalized age-1 pollock being consumed northwest of the Pribilof Islands where most of that age class are found. Pollock larger than 50 cm tend to consume most of the age-1 fish. Smaller pollock consume mostly age-0 fish. Although age-2 and age-3 pollock are sometimes cannibalized, the frequency of occurrence of these age groups in the stomach contents is quite low. Laboratory studies have shown the possibility of cannibalism among age-0 pollock (Sogard and Olla 1993). Field samples have confirmed this interaction, but so far this interaction appears not to be very important. The degree of cannibalism in an area may also be determined by thermal stratification of the water column and diel movements of large and small pollock in response to temperature gradients and food availability (Bailey 1989, Olla et al. 1995, Sogard and Olla 1993, 1996).

Modeling studies suggest cannibalism is a stabilizing influence, with the population showing less variation compared to simulations in which cannibalism was not included (Knechtel and Bledsoe 1983). More recent modeling efforts (Honkalehto 1989, Livingston 1993, 1994) have examined cannibalism using more standard stock assessment procedures such as virtual population analysis or integrated catch-age models such as Methot's (1990) synthesis model. The purpose is to obtain better estimates of juvenile pollock abundance and mortality rates, which can improve our knowledge of factors affecting recruitment of pollock into the commercial fishery at age 3. Results from Livingston (1993, 1994) highlight several points with regard to cannibalism. In the current state of the EBS, cannibalism appears to be the most important source of predation mortality for age-0 and age-1 pollock. Predation mortality rates for juvenile pollock are not constant, as assumed in most population assessment models, but vary across time mainly due to changes in predator abundance but perhaps also due to predators feeding more heavily on more abundant year classes. The decline in pollock recruitment observed at high pollock spawning biomasses appears to be due to cannibalism. There also appears to be an environmental component to juvenile pollock survival (Wespestad et al. 1997b), wherein surface currents during the first 3 months of life may transport larvae to areas more favorable to survival (e.g., away from adult predators or in areas more favorable for feeding). Estimates of total amount of pollock consumed by important groundfish predators show that cannibalism is the largest source of removal of juvenile pollock by groundfish predation (Livingston 1991a, Livingston and DeReynier 1996, Livingston *et al.* 1993).

Other groundfish predators of pollock include Greenland turbot, arrowtooth flounder, Pacific cod, Pacific halibut, and flathead sole (Livingston 1991a, Livingston and DeReynier 1996, Livingston *et al.* 1986, 1993). These species are some of the more abundant groundfish in the EBS, and pollock constitutes a large proportion of the diet for many of them. Other less abundant species that consume pollock include Alaska skate, sablefish, Pacific sandfish, and various sculpins (Livingston 1989a, Livingston and DeReynier 1996). Small amounts of juvenile pollock are even eaten by small-mouthed flounders such as yellowfin sole and rock sole (Livingston 1991a, Livingston and DeReynier 1996, Livingston *et al.* 1993). Age-0 and age-1 pollock are the targets of most of these groundfish predators, with the exception of Pacific cod, Pacific halibut, and Alaska skate, which may consume pollock ranging in age from age 0 to greater than age 6 depending on predator size.

Pollock is a significant prey item of marine mammals and birds in the EBS and has been the focus of many studies. Studies suggest that pollock is a primary prey item of northern fur seals when feeding on the shelf during summer (Sinclair *et al.* 1997, 1994). Squid and other small pelagic fish are also eaten in slope areas or in other seasons. The main sizes of pollock consumed by fur seals range from 3-20 cm or age-0 and age-1 fish. Older age classes of pollock may appear in the diet, during years of lower abundances of young pollock (Sinclair *et al.* 1997). Pollock is a prey item for other marine mammals including harbor seals, fin whales, minke whales, and humpback whales but stomach samples from these species in the EBS have been very limited so the importance of pollock in the diets has not been well-defined (Kajimura and Fowler 1984). Pollock are one of the most common prey in the diet of spotted seals and ribbon seals, which feed on pollock in the winter and spring in the areas of drifting ice (Lowry *et al.* 1997). Pollock have also been shown to be a major prey of Steller sea lions throughout their range in Alaskan waters (Calkins and Pitcher 1982, Frost and Lowry 1986, Calkins and Goodwin 1988, Merrick et al. 1997, Trites, unpubl. data).

Essentially five species of piscivorus birds are dominant in the EBS avifauna: northern fulmar, red-legged kittiwake, black-legged kittiwake, common murre, and thick-billed murre (Kajimura and Fowler 1984, Schneider and Shuntov 1993). Pollock is sometimes the dominant component in the diets of northern fulmar, black-legged kittiwake, common murre and thick-billed murre while red-legged kittiwakes tend to rely more heavily on myctophids (Hunt *et al.* 1981, Kajimura and Fowler 1984). Age-0 and age-1 pollock are consumed by these bird species, and the dominance of a particular pollock age-class in the diet varies by year and season. Fluctuations in chick production by kittiwakes have been linked to the availability of fatty fishes such as myctophids, capelin and sandlance (Hunt *et al.* 1995). Changes in the availability of prey, including pollock, to surface-feeding seabirds may be due to changes in sea surface temperatures and the locations of oceanographic features such as fronts which could influence the horizontal or vertical distribution of prey (Decker *et al.* 1995, Springer 1992).

In the GOA, the diet of pollock, particularly adults, has not been studied as thoroughly as in the EBS. Larvae, 5-20 mm in length, consume larval and juvenile copepods and copepod eggs (Canino 1994, Kendall *et al.* 1987). Early juveniles (25-100 mm) of pollock in the GOA primarily eat juvenile and adult copepods, larvaceans, and euphausiids while late juveniles (100-150 mm) eat mostly euphausiids, chaetognaths, amphipods, and mysids (Brodeur and Wilson 1996, Grover 1990, Krieger 1985, Livingston 1985, Merati and Brodeur 1997, Walline 1983). Juvenile and adult pollock in southeast Alaska rely heavily on euphausiids, mysids, shrimp and fish as prey (Clausen 1983). Euphausiids and mysids are important to smaller pollock and shrimp and fish are more important to larger pollock in that area. Copepods are not a dominant prey item of pollock in the embayments of southeast Alaska but appear mostly in the summer diet. Similarly, copepods are not a major component of the summer diet of pollock in the central and western GOA (Yang 1993). Euphausiids are the dominant prey and constitute a relatively constant proportion of the diet by weight across pollock sizes groups. Shrimp and fish are the next two important prey items.

Fish prey become an increasing fraction of the pollock diet with increasing size in the GOA. Over 20 different species of fish have been identified in the stomach contents of pollock from this area but the dominant fish consumed is capelin (Yang 1993). A high diversity of prey fish were also found in pollock stomachs. Commercially important fish prey included: Pacific cod, pollock, arrowtooth flounder, flathead sole, Dover sole, and Greenland halibut. Forage fish such as capelin, eulachon, and Pacific sand lance, were also found in pollock stomach contents.

Dominant populations of groundfish in the GOA that prey on pollock include arrowtooth flounder, sablefish, Pacific cod, and Pacific halibut (Albers and Anderson 1985, Best and St-Pierre 1986, Jewett 1978, Yang 1993). Pollock is one of the top five prey items (by weight) for Pacific cod, arrowtooth flounder, and Pacific halibut. Other prey fish of these species include Pacific herring and capelin. Other predators of pollock include great sculpins (Carlson 1995) and shortspined thornyheads (Yang 1993). As found in the EBS, Pacific halibut and Pacific cod tend to consume larger pollock, and arrowtooth flounder consumes pollock that are mostly less than age 3. Unlike the EBS, however, the main source of predation mortality on pollock at present appears to be from the arrowtooth flounder (Livingston 1994). Stock assessment authors have attempted to incorporate predation mortality by arrowtooth flounder, Pacific halibut, and sea lions in the stock assessment for pollock in the GOA (Hollowed *et al.* 1997).

Although less research has been conducted on the diets of marine mammals and birds in the GOA (relative to the Bering Sea), such research has been greatly accelerated (Brodeur and Wilson 1996, Calkins 1987, DeGange and Sanger 1986, Hatch and Sanger 1992, Lowry *et al.* 1989, Merrick and Calkins 1996, Pitcher 1980a, 1980b, 1981). Brodeur and Wilson's (1996) review summarized both bird and mammal predation on juvenile pollock. The main piscivorus birds that consume pollock in the GOA are black-legged kittiwakes, common murre, thick-billed murre, tufted puffin, horned puffin, and probably marbled murrelet. The diets of murres have been shown to contain around 5% to 15% age-0 pollock by weight depending on season. The tufted puffin diet is more diverse and tends to contain more pollock than that of the horned puffin (Hatch and Sanger 1992). Both horned puffins and tufted puffins consume age-0 pollock. The amount of pollock in the diet of tufted puffin varied by region in the years studied, with very low amounts in the north-central Gulf and Kodiak areas, intermediate (5-20%) amounts in the Semidi and Shumagin Islands, and large amounts (25-75%) in the Sandman Reefs and eastern Aleutians. The proportion of juvenile pollock in the diet of tufted puffin at the Semidi Islands varied by year and was related to pollock yearclass abundance.

Walleye pollock is a major prey of Steller sea lions and harbor seals in the GOA (Merrick and Calkins 1996, Pitcher 1980a, 1980b, 1981). Harbor seals tend to have a more diverse diet, and the occurrence of pollock in the diet is lower than in sea lions. Pollock is a major prey of both juvenile and adult Steller sea lions in the GOA. The data indicate that the proportion of animals consuming pollock increased from the 1970s to the 1980s, and this increase was most pronounced for juvenile Steller sea lions. Sizes of pollock consumed by Steller sea lions range from 5-56cm and the size composition of pollock consumed appears to be related to the size composition of the pollock population (i.e., pollock available). Juvenile sea lions appear to consume smaller pollock, on average, than adults consume. Age-1 pollock was dominant in the diet of juvenile Steller sea lions in 1985. However, these results likely reflect the fact that the pollock available to sea lions in the GOA at this time were primarily from the abundant 1984 year class. These data are not sufficient to conclude that sea lions prefer smaller pollock.

Fishery

Pollock supports the largest fishery in Alaskan waters. In 1999 in the BSAI, pollock comprised 72% of the total groundfish catch (by mass) through October; in the Gulf, pollock comprised 41% of the 1999 catch through October. Pollock are taken almost exclusively by pelagic trawling (EBS) or by pelagic and bottom trawling (GOA).

The pollock fisheries in the BSAI and the GOA are undergoing extensive changes due to management requirements to comply with the ESA, and to implement the AFA (see above, section 2.3). These fisheries have evolved from a foreign effort in the 1950s to the 1970s, a joint-venture effort in the 1980s, and a domestic effort in the 1990s. The fisheries may be entering a fourth phase now with the shift in pollock allocations from larger catcher/processors to smaller catcher vessels. These changes have social and economic implications, but also affect the prosecution of the fisheries in ways that may have significant effects on protected species in these regions, or the ecosystems at large.

The potential effects of the pollock fisheries was recently evaluated in a section 7 consultation completed on December 3, 1998. The resulting Biological Opinion concluded that the pollock fisheries, as they had been proposed in 1998 for 1999 to 2002, would jeopardize the continued existence of the western population of Steller sea lions and adversely modify its critical habitat. The Opinion included three principles for the required Reasonable and Prudent Alternatives (RPAs) and fourteen guidelines for management measures to accomplish those principles. The principles included protection of Steller sea lion food resources around rookeries and major haulouts, temporal dispersion of the fisheries, and spatial dispersion of the fisheries. The principles were designed to ensure that sea lions were not required to compete for food resources near rookeries and haulouts, and that fisheries also did not result in localized depletion of prey (relative to the needs of foraging sea lions) in remaining areas of critical habitat or where sea lions forage. After legal challenges to the conclusions of the Biological Opinion and the remedies required by the RPAs, a set of Revised Final Reasonable and Prudent Alternatives (RFRPAs) was issued on October 15, 1999 (Appendix). The following summary of the pollock fisheries describes their expected behavior in 2000 based on those RFRPAs.

The Aleutian Islands subarea has been closed to directed pollock fishing. The EBS pollock fishery is split among four sectors: the catcher/processors sector, the mothership sector, the inshore catcher-vessel sector, and the CDQ sector. Under the AFA, 10% of the annual TAC is allocated to the CDQ sector, 5% of the remainder is removed for bycatch allowance in other fisheries, and then the remainder is subdivided among catcher/processors (40%), motherships (10%), and the inshore sector (50%). The allocation of pollock TAC to each sector is managed by season and area to prevent competition among sectors. Within the sectors, only the catcher/processors have formed a fishery cooperative to date, but other sectors are expected to form such cooperatives for the 2000 fisheries.

The EBS pollock fishery is divided into two management areas: 1) inside the Steller Sea Lion Conservation Area (SCA; this area is comprised of the portion of Steller sea lion critical habitat known as the southeastern Bering Sea special foraging area combined with the eastern portion of the catcher-vessel-operation-area that does not overlap with critical habitat), and outside the SCA. Inside the SCA, the EBS pollock fishery is divided into four evenly spaced seasons beginning January 20 (A season), April 1 (B season), June 10 (C season), and August 20 (D season). Outside the SCA, the fishery is divided into two seasons from January 20 to June 10 (A/B season), and from June 10 to November 1 (C/D season). Fishing is closed in both areas from November 1 to January 20. Fishing is also closed around designated rookeries and haulouts out to 20 nm in the EBS (the designated sites are listed in the Appendix). The EBS pollock TAC is allocated 40% to the combined A/B seasons and 60% to the combined C/D seasons. Half of the 40% allocation to the A/B season (i.e., 20%) can be taken inside the SCA during the combined A and B seasons, but a maximum of three quarters of that (i.e., 15%) can be taken in either season singly. The 60% TAC allocation to the C/D season is similarly apportioned by area inside and outside the SCA, except that a maximum of 4.5% of the TAC can be taken inside the SCA in the C season and a maximum of 7.5% can be taken during the D season.

The GOA pollock fishery is not split into sectors: all fishing vessels are considered part of the inshore sector and catcher/processors are not allowed to fish for pollock. In addition, restrictions in both the RFRPAs and the AFA will limit participation of catcher vessels that might otherwise fish in both the GOA and the EBS pollock fisheries.

The GOA pollock fishery is divided into four principle management areas during the A and B seasons (Shelikof Strait, 610, 620 outside Shelikof Strait, and 630 outside Shelikof Strait) and three areas during the C and D seasons (610, 620, and 630). The season dates in the GOA do not coincide with the dates in the EBS. The dates are January 20 to March 1 (A season), March 15 to May 31 (B season), August 20 to September 15 (C season) and October 1 to November 1 (D season). Pollock fishing is not allowed during the period from November 1 to January 20. Pollock trawling is also closed or partially closed around designated rookeries and haulouts (see Appendix). The pollock TAC is apportioned to the four GOA seasons as follows: 30% to the A season, 15% to the B season, 30% to the C season, and 25% to the D season. In both the GOA and the EBS, rollover of TAC is allowed as long as it is consistent with areal and seasonal caps.

Pollock are caught as bycatch in other directed fisheries but because they occur primarily in well defined aggregations, the rate of this bycatch is typically minimal. Most discard of pollock occurs in the non-directed pollock trawl fisheries (72% of all BSAI discards in 1996). Recent discard rates (discards/retained catch) of pollock in the directed fishery BSAI have been about 7% (Wespestad et al. 1997b). Pollock are caught as bycatch in the trawl Pacific cod, rock sole, and yellowfin sole fisheries. In 1996, 21,000 mt of pollock were discarded in the directed BSAI fishery compared to 55,200 mt discarded in all other fisheries (Wespestad et al. 1997b). Starting in 1998, discarding of pollock was prohibited except in the fisheries where pollock are in bycatch only status.

Stock Assessment

Currently, information on pollock in the EBS comes from the NMFS observers aboard commercial fishing vessels, annual trawl surveys, and triennial echo integration (hydroacoustic) trawl surveys. In the Aleutian Islands, information comes from observer data and triennial bottom trawl surveys. In the GOA, stock assessment information is based on observer and port sampling data, annual hydroacoustic surveys in the Shelikof Straits area, and triennial bottom trawl surveys. These different data sets are analyzed simultaneously to obtain an overall view of each stock’s condition. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass may be pelagic and not available to bottom trawls. In addition, much of the Aleutian Islands shelf can not be trawled due to rough bottom.

In the EBS, walleye pollock are assessed with an age-structured model incorporating fishery and two types of survey catch data and age compositions. Bottom trawl surveys are conducted annually during May or June through August and provide a consistent time series of adult population abundance from 1982-1997. Echo-integrated trawl surveys are run every three years (typically) and provide an abundance index on more pelagic (typically younger) segments of the stock. Both surveys dispose their catches into their relative age compositions prior to analyses. Fishery data include estimates of the total catch by area/time strata and also the average body weight-at-age and relative age composition of the catch within each stratum. The results of the statistical model applied to these data are updated annually and presented in the BSAI pollock chapter of the Council’s BSAI SAFE report. Also included are separate analyses on pollock stocks in the Aleutian Islands and Bogoslof areas. These analyses are constrained by data limitations and are presented relative to the status of the EBS stock. The stock assessment is reviewed by the Council’s Plan Teams, the Scientific and Statistical Committee, and presented to the Council.

The age composition of EBS pollock has been dominated by strong year classes—most recently there appears to be higher than average 1992 year class (age 8 in 2000), and prior to that the 1989 (age 11) year class was very high. The abundance of these year classes is evident from the EIT and bottom trawl surveys in addition to the extensive fishery age-composition data that have been collected. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality. The fishery has tended to exhibit variable selectivity over time, but generally targets fish aged 5 years and older (Ianelli et al. 1999).

Pollock in the GOA are also assessed with an age-structured model incorporating fishery and survey data. The data used in this analysis consist of estimates of total catch biomass, bottom trawl biomass estimates, Echo Integration Trawl (EIT) survey estimates of the spawning biomass in Shelikof Strait, egg production estimates of spawning biomass in Shelikof Strait, fisheries catch at age and survey size and age compositions. Fishery catch statistics (including discards) are estimated by the NMFS Alaska Regional Office. These estimates are based on the best blend of observer-reported catch and weekly production reports. Age composition data are obtained from several sources including catch at age aggregated over all seasons, nations (historical data), vessel classes and INPFC statistical areas for the years, and numbers at age from the spring EIT survey and the bottom trawl surveys. An additional estimate of the age composition of the population in 1973 was available from a bottom trawl survey of the GOA. Length frequency data collected from the EIT survey are also included in the model, as is historical information on pollock size composition obtained from the Japanese Pacific ocean perch fishery from the period 1964-1975 (Hollowed *et al.* 1991).

The current age and size distributions of GOA pollock are discussed in Dorn *et al.* (1999). The estimated 2000 age composition of pollock from the stock assessment model is dominated by a recent strong 1994 year class.

Over the last 15 years, NOAA's Fisheries Oceanography Coordinated Investigations (FOCI) targeted much of their research on understanding processes influencing recruitment of pollock in the GOA. These investigations led to the development of a conceptual model of factors influencing pollock recruitment (for complete review collection of papers (Kendall *et al.* 1996)). Bailey *et al.* (1996) reviewed 10 years of data for evidence of density dependent mortality at early life stages. Their study revealed evidence of density dependent mortality only at the late larval to early juvenile stages of development. Bailey *et al.* (1996) hypothesize that pollock recruitment levels can be established at any early life stage (egg, larval or juvenile) depending on sufficient supply from prior stages. He labeled this hypothesis the supply dependent multiple life stage control model. In a parallel study, Megrey *et al.* (1996) reviewed data from FOCI studies and identified several events that are important to survival of pollock during the early life history period. These events are climatic events (Hollowed and Wooster 1995, Stabeno *et al.* 1995), preconditioning of the environment prior to spawning (Hermann *et al.* 1996), the ability of the physical environment to retain the planktonic life stages of pollock on the continental shelf (Bograd *et al.* 1994, Schumacher *et al.* 1993), and the abundance and distribution of prey and predators on the shelf (Bailey and Macklin 1994, Canino 1994, Theilacker *et al.* 1996). Thus, the best available data suggest that pollock year-class strength is controlled by sequences of biotic and abiotic events and that population density is only one of several factors influencing pollock production.

ABC Recommended in the Most Recent Stock Assessments

Ianelli et al. (1999) recommend ABC and OFL levels recommended for the EBS pollock stock following guidelines for both tier 1a and tier 3b. These recommendations are:

	OFL	ABC
Tier 1a	1,678,000 mt	1,197,000 mt
Tier 3b	1,471,000 mt	1,102,000 mt

For 2000, GOA pollock fall into tier 3b of the ABC/OFL definitions, which require reliable estimates of biomass. Dorn et al. (1999) recommend an ABC of 111,036 mt for the GOA west of 140°W long, and 6,460 mt for southeast Alaska (East Yakutat and Southeastern areas).

2.4.2 Atka Mackerel

Stock description, life history, and trophic interactions

Atka mackerel are distributed from the east coast of the Kamchatka peninsula, throughout the Aleutian Islands and the EBS, and eastward through the GOA to southeast Alaska (Wolotira *et al.* 1993). Their center of abundance is in the Aleutian Islands, where they are one of the most abundant fish species (Lowe and Fritz 1999). They are an important prey species for marine mammals and are the target of a directed trawl fishery. Adults are semi-pelagic and spend most of the year over the continental shelf in depths generally less than 200 m. Adults migrate annually to shallow coastal waters during spawning, forming dense aggregations near the bottom (Morris 1981, Musienko 1970). In Russian waters, spawning peaks in mid-June (Zolotov 1993) and in Alaskan waters in July through October (McDermott and Lowe 1997). Females deposit adhesive eggs in nests or rocky crevices. The nests are guarded by males until hatching occurs (Zolotov 1993). Genetic studies indicate that Atka mackerel form a single stock in Alaskan waters (Lowe *et al.* 1998). However, growth rates can vary extensively among different areas (Kimura and Ronholt 1988, Lowe *et al.* 1998, Lowe and Fritz 1999). Age and size at 50% maturity has been estimated at 3.6 years and 33 to 38 cm, respectively (McDermott and Lowe 1997). Atka mackerel are a fairly short-lived species. A maximum age of 15 years has been noted, however most of the population is probably less than 10 years old. Natural mortality estimates vary extensively, and range from 0.12 to 0.74 as determined by various methods (Lowe and Fritz 1999). For stock assessment purposes, a value of 0.3 is used (Lowe and Fritz 1999).

The diets of commercially important groundfish species in the Aleutian Islands during the summer of 1991 were analyzed by Yang (1996). More than 90% of the total stomach contents weight of Atka mackerel in the study was made up of invertebrates, with less than 10% made up of fish. Euphausiids (mainly *Thysanoessa inermis* and *Thysanoessa rachii*) were the most important prey item, followed by calanoid copepods. The two species of euphausiids comprised 55% by weight of the total stomach contents, and copepods comprised 17% of the total stomach contents weight. Larvaceans and hyperiid amphipods had high frequencies of occurrence (81% and 68%, respectively), but comprised less than 8% of the total stomach contents weight. Squid was another item in the diet of Atka mackerel; it had a frequency of occurrence of 31%, but only comprised 8% of the total stomach contents weight. Atka mackerel are known to eat their own eggs. Yang (1996) found that Atka mackerel eggs comprised 3% of the total stomach contents weight and occurred in 9% of the Atka mackerel stomachs analyzed. Walleye pollock were the second most important prey fish of Atka mackerel, comprising about 2% of the total stomach contents weight. Myctophids, bathylagids, zoarcids, cottids, stichaeids, and pleuronectids were minor components of the Atka mackerel diet; each category comprised less than 1% of the total stomach contents.

Atka mackerel are consumed by a variety of predators including groundfish, mainly arrowtooth flounder, Pacific halibut, and Pacific cod (Yang 1996); marine mammals, mainly northern fur seals and Steller sea lions (Kajimura 1984, NMFS 1995); and seabirds, mainly tufted puffins (Byrd *et al.* 1992). Atka mackerel are also components in the diets of the following marine mammals and seabirds: harbor seals, Dall's porpoise, thick-billed murre, and horned puffin (Yang 1996).

Fishery, stock assessment, and ABC recommendation

The directed fishery for Atka mackerel is prosecuted by catcher-processor bottom trawlers. The patterns of the fishery generally reflect the behavior of the species in that the fishery is highly localized, occurs in the same few locations each year, and generally occurs at depths between 100 and 200 m (Lowe and Fritz 1997). Important Atka mackerel fishery locations include Seguam Bank, Tanaga Pass, north of the Delarof Islands, Petrel Bank, south of Amchitka Island, east and west of Kiska Island, and on the seamounts and reefs near Buldir Island.

Atka mackerel are a difficult species to survey because they do not have a swim bladder, and therefore are poor targets for hydroacoustic surveys. They prefer rough and rocky bottoms that are difficult to trawl, and their schooling behavior makes the species susceptible to large variances in catches. They are particularly difficult to survey in the GOA due to their low abundance and patchy distribution. Consequently, trends in population for the species in the GOA have been difficult to assess. Stock assessment in the Aleutian Islands is based on the triennial trawl survey as well as total catch and catch at age data from the commercial fishery.

BSAI Atka mackerel are assessed with an age-structured model incorporating fishery and survey catch data and age compositions. Atka mackerel recruit to the fishery at age four. Survey data are from the NMFS Aleutian Islands triennial trawl groundfish surveys. Fishery catch statistics (including discards) are estimated by the NMFS Regional Office. These estimates are based on the best blend of observer reported catch and weekly production reports. The stock assessment includes catch history, fishery characteristics, assessment methodology, key life history parameters, survey and model estimated abundance trends, historical exploitation rates, reference fishing mortality rates, recommended harvest rates, projected catch and abundance trends for a range of fishing mortalities and recruitment assumptions, and recommended catch.

Atka mackerel are not caught as bycatch to a large extent in other directed fisheries. The largest amounts of discards of Atka mackerel occur in the directed Atka mackerel trawl fisheries. In 1998, the discard rate was the lowest recorded at 8.4%, as compared to previous rates on the order of 9% to 21% (Lowe and Fritz 1999). Atka mackerel are also caught as bycatch in the trawl Pacific cod and rockfish (primarily Pacific ocean perch, sharpchin and northern rockfish) fisheries. It is difficult to discern the level of natural bycatch of Atka mackerel in the rockfish fisheries, as vessels may actually be targeting Atka mackerel in particular hauls, but overall they are designated as targeting rockfish on a particular trip. In 1998, 4,600 mt of Atka mackerel were discarded in the directed fishery as compared to 1,100 mt discarded in all other fisheries.

For 2000, BSAI Atka mackerel fall into tier 3a of the ABC/OFL definitions. In this tier and under current stock conditions, the OFL estimate is 119,300 mt. The stock assessment authors also recommended an ABC of 78,500 mt based on stock analysis and modeling, and the use of a precautionary approach given uncertainties in the available data (Lowe and Fritz 1999).

Atka mackerel in the GOA are currently managed as a bycatch fishery. They are caught as bycatch in the pollock, Pacific cod, Pacific ocean perch, and northern rockfish fisheries. The low level of TAC likely precludes directed targeting of Atka mackerel on a haul by haul basis, and the catches of Atka mackerel in other directed fisheries may represent true bycatch of Atka mackerel.

Current biomass of Atka mackerel in the GOA cannot be reliably estimated. The species is not commonly caught in the GOA triennial trawl surveys. Consequently, the general GOA groundfish bottom trawl survey does not assess the GOA portion of the Atka mackerel stock well, and the resulting biomass estimates have little value as absolute estimates of abundance or as indices of trend (Lowe and Fritz 1999). Therefore, GOA Atka mackerel are not assessed with a model and the assessment does not utilize abundance estimates from the trawl survey. The stock assessment for GOA Atka mackerel consists of descriptions of catch history, length and age distributions from the fishery during 1990 to 1994, and length and age distributions from the trawl surveys (1990, 1993, 1996, and 1999).

Atka mackerel in the GOA fall into tier 6 of the ABC/OFL definitions, which defines the OFL as the average catch from 1978 to 1995, and that ABC cannot exceed 75% of the OFL. The average annual catch from 1978-95 is 6,200 mt; thus ABC cannot exceed 4,700 mt. The current ABC recommendation from the stock assessment is below the maximum prescribed under tier 6, to provide a very risk-averse harvest rate given the uncertainty about GOA Atka mackerel. The 1999 stock assessment recommended an ABC of 600 mt, with the intention of precluding a directed fishery, but providing for bycatch needs in other trawl fisheries. An ABC lower than the maximum prescribed under tier 6 was recommended because: 1) When past ABCs were lower than 4,700 mt (approximately 3,000 mt in 1994), it was shown that the fishery might have created localized depletions of Atka mackerel even at those catch levels (appendix in (Lowe and Fritz 1996)). This analysis indicated that the fishery was very efficient in removing fish from local areas and at rates which far surpassed the target harvest rate. 2) Analyses of local fishery CPUEs indicated that the Atka mackerel populations may have declined significantly between 1992 and 1994 (appendix in (Lowe and Fritz 1996)), reflecting the trend of the Aleutian Islands Atka mackerel population during that period, which has continued to decline since 1994 (Lowe and Fritz 1999). 3) The GOA Atka mackerel population appears to be particularly vulnerable to fishing pressure because of sporadic movement of fish eastward from the Aleutian Islands.

2.4.3 Pacific Cod

Stock Description and Life History

Pacific cod (*Gadus macrocephalus*) is a demersal species that occurs on the continental shelf and upper slope from Santa Monica Bay, California through the GOA, Aleutian Islands, and EBS to Norton Sound (Bakkala 1984). The Bering Sea represents the center of greatest abundance, although Pacific cod are also abundant in the GOA and Aleutian Islands (Outer Continental Shelf Environmental Assessment Program 1987). Gulf of Alaska, Bering Sea, and Aleutian Islands cod stocks are genetically indistinguishable (Grant *et al.* 1987), and tagging studies show that cod migrate seasonally over large areas (Shimada and Kimura 1994). The nature of those migratory movements are largely undescribed and, therefore, unknown.

However, in the late winter, Pacific cod are known to converge (to some undetermined extent) in large spawning masses over relatively small areas. Major aggregations occur between Unalaska and Unimak Islands, southwest of the Pribilof Islands and near the Shumagin Islands in the western GOA (Shimada and Kimura 1994). Spawning takes place in the sublittoral-bathyal zone (40-290 m) near the bottom. The eggs sink to the bottom and are somewhat adhesive (Hirschberger and Smith 1983).

Pacific cod reach a maximum recorded age of 19. Estimates of natural mortality vary widely and range from 0.29 (Thompson and Shimada 1990) to 0.83-0.99 (Ketchen 1964). For stock assessment purposes, a value of 0.37 is used in both the BSAI (Thompson and Dorn 1999) and the GOA (Thompson *et al.* 1999). Cod grow steadily in length, with an approximate maximum length probably around 1 m. The average length at age is illustrated in Figure 3, along with average mass at length and portion mature at length. Approximately 50% of cod are mature by age six, at about 65-69 cm length (Thompson and Dorn 1999).

Trophic Interactions

Pacific cod are omnivorous. Livingston (1991b) characterized the diet of Pacific cod in the BSAI and GOA as follows: "In terms of percent occurrence, the most important items were polychaetes, amphipods, and crangonid shrimp; in terms of numbers of individual organisms consumed, the most important items were euphausiids, miscellaneous fishes, and amphipods; and in terms of weight of organisms consumed, the most important items were pollock, fishery offal, and yellowfin sole. Small Pacific cod were found to feed mostly on invertebrates, while large Pacific cod are mainly piscivorous." Predators of Pacific cod include halibut, salmon shark, northern fur seals, Steller sea lions, harbor porpoises, various whale species, and tufted puffin (Westrheim 1996).

Fishery

The Pacific cod fishery is the second largest Alaskan groundfish fishery. Catches in both the BSAI and the GOA have increased relatively steadily (moreso in the BSAI fishery) since the late 1970s (Fig. 4). In 1999, the TACs for Pacific cod constituted 9% of combined groundfish TAC in the BSAI and 22% of the combined TAC in the GOA. The fishery for Pacific cod is conducted with bottom trawl, longline, pot, and jig gear, generally at depths less than 150 m (Fig. 5). In the BSAI, 47% of the TAC is allocated to trawl fishing, 51% to longline and pot fishing combined, and 2% to jig fishing. In the GOA, Pacific cod is allocated between the processing components, 90% to inshore and 10% to offshore. The age at 50% recruitment to the fishery varies between regions. For trawl, longline, and pot gear, the age at 50% recruitment is 4 years in the EBS (Thompson and Dorn 1997) and 5 years in the GOA (Thompson *et al.* 1997). Size distributions of the catch are illustrated in Figure 6. Overall harvest rates (catch [mt] divided by estimated biomass [age 3+]) have increased in a manner consistent with the increase in catches. In the GOA, both catch and overall harvest rate could be described as shifting from a period of relatively low catch and harvest rate prior to the late 1980s to a period of relatively higher catch and harvest rate since the late 1980s. In both the BSAI and the GOA, the observed changes in catch and harvest parallel a shift in the nature of the fisheries from foreign in the 1970s to joint venture in the 1980s and then domestic in the 1990s.

The trawl fishery is typically concentrated during the first few months of the year, whereas fixed-gear fisheries tend to occur in all months except the summer (Fig. 7). In the EBS, trawl fishing is concentrated immediately north of Unimak Island, whereas the longline fishery is distributed along the shelf edge to the north and west of the Pribilof Islands (Fig. 8). For all gear types combined, the catch from Steller sea lion critical habitat in the BSAI has approached and exceeded 120,000 mt and constitutes approximately half of the total catch of cod in all BSAI areas (Fig. 9). In the GOA, the trawl fishery has centers of activity around the Shumagin Islands and south and east of Kodiak Island, while the longline fishery is located primarily in the vicinity of the Shumagins (Fig. 8). For all gear types combined, the catch from Steller sea lion critical habitat in the GOA has been around 40,000 mt or more in recent years and constitutes approximately 60% to 70% of the total catch of cod in all GOA areas (Fig. 10).

Bycatch of crab and halibut often causes the Pacific cod fisheries to close prior to reaching the TAC. In addition, Pacific cod is taken as bycatch in a number of trawl fisheries, including pollock, yellowfin sole, and rock sole in the EBS, Atka mackerel in the Aleutian Islands, and shallow-water flatfish, flathead sole, arrowtooth flounder, and other fisheries in the GOA. Pacific cod is also discarded in its own directed fisheries (specifically, the directed trawl fisheries in all three areas and the directed longline fisheries in the EBS and Aleutian Islands region). Since1998, discarding is prohibited except in the fisheries where Pacific cod can be taken as bycatch only.

Stock Assessment

Annual biomass estimates have varied from just over 0.5 mmt in the EBS to nearly 1.4 mmt, but are currently under 0.6 mmt (Fig. 11). In the GOA, biomass estimates have ranged from about 0.3 mmt to 0.6 mmt, and are currently at their lowest level since triennial surveys began (Fig. 11). Beginning with the 1993 BSAI SAFE report (Thompson and Methot 1993) and the 1994 GOA SAFE report (Thompson and Zenger 1994), a length-based Synthesis model (Methot 1990) has formed the primary analytical tool used to assess Pacific cod. Although the Pacific cod stocks in the EBS and GOA are modeled separately, the model structures in recent years have been identical (Thompson and Dorn 1999, Thompson *et al.* 1999). No formal assessment model exists for the Aleutian Islands portion of the BSAI stock. Instead, results from the EBS assessment are inflated proportionally to account for Aleutian Islands fish.

Annual trawl surveys in the EBS and triennial trawl surveys in the Aleutian Islands and Gulf are the primary fishery-independent sources of data for Pacific cod stock assessments (Thompson and Dorn 1999, Thompson *et al.* 1999). For the most recent assessments, fishery size compositions were available, by gear, for the years 1978 through the first part of 1999. The catch history was divided into two portions determined by the relative importance of the domestic fishery. A “pre-domestic” portion was defined as those years in which the domestic fishery took less than half the catch, and a “domestic” portion was defined as those years in which the domestic fishery took at least half the catch. Within each year (in both portions of the time series), catches were divided according to three time periods: January-May, June-

August, and September-December. This particular division, which was suggested by participants in the EBS fishery, is intended to reflect actual intra-annual differences in fleet operation (e.g., fishing operations during the spawning period may be different than at other times of year). Four fishery size composition components were included in the likelihood functions used to estimate model parameters: the period 1 trawl fishery, the periods 2-3 trawl fishery, the longline fishery, and the pot fishery. In addition to the fishery size composition components, likelihood components for the size composition and biomass trend from the bottom trawl surveys were included in the model. All components were weighted equally.

Quantities estimated in the most recent stock assessments include parameters governing the selectivity schedules for each fishery and survey in each portion of the time series, parameters governing the length-at-age relationship, population numbers at age for the initial year in the time series, and recruitments in each year of the time series. Given these quantities, plus parameters governing natural mortality, survey catchability, the maturity schedule, the weight-at-length relationship, and the amount of spread surrounding the length-at-age relationship, the stock assessments reconstruct the time series of numbers at age and the population biomass trends (measured in terms of both total and spawning biomass). The model around which the most recent Pacific cod assessments are structured uses an assumed survey catchability of 1.0 and an assumed natural mortality rate of 0.37. Other outputs of the assessments include projections of biomass and harvest under a variety of reference fishing mortality rates. Based on these projections, the scientists responsible for conducting the assessments recommend a pair of ABC values for the coming year (one value for the BSAI and one for the GOA).

ABC as Recommended in the Most Recent Stock Assessments

Pacific cod is currently managed under tier 3 of the Council's ABC and OFL definitions (Amendment 44 to each of the respective FMPs). Management under tier 3 requires reliable estimates of projected biomass, $B_{40\%}$, $F_{40\%}$ (for ABC), and $F_{30\%}$ (for OFL). Under tier 3, the $F_{40\%}$ rate is the highest harvest rate permissible for stocks projected to be above the $B_{40\%}$ level in the coming year. For the BSAI, the base model in the 1999 assessment projected a 2000 ABC (maximum permissible) of 206,000 mt under an $F_{40\%}$ harvest strategy (Thompson and Dorn 1999). For the GOA, the base model in the 1999 assessment projected a 2000 ABC (maximum permissible) of 86,000 mt under an $F_{40\%}$ harvest strategy (Thompson *et al.* 1999). Because the yield corresponding to an $F_{40\%}$ harvest strategy is only the upper limit on ABC under tier 3a, the 1997 assessments considered whether reasons might exist to adopt lower ABC values. In this context, each assessment presented a decision-theoretic analysis of the statistical uncertainty surrounding the respective model’s projected $F_{40\%}$ catch level, specifically the uncertainty associated with the assumed values of the natural mortality rate (M=0.37) and survey catchability coefficient (q=1.0). These analyses resulted in a recommended 2000 ABC of 193,000 mt for the BSAI region and 76,400 mt for the GOA region.

2.4.4 Flathead Sole

Stock description, life history, and trophic interactions

Flathead sole (*Hippoglossoides elassodon*) is distributed from northern California northward throughout Alaska (Wolotira *et al.* 1993). In the northern part of its range, it overlaps with the related and very similar Bering flounder (*Hippoglossoides robustus*) (Hart 1973). Because it is difficult to separate these two species at sea, they are currently managed as a single stock (Walters and Wilderbuer 1997). Adults are benthic and occupy separate winter spawning and summer feeding distributions. From over-wintering grounds near the continental shelf margin, adults begin a migration onto the mid and outer continental shelf in April or May. The spawning period occurs in the spring, primarily in deeper waters near the margins of the continental shelf (Walters and Wilderbuer 1997). Eggs are large and pelagic. Upon hatching, the larvae are planktonic and usually inhabit shallow areas (Waldron and Vinter 1978). Exact age and size at maturity are unknown. The maximum age for flathead sole is approximately 20 years. An estimated natural mortality rate of 0.20 is used for stock assessment (Spencer et al. 1999a, Waldron and Vinter 1978). Flathead sole feed primarily on invertebrates (amphipods and decapods). In the EBS, other fish species represented 5-25% of their diet (Livingston *et al.* 1993).

Fishery, stock assessment, and ABC recommendation

Flathead sole are taken in bottom trawls both as a directed fishery and in pursuit of other bottom dwelling species. Recruitment to the fishery begins at age 3. Prior to 1977, the species was combined with other species in the "other flatfish" category. Catches from 1977 to 1989 averaged 5,286 mt, and then average increased to 17,706 mt from 1990 to 1998. However, the species is lightly exploited, and as of early October, only 26% of the 1999 TAC had been taken (Spencer et al. 1999a). The catch of flathead sole occurs on the EBS continental shelf northward to about 58°N, and between the 100-m and 200-m contour to the U.S. - Russian Convention Line. In the GOA, the catch is taken along the 200-m contour, with additional concentrations at Davidson Bank, around the Shumagin Islands, in Shelikof Strait, south of Shelikof Strait along the 200-m contour, and southeast and east of Kodiak Island out to the 200-m line (Fritz et al. 1998).

For the Bering Sea stock, the following information is available to assess stock status:

Data Component	Years of Data
Fishery catch	1977 to 1999
Foreign fishery size composition data	1977 to 1989
Domestic fishery size composition data	1990 to 1998
NMFS trawl survey biomass estimates	1982 to 1999
NMFS trawl survey size composition data	1982 to 1999
NMFS trawl survey age composition data	1980, 1982, 1985, 1992, 1995

Annual trawl survey biomass results have been the primary data component used to assess stock level since 1982, although all the above information was also input into a length-based stock assessment model for the first time in the 1997 stock assessment (Walters and Wilderbuer 1997). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate ABC.

The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE document. Based, in part, on an estimated spawning BSAI stock biomass of 261,342 mt in 2000, the stock assessment authors recommended an OFL of 89,958 mt and an ABC of 73,537 mt for this region. For information on flathead sole assessment in the GOA, see Section 2.4.8.

2.4.5 Rock Sole

Stock description, life history, and trophic interactions

Rock sole are distributed from southern California northward through Alaska (Wolotira *et al.* 1993). Two species of rock sole occur in the North Pacific ocean: a northern rock sole (*Lepidopsetta* sp. cf. *bilineata*) and a southern rock sole (*L. bilineata*). These species have an overlapping distribution in the GOA, but the northern species primarily comprises the BSAI population, which is managed as a single stock (Wilderbuer and Walters 1999). Adults are benthic and, in the EBS, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Spawning takes place during the late winter-early spring, near the edge of the continental shelf at depths of 125 to 250 m. Eggs are demersal and adhesive (Forrester 1964). The estimated age at 50% maturity for female rock sole is 9-10 years at a length of 35 cm (Wilderbuer and Walters 1997). The best estimate for natural mortality is 0.18 for the BSAI (Wilderbuer and Walters 1992) and 0.20 for the GOA (Turnock *et al.* 1997).

Fishery, stock assessment, and ABC recommendation

Commercial harvest of rock sole occurs primarily on the southeastern Bering Sea continental shelf between the-50 and 100-m contours, from the shelf break to the 100-m contour, and in lesser amounts in the Aleutian Islands region. Approximately 50% of rock sole are recruited to the fishery by age 7-8, and 100% by age 12. Catch has increased from less than 10,000 mt prior to 1982 to over 86,000 mt in 1988, and have averaged about 50,540 mt since 1987 (Wilderbuer and Walters 1999). In 1998, only 33,645 mt were taken, which was about 40% of the TAC. In 1999, 33,249 was taken through September 18 (Wilderbuer and Walters 1999).

Rock sole are important as the target of a high value roe fishery occurring in February and March, which accounts for the majority of the BSAI catch. Although female rock sole are highly desirable when in spawning condition, large amounts are discarded in other trawl fisheries during the rest of the year.

Stock assessment is based, in part, on the following information.

Data Component	Years of Data
Trawl Fishery catch at age	1980 to 1998
Trawl survey population age composition	1975, 1979 to 1998
Catch weight	1975 to 1998
Trawl survey biomass estimates and Standard Error	1982 to 1999
Maturity Schedule	1993 to 1994
Mean weight at age	1985 to 88

The time-series of fishery and survey age compositions allows the use of an age-based stock assessment model (Wilderbuer and Walters 1999). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE document. Based, in part, on an estimated spawning BSAI stock biomass of 675,500 mt in 2000, the stock assessment authors recommended an OFL of 272,500 mt and an ABC of 229,500 mt for this region. For information on rock sole assessment in the GOA, see Section 2.4.8.

2.4.6 Greenland Turbot

Stock description, life history, and trophic interactions

Greenland turbot (*Reinhardtius hippoglossoides*) are distributed from Baja California northward throughout Alaska. The species is rare south of Alaska and is primarily distributed in the eastern BSAI region (Hubbs and Wilimovsky 1964). Juveniles are believed to spend the first three or four years of life on the continental shelf and then move to the continental slope as adults (Alton *et al.* 1988, Templeman 1973). Greenland turbot are demersal to semi-pelagic. Unlike most flatfish, the migrating eye of Greenland turbot does not move completely to one side, but stops at the top of the head, which presumably results in a greater field of vision and helps to explain this species' tendency to feed off the sea bottom (de Groot 1970). Spawning occurs in winter and may be protracted, starting as early as September and continuing until March (Bulatov 1983). The eggs are benthypelagic (suspended in the water column near the bottom) (D'yakov 1982).

Juveniles are absent in the Aleutian Islands region, suggesting that populations in that area originate from elsewhere (Alton *et al.* 1988). Greenland turbot are a moderately long-lived species, with a maximum recorded age of 21 years (Ianelli and Wilderbuer 1995) and an estimated natural mortality rate of 0.18 (Ianelli *et al.* 1999). Pelagic fish are the main prey of Greenland turbot, with pollock often a major species in the diet (Livingston 1991b). Greenland turbot also feed on squid, euphausiids and shrimp.

Fishery, stock assessment, and ABC recommendation

Greenland turbot have been fished primarily along the 200-m contour of the shelf break in the Bering Sea from the horseshoe area just north of the Aleutian Islands to the U.S. - Russia Convention Line. Catches have declined from highs of 63,000 mt to 78,000 mt between 1972 to 1976 of 2,689 mt to 14,731 mt from 1985 to the present.

Abundance of juvenile Greenland turbot is estimated in the EBS by the annual trawl survey and in the Aleutian Islands by the triennial trawl survey. Abundance of adults has been estimated by trawl slope surveys conducted cooperatively by the U.S. and Japan. In the GOA, abundance is estimated by the triennial trawl survey. A lack of deepwater samples, however, creates a high degree of uncertainty for these estimates (Ianelli et al. 1999). The biomass of Greenland turbot in the BSAI increased during the 1970s and is currently estimated to be about half of the unfished level.

The following information is available to assess the stock condition of Greenland turbot in the BSAI.

Data Component	Years of Data
Trawl survey size-at-age	1975, 1979 to 1982
Shelf survey size composition and biomass	1979 to 1999
Slope survey size composition and biomass	1979, 1981, 1982, 1985, 1988, 1991
Longline survey size comp and abundance index	1984 to 1993
Total fishery catch data	1960 to 1999
Trawl fishery CPUE index	1978 to 1984
Trawl fishery size compositions	1977 to 1987,1989 to 1991, 1993 to 1998
Longline catch size composition	1977, 1979 to 1985, 1992 to 1998

The time-series of fishery and survey length compositions allows the use of a length-based stock assessment model (Ianelli *et al.* 1997). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE document. A lack of recruitment success during recent years has led to extra caution in setting harvest levels. Greenland turbot is a relatively valuable species, however, because of low ABC and TAC amounts, it is primarily a bycatch only fishery. For 2000, the stock assessment authors recommend a OFL of 42,000 mt and an ABC of 9,300 mt.

2.4.7 Yellowfin Sole

Stock description, life history, and trophic interactions

Yellowfin sole (*Limanda aspera*) is the most abundant flatfish species in the EBS and is the target of the largest flatfish fishery in the United States. The species is distributed from British Columbia to the Chukchi Sea (Hart 1973). In the Bering Sea, yellowfin sole inhabit the Bering Sea shelf and are considered one stock. The species is also found in the Aleutian Islands and GOA, but stock sizes are negligible in those areas.

Adults are benthic and occupy separate winter spawning and summer feeding grounds. Adults overwinter near the shelf-slope break at approximately 200 m and move into nearshore spawning areas as the shelf ice recedes (Nichol 1997). Spawning is protracted and variable, beginning as early as May and continuing through August. Spawning occurring primarily in shallow water at depths less than 30 m (Wilderbuer *et al.* 1992). Eggs, larvae and juveniles are pelagic and usually are found in shallow areas (Nichol 1994). The estimated age at 50% maturity is 10.5 years at a length of approximately 29 cm (Nichol 1994). The natural mortality rate likely falls within the range of 0.12 to 0.16, with a maximum recorded age of 33 years (Wilderbuer 1997). Yellowfin sole feed primarily on benthic invertebrates, with polychaetes, amphipods, decapods and clams dominating the diet in the EBS (Livingston 1993).

Fishery, stock assessment, and ABC recommendation

Yellowfin sole stocks were over-exploited by foreign fisheries in 1959-1962. Since that time, indices of relative abundance have shown major increases in abundance during the late 1970s. Since 1981, abundance has fluctuated widely but biomass estimates indicate that the yellowfin sole population remains at a high, stable level. The 1997 catch was 181, 389 mt (the largest since the fishery became completely domestic), and the 1998 catch decreased to 101,201 mt (Wilderbuer and Nichol 1999). The 1999 catch through September 18 has been 58,972, or 28% of the 1999 ABC. Catch of yellowfin sole (by bottom trawling) has been concentrated in the central portion of the southeastern Bering Sea continental shelf between the 50-m and 100-m contours (Fritz et al. 1998). Recruitment to the fishery occurs at about age seven.

Information on yellowfin sole stock conditions in the BSAI comes primarily from the annual EBS trawl survey. This species represents a “data-rich” case where the following stock assessment information is available.

Data Component	Years of Data
Trawl Fishery catch-at-age	1964 to 1998
Trawl survey population age composition	1975, 1979 to 1998
Catch weight	1954 to 1998
Trawl survey biomass estimates and S.E..	1982 to 1999
Maturity schedule	1992 to 1993
Mean weight at age	1979 to 1990

Estimates of yellowfin sole biomass derived from these surveys have been more variable than would be expected for a comparatively long-lived and lightly exploited species (Wilderbuer 1997). The reason for this variability is not known. However, Nichol (1997) hypothesized that much of the yellowfin sole resource is found at depths less than 30 m during the summer when bottom trawl surveys are conducted. This would probably cause the survey to underestimate the abundance of yellowfin sole. The time-series of fishery and survey age compositions allows the use of an age-based stock assessment model (Wilderbuer and Nichol 1999). The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE document. Based on stock analysis and modeling, stock assessment authors recommend for 2000 an OFL of 226,000 mt and an ABC of 190,600 mt. For information on the GOA yellowfin sole assessment see Section 2.4.8.

2.4.8 Arrowtooth Flounder

Stock description, life history, and trophic interactions

Arrowtooth flounder (*Atheresthes stomias*) is common from Oregon through the EBS (Allen and Smith 1988). The very similar Kamchatka flounder (*Atheresthes evermanni*) also occurs in the Bering Sea. Because it is not usually distinguished from arrowtooth flounder in commercial catches, both species are managed as a group. Arrowtooth flounder is a relatively large flatfish that occupies continental shelf waters almost exclusively until age 4, but at older ages occupies both shelf and slope waters, with concentrations at depths between 100 and 200 m (Martin and Clausen 1995). Spawning is protracted and variable and probably occurs from September through March (Zimmermann 1997). For female arrowtooth flounder collected off the Washington coast, the estimated age at 50% maturity was 5 years with an average length of 37 cm. Males matured at 4 years and 28 cm (Rickey 1995). The maximum reported age is 15 years in the Bering Sea and 21 years in the GOA, with a natural mortality rate used for assessment purposes of 0.2 (Wilderbuer and Sample 1999, Turnock et al. 1999). Arrowtooth flounder are important as a large and abundant predator of other groundfish species. Adults are almost exclusively piscivorous and over half their diet can consist of pollock (Livingston 1991b).

Fishery, stock assessment, and ABC recommendations

Arrowtooth flounder has a low perceived commercial value because the flesh softens soon after capture, possibly owing to an enzyme released by a parasite (Greene and Babbitt 1990). It is primarily taken by bottom trawls as bycatch in other high value fisheries. Stocks are lightly exploited and appear to be increasing in both the GOA and the BSAI. Information on arrowtooth flounder stock conditions in the BSAI comes from the annual EBS trawl survey, the triennial slope survey and catch in the commercial fishery:

Data Component	Years of Data
Fishery catch	1970 to 1999
Shelf survey biomass and Southeast	1982 to 1999
Slope survey biomass and Southeast	1981,82,85,88,91
Shelf survey size composition (by sex)	1979 to 1999
Slope survey size composition (by sex)	1981,82,85,88,91
Fishery length-frequencies from observers	1978 to 1991

The time-series of fishery and survey size compositions allows the use of a size-based stock assessment model (Wilderbuer and Sample 1999). The outputs include estimates of sex-specific abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate ABC. The stock assessment is updated annually at the conclusion of the summer trawl survey and is incorporated into the BSAI SAFE document.

Arrowtooth flounder fall into tier 3a of the ABC/OFL definition, because equilibrium recruitment could be approximated by the average recruitment from the time-series estimated in the stock assessment, and $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ could be estimated. For 2000, $B_{current}>B_{40\%}$ for arrowtooth flounder, and ABC was based on the $F_{40\%}$ fishing mortality rate because reliable estimates of F_{MSY} and B_{MSY} were unavailable. For the BSAI, the 2000 OFL and ABC recommendations of the stock assessment authors are 160,200 mt and 130,500 mt, respectively.

Information on GOA arrowtooth flounder used for stock assessments is available from the following sources:

Data Component	Years of Data
Fishery catch	1960 to 1999

IPHC trawl survey biomass and S.E.	1961 to 1962
NMFS research trawl survey biomass and S.E.	1973 to 1976
NMFS triennial trawl survey biomass and S.E.	1984, 1987, 1990, 1993, 1996, 1999
Fishery size compositions	1977 to 1981, 1984 to 1993,1995, 1996
NMFS triennial trawl survey size compositions	1975, 1999
NMFS triennial trawl survey age composition data	1984, 1987, 1990, 1993, 1996

The time-series of fishery and survey size compositions allows the use of a size-based stock assessment model (Turnock *et al.* 1999). The outputs include estimates of sex-specific abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate ABC. The stock assessment is updated annually and incorporated into the GOA SAFE document.

The reference fishing mortality rate and ABC for GOA arrowtooth flounder are determined by the amount of population information available. For 2000, this species falls in the tier 3a category. For the GOA stock in 2000, the stock assessment authors recommend OFL and ABC of 173,915 mt and 145,361 mt, respectively. The ABC would be partitioned with 16,615 mt to the western GOA, 97,712 mt to the central GOA, 23,768 mt to West Yakutat, and 7,715 mt to East Yakutat/Southeast.

2.4.9 Other Flatfish

In the Bering Sea, eight other flatfish species are managed under the FMPs (Alaska plaice (*Pleuronectes quadrituberculatus*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), starry flounder (*Platichthys stellatus*), English sole *(Parophrys vetulus*), butter sole (*Isopsetta isolepis*), sand sole (*Psettichthys melanostictus*) and deep sea sole (*Embassichthys bathybius*). Adults of all species are benthic and occupy separate winter spawning and summer feeding grounds. Adults overwinter in deeper water and move into nearshore spawning areas in the late winter and spring. Spawning takes place as early as November for Dover Sole (Hagerman 1952) but occurs from February through April for most species (Hart 1973). All flatfish eggs are pelagic and sink to the bottom shortly before hatching (Alderdice and Forrester 1968, Hagerman 1952, Orcutt 1950, Zhang 1987), except for butter sole, which has demersal eggs (Levings 1968).

In the Bering Sea, Alaska plaice is the most abundant and commercially important of the other flatfish species. It is a comparatively long-lived species, and has frequently been aged as high as 25 years. For stock assessment purposes, a natural mortality rate of 0.25 is used (Spencer et al. 1999b). Alaska plaice appear to feed primarily on polychaetes, marine worms and other benthic invertebrates (Livingston and DeReynier 1996, Livingston *et al.* 1993). Flatfish consume a variety of benthic prey, including fish, polychaetes, crustaceans, and mollusks.

These other flatfish are taken as bycatch in bottom trawl fisheries for other groundfish. Alaska plaice are also taken in directed bottom trawl fisheries in the EBS. Because other flatfish are generally not targeted, commercial catch data is of limited use for stock assessment purposes. The principal source of information for evaluating the condition of other flatfish stocks in the BSAI is the annual EBS trawl survey.

A moderate amount of information is available for Alaska plaice in the Bering Sea and is summarized below.

Data Component	Years of Data
Proportional catch number at age	1971-79, 1988, 1995
Total catch weight	1971 to 1999
Survey biomass and standard error	1975, 1979 to 1999
Survey age composition	1979, 1981, 1982, 1988, 1992 to 1995, 1998

The available data is sufficient to use an age-based stock assessment model for Alaska plaice (Spencer et al. 1999b). The output includes estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate OFL and ABC. For 2000, the estimated OFL and ABC were 122,659 mt and 101,913 mt, respectively. For the rest of the species of the "other flatfish" management group, OFLs and ABCs for 2000 were estimated using the catch equation to apply the $F_{40\%}$ and $F_{35\%}$ estimated from the 1999 flathead sole assessment to the 1999 survey biomass of miscellaneous flatfish. For these species combined, estimated OFL and ABC for 2000 were 18,772 mt and 15,506 mt, respectively.

The other flatfish species complex in the GOA is currently managed as four categories with separate ABCs: shallow-water flatfish, deep-water flatfish, flathead sole (*Hippoglossoides elassodon*) and rex sole (*Glyptocephalus zachirus*). The shallow-water flatfish consists of Alaska plaice (*Pleuronectes quadrituberculatus*), starry flounder (*Platichthys stellatus*), yellowfin sole (*Pleuronectes asper*), English sole (*Parophrys vetulus*), butter sole (*Isopsetta isolepis*), northern rock sole (*Lepidopsetta perarcuata*) and southern rock sole (*Pleuronectes bilineatus*). Deep-water flatfish are: Dover sole (*Microstomus pacificus*), Greenland turbot (*Reinhardtius hippoglossoides*) and deepsea sole (*Embassichthys bathybius*).

The classification into the shallow-water and deep-water groups was due to significant differences in halibut bycatch rates in directed fisheries targeting on shallow- and deep-water flatfish species. Flathead sole were assigned a separate ABC due to their overlap in depth distribution of the shallow and deep water groups. In 1993 rex sole was split out of the deep-water management category because of concerns regarding the Pacific ocean perch bycatch in the rex sole target fishery. The shallow-water category catch in 1997 was about 66% rock sole (southern and northern combined), 25% butter sole, 6% starry flounder, 1% English sole, and the remaining 2%consisted of yellowfin sole, Alaska plaice and sand sole. The deep-water catch is practically all Dover sole (over 99% in 1997). In 1998, these flatfish categories were lightly to moderately harvested, with catches amounting to 5%, 50%, 7%, and 29% of the shallow-water flatfish, deep-water flatfish, flathead sole, and rex sole ABCs, respectively.

The information available for each species varies.

Data Component	Years of Data
Age composition from surveys-not all species	Various years
Triennial bottom trawl survey biomass and S.E.	1984, 1987, 1990, 1993, 1996, 1999
Total fishery catch weight by management category	Various years
Survey size composition	1984, 1987, 1990, 1993, 1996, 1999

Natural mortality was assumed to be 0.2 for all flatfish species except Dover sole where M is 0.1. ABCs for all flatfish except rock sole, deep-sea sole, and Greenland turbot were calculated using F_{ABC} = 0.75M and F_{OFL} = M (tier 5) (Turnock et al. 1999). Rock sole falls in tier 4, where $F_{ABC} = F_{40\%}$ and $F_{OFL} = F_{35\%}$. Deep-sea sole and Greenland turbot fall in tier 6, where ABC = 0.75 OFL and OFL = the average catch from 1978 to 1995. ABCs and OFLs are presented below for each management group.

Management group	2000 ABC	2000 OFL
Shallow-water	37,855	45,326
Deep-water	5,300	6,984
Flathead sole	26,264	34,208
Rex sole	9,442	12,298

2.4.10 Sablefish

Stock description, life history, and trophic interactions

Sablefish is found from northern Mexico to the GOA, westward to the Aleutian Islands, and in gullies and deep fjords, generally at depths greater than 200 m. Sablefish observed from a manned submersible were found on or within 1 m of the bottom (Krieger 1997). Several studies have shown sablefish to be highly migratory for at least part of their life cycle (Heifetz and Clausen 1991, Maloney and Heifetz 1997), and substantial movement between the BSAI and the GOA has been documented (Heifetz and Clausen 1991). Thus sablefish in Alaskan waters (BSAI and GOA combined) are assessed as a single stock (Sigler *et al.* 1999). Adults reach maturity at 4 to 5 years and a length of 51 to 54 cm (McFarlane and Beamish 1990). Spawning is pelagic at depths of 300-500 m near the edges of the continental slope (McFarlane and Nagata 1988). Juveniles are pelagic and appear to move into comparatively shallow near-shore areas where they spend the first 1 to 2 years (Rutecki and Varosi 1997). Sablefish are long-lived, with a maximum recorded age in Alaska of 62 years (Sigler *et al.* 1997b). For stock assessments, a natural mortality rate of 0.10 is used (Sigler *et al.* 1997a).

Sablefish are opportunistic feeders. Feeding studies conducted in Oregon and California, found that fish made up 76% of the diet (Laidig *et al.* 1997). Other studies, however, have found a diet dominated by euphausiids (Tanasichuk 1997). Larval sablefish feed on a variety of small zooplankton ranging from copepod nauplii to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids). The older demersal juveniles and adults appear to be opportunistic feeders, with food ranging from variety of benthic invertebrates, benthic fishes, as well as squid, mesopelagic fishes, jellyfish, and fishery discards. Gadid fish (mainly pollock) comprise a large part of the sablefish diet. Nearshore residence during their second year provides the opportunity to feed on salmon fry and smolts during the summer months. Young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the southeast troll fishery during the late summer.

Fishery, stock assessment, and ABC recommendation

Sablefish are allocated between trawl and hook-and-line (longline) gear in both the BSAI and GOA. In the BSAI, the fishery occurs along the continental shelf break (200-m contour) or in adjacent deeper waters (particularly in the horseshoe area just north of the eastern Aleutian Islands), and at sites scattered throughout the Aleutian Islands. In the GOA, the fishery occurs primarily along the shelf break (200-m contour) or in adjacent deeper waters. In the eastern GOA regulatory area, trawl gear may only retain sablefish as bycatch in other trawl fisheries. The directed fishery is prosecuted by hook-and-line, and the hook-and-line allocation is utilized entirely by an individual fishing quota program (IFQ). Each year the Regional Administrator determines the opening and closing dates of the IFQ sablefish fishery, taking into account the opening date of the Pacific halibut fishery so that they may be concurrent. Since the beginning of the IFQ management program, the open season for hook-and-line gear has been from March 15 through November 15 each fishing year in both FMP areas. The IFQ season for longline pot gear in the BSAI is from March 15 through May 30 and from June 30 through November 15.

Abundance has fallen in recent years because recent recruitment is insufficient to replace older, strong year-classes which are dying off (e.g. 1990 and 1995). The dominant factor determining the age composition of the recruited population is the magnitude of the recruiting year classes. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of a fished population with a several-decade catch history. How the current age composition of the population compares with the unfished population is unknown.

As noted above, Alaskan sablefish are considered a single stock and assessed in a combined area (Bering Sea, Aleutian Islands, and GOA) with an age-structured model incorporating fishery and survey catch data and age and length compositions. Survey data come from annual sablefish longline surveys in the GOA, and biennial longline survey in the Aleutian Islands and the Bering Sea. These surveys indicate that the stock size peaked in the mid-1980s because of a series of strong year classes, and has been declining since. The stock assessment includes catch history, fishery description, assessment methods, abundance and exploitation trends, and projected catch and abundance. Sablefish fall into tier 3 of the ABC/OFL definitions. Under the definitions and projected stock conditions in 2000, the OFL and ABC recommendations were 17,200 mt and 17,000 mt, respectively.

2.4.11 Rockfish

At least 32 rockfish species of the genus *Sebastes* and *Sebastolobus* have been reported to occur in the GOA and BSAI (Eschmeyer *et al.* 1984), and several are of commercial importance. Pacific ocean perch (*S. alutus*) has historically been the most abundant rockfish species in the region and has contributed most to the commercial rockfish catch. Other species such as northern rockfish (*S. polyspinis*), rougheye rockfish (*S. aleutianus*), shortraker rockfish (*S. borealis*), shortspine thornyheads (*S. alascanus*), yelloweye rockfish (*S. ruberrimus*), and dusky rockfish (*S. ciliatus*) are also important to the overall rockfish catches.

Rockfish in the GOA is currently managed as four assemblages: 1) slope rockfish, 2) pelagic shelf rockfish, 3) demersal shelf rockfish, and 4) thornyheads. Separate ABCs, OFLs, and TACs are set for each assemblage except for slope rockfish which is further subdivided into four subgroups with separate ABCs, OFLs, and TACs: 1) Pacific ocean perch, 2) shortraker and rougheye rockfish, 3) northern rockfish, and 4) "other slope rockfish".

Rockfish in the BSAI are currently managed as two assemblages; 1) Pacific ocean perch complex and 2) other rockfish. The Pacific ocean perch complex includes Pacific ocean perch, rougheye rockfish, shortraker rockfish, sharpchin rockfish, and northern rockfish. For the EBS region, the Pacific ocean complex is divided into two subgroups with: 1) Pacific ocean perch, and 2) shortraker, rougheye, sharpchin, and northern rockfish combined. For the Aleutian Island region, the Pacific ocean perch complex is divided into three subgroups: 1) Pacific ocean perch, 2) shortraker and rougheye rockfish, and 3) sharpchin and northern rockfish. Separate ABC, and TAC, and OFLs are assigned to each subgroup. Other rockfish includes all Sebastes and Sebastolobus species in the BSAI region other than the Pacific ocean perch complex. Shortspine thornyheads account for most of the estimated biomass and commercial catch of the other rockfish assemblage in the BSAI.

Rockfish fisheries open July 1 for trawl gear and January 1 for other gear types and close December 31 in both FMP areas if the NMFS determines the TACs available are large enough to manage the fishery. BSAI Plan Amendment 53 allocated 70% of the shortraker and rougheye rockfish TAC in the Aleutian Islands subarea to trawl gear and 30% to non-trawl gear. For several rockfish targets, the Regional Administrator has established a directed fishery allowance of 0 mt after considering the amount of incidental catch expected in other directed fisheries. These actions have effectively closed directed fishing for rockfish throughout the year in all, or portions of, the BSAI and GOA.

Rockfish are assessed with either an age-structured model or trawl a model based on trawl surveys, depending on the management group. Pacific ocean perch are assessed with an age-structured model incorporating fishery and survey catch and age composition data. Most other species of rockfish are assessed based on trawl survey catch data. Survey data are from the NMFS triennial trawl surveys. The stock assessments provide the best available information. For all rockfish management groups the assessment includes catch history, characterizations of the fishery, assessment methodology, and abundance and exploitation trends. The results of the analyses, which are updated annually, are presented in the GOA and BSAI stock assessment report, which is incorporated into the Council's SAFE reports.

Pacific ocean perch

Pacific ocean perch is primarily a demersal species which inhabits the outer continental shelf and slope regions of the North Pacific and Bering Sea, from southern California to Japan (Allen and Smith 1988). As adults, they live on or near the sea floor, generally in areas with smooth bottoms (Krieger 1993) and generally at depths ranging from 180 to 420 m.

Though more is known about the life history of Pacific ocean perch than about other rockfish species (Kendall and Lenarz 1986), much uncertainty still exists about its life history. Pacific ocean perch are viviparous, with internal fertilization and the release of live young (Hart 1973). Insemination occurs in the fall, and release of larvae occurs in April or May. Pacific ocean perch larvae are thought to be pelagic and drift with the current. Juveniles seem to inhabit rockier, higher relief areas than adults (Carlson and Straty 1981, Krieger 1993). Pacific ocean perch is a slow growing species that, in the GOA, reaches maturity at approximately 10 years, or 36 cm in length (Heifetz *et al.* 1997) and has a maximum life span of 90 years (Chilton and Beamish 1982). The natural mortality rate likely is between 0.02 and 0.08 (Archibald *et al.* 1981, Chilton and Beamish 1982).

The diets of commercially important groundfish species in the GOA during the summer of 1990 were analyzed by Yang (1993). About 98% of the total stomach content weight of Pacific ocean perch in the study was made up of invertebrates and 2% of fish. Euphausiids (mainly *Thysanoessa inermis*) were the most important prey item. Euphausiids comprised 87% by weight of the total stomach contents. Calanoid copepods, amphipods, arrow worms, and shrimp were frequently eaten by Pacific ocean perch. Documented predators of Pacific ocean perch include Pacific halibut and sablefish, and it likely that Pacific cod and arrowtooth flounder also prey on Pacific ocean perch. Pelagic juveniles are consumed by salmon, and benthic juveniles are eaten by lingcod and other demersal fish.

Commercially, Pacific ocean perch is the most important rockfish in Alaska's fisheries and is taken almost exclusively with bottom trawls. The species is highly valued and supported large Japanese and Soviet trawl fisheries throughout the 1960s. Apparently, stocks were not productive enough to support the large removals that took place, and they declined throughout the 1960s and 1970s, reaching their lowest levels in the early 1980s. Since that time, stocks have stabilized in the EBS, and increased in the Aleutian Islands and GOA.

In the BSAI, Pacific ocean perch are assessed with an age-structured model incorporating fishery and survey catch data and age compositions. Survey data are from the NMFS triennial trawl groundfish surveys and the fishery data comes from the observer program. The stock assessment includes catch history, characterizations of the fishery, assessment methodology, abundance and exploitation trends, and projected catch and abundance trends for a range of fishing mortalities and recruitment assumptions (Ito et al. 1999). The assessments for the other species in the POP complex and for the "other rockfish" management category are based on substantially less information (Ito and Spencer 1999). For 2000, the stock assessment authors recommended an ABC of 12,300 mt for the Aleutian Islands and 2,600 mt for the EBS.

The current age and size distributions of Pacific ocean perch in the GOA are discussed in Heifetz *et al.* (1999). The age composition estimated from the stock assessment model is dominated by recent strong year classes from 1986, and considerable numbers from the strong 1976 and 1980 year classes are still in the population. The dominating factor determining the age composition is the magnitude of the recruiting year classes which are highly variable. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of a fished population with a 37-year catch history. It is not certain how the current age composition of the population compares with the unfished population.

In the GOA, the directed fishery for Pacific ocean perch is prosecuted by catcher-processor and catcher bottom trawlers. The fishery generally occurs at depths between 150 and 300 m along the outer continental shelf, the upper continental slope and at the mouth of gullies. Important Pacific ocean perch fishery locations include: in the Eastern GOA, the gully and slope southwest of Yakutat Bay and off Cape Omaney; in the Central GOA, the shelf, slope and gullies off of Kodiak Island south of Portlock Bank and near Albatross Bank; and in the western GOA, the shelf and slope south of Unimak and Umnak Islands.

In the GOA, Pacific ocean perch are caught as bycatch (not necessarily discarded) in other directed fisheries aimed mostly at other species of rockfish. Heifetz and Ackley (1997) analyzed bycatch in rockfish fisheries of the GOA. Bycatch rates of Pacific ocean perch are highest in the pelagic shelf rockfish, "other slope rockfish", and shortspine thornyhead fisheries. Information on bycatch in non-rockfish fisheries has not been analyzed. Recent discard rates (discards/total catch) of Pacific ocean perch were 14% in 1998, but have been as high as 79% in 1993 (Heifetz *et al.* 1999).

A time series of fishery and survey age compositions allows the use of an age-based stock assessment model for Pacific ocean perch. The outputs include estimates of abundance, spawning biomass, fishery and survey selectivity, exploitation trends, and projections of future biomass. The model also estimates reference fishing mortality rates in terms of the ratio of female spawning biomass to unfished levels which are used to calculate ABC. Based on the stock analysis and modeling, the stock assessment authors recommended an ABC of 13,020 mt.

Shortraker and rougheye rockfish

Shortraker and rougheye rockfish inhabit the outer continental shelf of the north Pacific from the EBS as far south as southern California (Kramer and O'Connell 1988). Adults of both species are semi-demersal and are usually found in deeper waters (from 50 to 800 m) and over rougher bottoms than Pacific ocean perch. Little is known about the biology and life history of these species, but they appear to be long-lived, with late maturation and slow growth. Shortraker rockfish have been estimated to reach ages in excess of 120 years and rougheye rockfish in excess of 140 years. Natural mortality rates have been estimated by Heifetz and Clausen (1991) at 0.025 for rougheye rockfish and 0.030 for shortraker rockfish. Length at 50% sexual maturity is about 45 cm for shortraker rockfish and about 44 cm for rougheye rockfish (McDermott 1994). Like other members of the genus Sebastes, they are viviparous (bear live young) and parturition occurs in the early spring through summer (McDermott 1994).

Food habit studies conducted by Yang (1993) indicate that the diet of rougheye rockfish is dominated by shrimp. The diet of shortraker rockfish is not well known, but based on a small number of samples the diet appears to be dominated by squid. Because shortraker rockfish have large mouths and short gill rakers, it is possible that they are potential predators of other fish species (Yang 1993). Though shortraker/rougheye are highly valued, amounts available to the commercial fisheries are limited by relatively small TAC and ABC amounts that are taken as bycatch in other groundfish fisheries. As a result, the directed fishery for these species typically is closed at the beginning of the fishing year.

The primary methods of harvest for shortraker and rougheye rockfishes are bottom trawl and longline gears. The bulk of the commercial harvest usually occurs at depths between 200 and 500 m along the upper continental slope. Both species are associated with a variety of habitats from soft to rocky habitats, although boulders and sloping terrain appear also to be desirable habitat. Age at recruitment is uncertain, but is probably on the order of 20+ years for both species.

A sufficient time series of fishery and survey age compositions is not available to construct an age-based stock assessment model for shortraker and rougheye rockfish. Thus assessment is based mostly on biomass estimates provided by trawl surveys. Life history information allows estimates of reference fishing mortality rates which are used to calculate ABC. For 2000, the stock assessment authors recommended ABCs of 160 mt in the EBS, 885 mt in the Aleutian Islands, and 1730 mt in the GOA (Ito et al. 1999, Heifitz et al. 1999).

In recent years a directed fishery for shortraker and rougheye rockfish has not been allowed, because TACs are small. Shortraker and rougheye rockfishes are often caught as bycatch and retained in the sablefish and halibut longline fisheries and fisheries targeting other species of rockfish. Heifetz and Ackley (1997) analyzed bycatch (not necessarily discarded) in rockfish fisheries of the GOA. Bycatch rates of shortraker and rougheye rockfish are highest in the shortspine thornyhead and Pacific ocean perch fisheries. An analysis of bycatch rates in non-rockfish fisheries has not been conducted. Discard rates (discards/total catch) of shortraker and rougheye rockfish during 1996 to 1997 have been about 22% (Heifetz and Ackley 1997). In 1997, about 430 mt of shortraker and rougheye rockfish were discarded compared to a total catch of 1,600 mt.

Northern rockfish

Northern rockfish inhabit the outer continental shelf from the EBS, throughout the Aleutian Islands and the GOA (Kramer and O'Connell 1988). This species is semi-demersal and is usually found in comparatively shallower waters of the outer continental slope (from 50 to 600 m). Little is known about the biology and life history of northern rockfish. However, they appear to be long lived, with late maturation and slow growth. Heifetz and Clausen (1991) estimated the natural mortality rate for northern rockfish to be 0.060. Like other members of the genus Sebastes, they bear live young, and parturition occurs in the early spring through summer (McDermott 1994). Food habit studies conducted by Yang (1993) indicate that the diet of northern rockfish is dominated by euphausiids. Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities. Predators of northern rockfish are not well documented but likely include larger fish such as Pacific halibut that are known to prey on other rockfish species.

Although northern rockfish are lower in value than Pacific ocean perch, they still support a valuable directed trawl fishery, especially in the GOA. The directed fishery for northern rockfish is prosecuted by catcher-processor and catcher bottom trawlers. The patterns of the fishery generally reflect the distribution of the species. The fishery is concentrated at discrete, relatively shallow offshore banks of the outer continental shelf at depths between 75 and 125 m. Important northern rockfish fishery locations include Portlock Bank and Albatross Bank south of Kodiak Island, Shumagin Bank south of the Shumagin Islands, and Davidson Bank south of Unimak Island.

The age and size distributions of northern rockfish are discussed in Heifetz *et al.* (1999) and Ito et al. (1999). The most recent age-composition information for northern rockfish is from the 1996 GOA trawl survey. The age composition is dominated by recent strong 1984 and 1985 year classes and, considerable numbers from strong 1968-1971 and 1975-1977 year classes are still in the population. The dominating factor determining the age composition is the magnitude of the recruiting year classes, which is highly variable. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality. It is not certain how the current age composition of the population compares with the unfished population.

Heifetz and Ackley (1997) analyzed bycatch (not necessarily discarded) in rockfish fisheries of the GOA. Bycatch rates of northern rockfish are highest in the pelagic shelf rockfish, “other slope rockfish”, and Pacific ocean perch fisheries. Information on bycatch of northern rockfish in non-rockfish fisheries has not been analyzed. Discard rates (discards/total catch) of northern rockfish during 1996 to 1997 have been about 22% (Heifetz and Ackley 1997). In 1997, about 820 mt of northern rockfish were discarded compared to a total catch of 2,900 mt.

Northern rockfish fall into tier 4 of the ABC/OFL definitions. For the GOA, the stock assessment authors (Heifitz et al. 1999) recommended an ABC for 2000 of 5,120 mt. The ABC estimate was confounded by highly variable results from the most recent trawl survey. Adjustments were made to account for that uncertainty in estimating the ABC, to afford more protection given the variability and uncertainty associated with the estimated abundance. For the EBS and Aleutian Islands, the stock assessment authors (Ito et al. 1999) recommended ABCs of 34 mt and 5,153 mt, respectively.

Pelagic shelf rockfish

Dusky rockfish is by far the most important species in the group, both in terms of abundance and commercial value, although black rockfish has also been of some importance. As of April 1998, however, black rockfish were removed from both the pelagic shelf group and the GOA groundfish FMP. Consequently, black rockfish are not discussed in this report, and the focus is on dusky rockfish.

Trophic interactions of dusky rockfish are not well known. Food habits information is available from just one study with a relatively small sample size for dusky rockfish (Yang 1993). This study indicated that adult dusky rockfish consume primarily euphausiids, followed by larvaceans, cephalopods, and pandalid shrimp. Predators of dusky rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

Dusky rockfish are caught almost exclusively with bottom trawls. Factory trawlers dominated the directed fishery from 1988 to 1995. Since 1996, some of catch has also been taken by shore-based trawlers for delivery to plants in Kodiak. Catches are concentrated at a number of relatively shallow, offshore banks of the outer continental shelf, especially the “W” grounds west of Yakutat, and Portlock Bank. Other fishing grounds include Albatross Bank, the “Snakehead” south of Kodiak Island, and Shumagin Bank. Catch distribution by depth has not been summarized, but most of the fish are apparently taken at depths of 75-200 m.

Dusky rockfish often co-occur with northern rockfish, and they are caught as bycatch in the northern rockfish and “other slope rockfish” fisheries (Heifetz and Ackley 1997). To a lesser extent, they are also taken as bycatch in the Pacific ocean perch fishery. Overall discard rates (discards/total catch) of dusky rockfish in recent years have been quite low, generally 10% or less (Clausen and Heifetz 1999).

In the GOA, pelagic shelf rockfish are assessed with a biomass-based model using data from the NMFS GOA triennial trawl surveys. The stock assessments provide the best available information for pelagic shelf rockfish, and include discussions of catch history, characterizations of the fishery, assessment methodology, and abundance and exploitation trends. Age and size distributions of dusky rockfish are based on results of the 6 triennial trawl surveys from 1984 to 1999, and are discussed in Clausen and Heifetz (1999). Age results are only available from the 1987, 1990, 1993, and 1996 surveys, and these show that substantial recruitment of dusky rockfish appears to be a relatively infrequent event. Strong year classes are only seen for 1976 to 1977, 1979 to 1980, and 1986. Mean age of the population in 1993 was 12 years. Likewise, the size compositions from each of the surveys indicate that recruitment of small fish to the survey occurred only in 1993, corresponding to the 1986 year class. The effects of fishing on the age and size compositions are unknown, as no age or size data are available from either the fishery, or the unfished population prior to the beginning of the fishery.

Pelagic shelf rockfish fall into tier 4 of the current ABC/OFL definitions. Stock assessment authors recommend a 2000 ABC of 5,980 mt, split among the western area (549 mt), central area (4,081 mt), and the eastern area (1,351 mt).

Demersal Shelf rockfish

Demersal Shelf Rockfish (DSR) include seven species of nearshore, bottom-dwelling rockfish: canary rockfish (*S. pinniger*), China rockfish (*S. nebulosus*), copper rockfish (*S. caurinus*), quillback rockfish (*S. maliger*), rosethorn rockfish (*S. helvomaculatus*), tiger rockfish (*S. nigrocinctus*), and yelloweye rockfish (*S. ruberrimus*). DSR are managed under the Council as a distinct assemblage only off southeast Alaska east of 140°W long. Yelloweye rockfish comprise 90% of the catch and will be the focus of this section.

Yelloweye rockfish occur on the continental shelf from northern Baja California to the EBS, commonly in depths less than 200 m (Kramer and O'Connell 1988). They are long-lived, slow growing, and late maturing. Yelloweye have been estimated to reach 118 years and their natural mortality rate is estimated at 0.20 (O'Connell and Funk 1987). They are viviparous with parturition occurring primarily in late spring through mid-summer (O'Connell 1987). Yelloweye inhabit areas of rugged, rocky relief and adults appear to prefer complex bottoms with the presence of “refuge spaces” (O'Connell and Carlile 1993).
Yelloweye are a large, predatory fish that usually feeds close to the bottom. Food habit studies indicate that the diet of yelloweye rockfish is dominated by fish remains, which comprised 95%, by volume, of the stomachs analyzed. Herring (*Clupea harengus*), sandlance (*Ammodytes hexapterus*) and Puget Sound rockfish (*S. empheaus*) were particularly dominant. Shrimp are also an important prey item (Rosenthal *et al.* 1988).

The age and size distributions of yelloweye rockfish are discussed in O’Connell *et al.* (1997) and O’Connell and Funk (1987). Estimated length and age at 50% maturity for yelloweye collected in Central Southeast Outside (CSEO) in 1988 are 45 cm and 21 years for females and 50 cm and 23 years for males. Age of first recruitment into the fishery is between 13 and 18 years. The most recent age data is from the 1996 commercial catch samples. Age frequency data from the commercial catch differs somewhat by management area. In CSEO, the area with the longest catch history, the 1996 distribution shows a strong mode at 27 years of age (1969 year class) with some younger recruitment. The older ages have declined in frequency over time and the average age continues to decline and remains the lowest of all areas. In Southern Southeast Outside (SSEO) the 1996 age data shows a pronounced mode at 43 years with smaller modes at 38, 27, and 20.

Some signs of younger recruitment are seen in this area, and although the older ages appear to be contributing less, the mean age remains stable at 41 years. In East Yakutat (EYKT), the 1996 age distribution is bimodal, the largest mode at 28 years and a second one at 39 years. Mean age of these samples is 38 years, somewhat lower than in past samples, and fish older than 60 are declining in frequency of occurrence. Unlike other areas, no sign of recruitment is seen here. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of a fished population with 20 years of directed catch in some areas, as well as many decades of bycatch. How the current age composition of the population compares with the unfished population is unknown.

The directed fishery for DSR is prosecuted by longliners. Yelloweye rockfish occur in areas of rugged, rocky bottom, commonly between 100 and 200 m. The lava fields off Cape Edgecumbe in CSEO and the offshore Fairweather Ground in EYKT are the most important fishing areas. A small amount of DSR are taken as bycatch in jig and troll fisheries. Trawling is prohibited in the eastern GOA. Yelloweye rockfish is the dominant bycatch species in the halibut longline fishery. The majority of the longline vessels in the eastern GOA are unobserved so it is difficult to get an accurate accounting of discard at sea. For the past several years we have estimated unreported mortality of DSR during the halibut fishery based on International Pacific Halibut Commission (IPHC) interview data. The 1993 interview data indicates a total mortality of DSR of 13% of the June halibut landings (by weight) and 18% of the September halibut landings. Unreported mortality data has been more difficult to collect under the halibut IFQ fishery and appears to be less reliable than previous data. The allowable bycatch limit of DSR during halibut fishing is 10% of the halibut weight. The total bycatch of DSR during the 1998 halibut fishery in the eastern GOA is estimated to be 300 mt, much of which is unreported. Catch statistics do not accurately reflect true mortality of DSR.

Traditional abundance estimation methods (e.g., area-swept trawl surveys, mark recapture) are not considered useful for these fishes given their distribution, life history, and physiology. However, ADF&G is continuing research to develop and improve a stock assessment approach for them. As part of that research a manned submersible, Delta, is used to conduct line transects (Buckland *et al.* 1993, Burnham *et al.* 1980). Density estimates are limited to adult yelloweye, because it is the principal species targeted and caught in the fishery, and therefore ABC/TAC recommendations for the entire assemblage are keyed to adult yelloweye abundance. Total yelloweye rockfish biomass is estimated for each management subdistrict as the product of density, mean weight of adult yelloweye, and areal estimates of DSR habitat (O'Connell and Carlile 1993). For estimating variability in yelloweye biomass, log-based confidence limits are used because the distribution of density tends to be positively skewed and density is assumed to be log-normal (Buckland *et al.* 1993). Estimation of both line length for the transects and total area of rocky habitat are difficult and result in some uncertainty in the biomass estimates. During the 1997 survey, the area estimate of rock habitat in the East Yakutat management area was reduced by 60% compared to past assessments, resulting in a similar reduction in the biomass estimate for this area. The sum of the lower 90% confidence limits of biomass, by area, is the reference number for setting ABC because of the continued uncertainty in yelloweye biomass estimation. This resulted in a biomass estimate of 25,031 mt for 1998.

DSR falls into tier 4 of the ABC/OFL definitions. However, the stock assessment authors recommend a more conservative method for setting ABC and TAC (O’Connell et al. 1999). They recommend an ABC for 2000 of 340 mt. Conservative management of this fishery is warranted given the life history of the species and the uncertainty of the biomass estimates.

Thornyheads

Thornyheads in Alaskan waters are comprised of two species, the shortspine thornyhead and the longspine thornyhead. Only the shortspine thornyhead is of commercial importance. It is a demersal species found in deep water from 93 to 1,460 m from the Bering Sea to Baja California. Little is known about thornyhead life history. Like other rockfish, they are long lived and slow growing. The maximum recorded age is probably in excess of 50 years, and females do not become sexually mature until an average age of 12 to 13 at a length of about 21 cm. Thornyheads spawn large masses of buoyant eggs during the late winter and early spring (Pearcy 1962). Juveniles are pelagic for the first year. Yang (1993, 1996) showed that shrimp were the top prey item for shortspine thornyheads in the GOA; while, cottids were the most important prey item in the Aleutian Islands region.

Until recently, thornyheads were not targeted by the commercial fishery. However, they are now among the most valuable rockfish species and are harvested by trawl and longline gear. Most of the domestic harvest is exported to Japan. Thornyheads are taken with some frequency in the longline fishery for sablefish and cod and are often part of the bycatch of trawlers concentrating on pollock and other rockfish species.

In the GOA, shortspine thornyheads are assessed with an age-structured model incorporating data from two fisheries (longline and trawl) and two types of survey data. Bottom trawl surveys are conducted every three years in the GOA during June through August and provide a limited time-series of abundance since 1977. Longline surveys occur annually and extend into the deeper waters (300 – 800 m) of shortspine thornyhead habitat. Both surveys provide estimates of the size distributions of their respective catches. These are used in the stock assessment model in place of age compositions because extensive age-determinations on this species are currently impractical given the difficulties in interpretation of their otoliths. Biologically, the biggest area of uncertainty for this species is in their longevity and natural mortality rate. Currently, NMFS scientists believe they are slow-growing and long-lived fish that are relatively sedentary on the ocean floor. Survey and fishery catch rates indicate that they are relatively evenly distributed within their habitat and do not tend to form dense aggregations like many other groundfish species. This distribution pattern is important in interpreting the survey results because the assumptions implied in "area-swept" methods for the bottom trawl gear are likely to be satisfied. Fishery data include estimates of the total catch and size distribution information by gear type. For 2000 in the GOA, stock assessment authors recommended an ABC of 2,359 mt (Ianelli and Gaichas 1999).

Other rockfish species

Numerous other rockfish species of the genus Sebastes have been reported in the GOA and BSAI (Eschmeyer *et al.* 1984), and several are of commercial importance. Most are demersal or semi-demersal with different species occupying different depth strata (Kramer and O'Connell 1988). All are viviparous and bear live young (Hart 1973). Life history attributes of most of these rockfish are poorly known or unknown. Because they are long lived and slow growing, natural mortality rates are probably low (less than 0.10). Species for which dietary information exists, the diet seems to consist primarily of planktonic invertebrates (Yang 1993, 1996). Predators of "other slope rockfish" are also not well documented, but likely include larger fish such as Pacific halibut that are known to prey on other rockfish species.

Other rockfish species are taken both in directed fisheries and as bycatch in trawl and longline fisheries. In the EBS and Aleutian Islands, 27 species of rockfish have been found in catches. However, thornyheads are managed as part of the "other rockfish" management assemblage for these areas, and the shortspine thornyhead is the primary species in this assemblage. Assessment is based on the most recent catch and survey data. Traditionally, the biomass estimates (split according to management area) from all bottom trawl surveys (EBS shelf/slope and Aleutian Islands) are averaged over all years to obtain the best estimates of biomass for the species in this complex. For 2000, this procedure produced a biomass estimate for "other rockfish" of 7,030 mt in the EBS, and a biomass estimate of 13,041 mt in the Aleutian Islands. The great majority of this biomass is comprised of thornyhead rockfish. Based on these estimates, the stock assessment authors have recommended 2000 ABCs of 369 mt and 685 mt for the EBS and Aleutian Islands, respectively (Ito and Spencer 1999).

In the GOA, the "other slope rockfish" management group comprises 17 species, but five species alone make up 95% of the catch and estimated abundance: sharpchin, redstripe, harlequin, silvergrey, and redbanded rockfish. Heifetz and Ackley (1997) analyzed bycatch (not necessarily discarded) in rockfish fisheries of the GOA. Bycatch rates of "other slope rockfish" are highest in the pelagic shelf rockfish and Pacific ocean perch fisheries. Information on bycatch of "other slope rockfish" in non-rockfish fisheries has not been analyzed. Discard rates (discards/total catch) of "other slope rockfish" during 1996 to 1997 have been about 65% (Heifetz and Ackley 1997). In 1997, about 670 mt of "other slope rockfish" were discarded compared to a total catch of 1,210 mt. High discard rates are seen because many species of "other slope rockfish" are small in size and of low economic value, and fishermen have little incentive to retain these fish.

Of the five main species comprising the GOA "other slope rockfish" category, sharpchin rockfish falls into tier 4, and the remaining species fall into tier 5 of the ABC/OFL definitions. For all of these species combined, the stock assessment authors recommended an ABC for 2000 of 4,900 mt. The "other slope rockfish" ABC and TAC are generally more conservative than the maximum prescribed under the definitions to lessen risk of an overly aggressive harvest rate. This affords more protection to the stocks given the variability and uncertainty associated with the abundance.

2.4.12 Squid and other species

Other species in the BSAI consist of sculpins, skates, sharks, and octopus; a separate ABC and TAC is established for squid. In the GOA, the "other species" assemblage includes sculpins, skates, sharks, squid, and octopus. The GOA FMP specifies that the annual TAC for these species is 5% of the sum of the combined TACs for other groundfish targets.

Squid are found throughout the Pacific Ocean. They are not currently the target of groundfish fisheries in the GOA or BSAI, though they are taken as bycatch in trawl fisheries for pollock and rockfish. The red, or magistrate, armhook squid (*Berryteuthis magister*) is probably the best known species found in Alaskan waters. It is abundant over continental slopes throughout the North Pacific from Oregon to southern Japan (Nesis 1987). It is the basis of fisheries in both Russian and Japanese waters. Little is known about the reproductive biology of squid. Fertilization is internal and juveniles have no larval stage. Eggs of inshore species are often enveloped in a gelatinous matrix attached to substrate, while the eggs of offshore species are extruded as drifting masses. The red armhook squid appears to spawn in the spring and to live as long as 4 years, though most die after spawning at one year to 16 months old (Arkhipkin *et al.* 1996). Perez (1990) estimated that squids comprise over 80% of the diet of some whales. Seabirds and some salmon species are also known to feed heavily on squid at certain times of the year.

In the BSAI FMP, squid are grouped in a "Squid and Other Species" group made up of squids, which are considered separately, and sculpins, skates, sharks, and octopus, which comprise the true "other species" category. Because insufficient data exist to manage each of the other species groups separately, they are considered collectively. Neither squid nor any of the species in the other species category are currently targeted by the groundfish fisheries in the BSAI and GOA. As such, they are only caught as bycatch by fisheries targeting groundfish. Beginning in 1999, smelts have been removed from the other species category and been placed, along with a wide variety of other fish and crustaceans including euphausiids, Bathylagidae, and Myctophidae, in the forage fish category.

Assessment data are not available for squid from AFSC surveys because of their mainly pelagic distribution over deep water. Information on the distribution, abundance, and biology of squid stocks in the EBS and Aleutian Islands region is generally lacking. *Berryteuthis magister* predominates in commercial catches in the EBS and GOA, and *Onychoteuthis borealijaponicus* is the principal species encountered in the Aleutian Islands region.

Forty-one species of sculpins were identified in the EBS and 22 species in the Aleutian Islands region (Bakkala 1993, Bakkala *et al.* 1985, Ronholt *et al.* 1985). During these same surveys, 15 species of skates were identified but inadequate taxonomic keys for this family may have resulted in more species being identified than actually exist. Species that have been consistently identified during surveys are the Alaska skate (*Bathyraja parmifera*), big skate (*Raja binoculata*), longnose skate (*R. rhina*), starry skate (*R. stellulata*), and Aleutian skate (*B. aleutica*). Biomass estimates of sculpins and skates from demersal trawl surveys serve as valuable indices of their relative abundance.

While biomass estimates have been made for sharks and octopi, the AFSC bottom trawl surveys are not designed to adequately sample the realms they inhabit. Sharks are rarely taken during demersal trawl surveys in the Bering Sea; however, spiny dogfish (*Squalus acanthias*) is the species usually caught, and the Pacific sleeper shark (*Somniosus pacificus*) has been taken on occasion. Two species of octopus have been recorded, with *Octopus dofleini* the principal species and *Opisthoteuthis california* appearing only intermittently.

Many species in the squid and other species assemblage are important as prey for marine mammals and birds as well as commercial groundfish species. Squid and octopus are consumed primarily by marine mammals, such as Steller sea lions (Lowry *et al.* 1982), northern fur seals (Perez and Bigg 1986), harbor seals (Lowry *et al.* 1982, Pitcher 1980b), sperm whales (Kawakami 1980), Dall's porpoise (Crawford 1981), and Pacific white-sided dolphins (Morris *et al.* 1983) and beaked whales (Loughlin and Perez 1985). Sculpins have also been found in the diet of Steller sea lions and harbor seals (Lowry *et al.* 1982).

Stock assessment and ABC recommendations

No reliable biomass estimates for squid exist, and no stock assessment per se. Sobolevsky (1996) cites an estimate of 4 million tons for the entire Bering Sea made by squid biologists at TINRO (Shuntov *et al.* 1993), and an estimate of 2.3 million tons for the western and central Bering Sea (Radchenko 1992), but admits that squid stock abundance estimates have received little attention. AFSC bottom trawl surveys almost certainly underestimate squid abundance. Squid catches and ABCs are almost certainly a very small percentage of the total squid biomass in the EBS and GOA. BSAI squid ABC and OFL are set using criteria in tier 6 as described in Amendment 44 to the BSAI FMP given the lack of data on their population dynamics and biomass. Overfishing level is set equal to the average annual catch from 1978 to 1995 (2,624 mt), while ABC is capped at no greater than 75% of OFL (1,970 mt). As currently defined, BSAI squid ABC and OFL values would remain constant in the future, unless different methodologies were employed to assess squid abundance (e.g., analysis of fishery CPUE data). This methodology change could occur under any of the alternatives considered. The BSAI squid TAC has been set equal to the stock assessment recommended ABC by the Council.

Reliable biomass estimates exist for skates and sculpins, the two groups that comprise the bulk of the biomass and fishery catches in the other species category. Survey biomass estimates for sharks, smelts, and octopus, while not reliable, represent the best data available on the abundance of these species. A single estimate of M for this diverse assemblage, while not known, is conservatively estimated at 0.2. OFL for the other species assemblage is set using the criteria in tier 5 as described in Amendment 44, where F_{OFL}=M, and OFL=M x (total other species survey biomass). Using tier 5 criteria, ABC is capped at 75% of OFL. However, rather than use this method, the other species ABC has been calculated as the average annual catch since 1978 to avoid potentially 4-fold increases in other species catches that could occur if it were set at 75% of OFL. The recommended ABC for other species in 2000 is 26,800 mt.

In the past, the annual TAC for other species in the GOA (which includes squid) has been set equal to 5% of the sum of all GOA groundfish TACs. Catches of other species in the GOA have ranged between 1,570 and 6,867 mt from 1990 to 1997. However, to ensure protection of each species included in the other species group, the stock assessment authors recommended a separate ABC and OFL be set for each species or small species groups. Based on definitions in tier 5 of the TAC-setting process, recommended values are:

	Sharks	Skates	Sculpins	Octopi	Squids
ABC	2,309	5,412	3,404	124	640
OFL	3,079	7,216	4,539	165	854

2.5 Action areas for the groundfish fisheries

The action area for 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. Exclusive Economic Zone (Fig. 1). 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 lack of important information on distribution and stock structure of target species confounds a clear and precise definition of the action area, but 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.

The catch-per-unit-effort records illustrated in Fritz et al. (1998) provide the best view of the areas fished. The BSAI pollock fishery occurs primarily over the southeastern Bering Sea shelf in winter months and extends northwestward along the shelf break in the summer/autumn season (Wespestad et al. 1997b). The GOA pollock fishery is primarily west of 145°W long. to 170°W long. with effort concentrated along the shelf break, Davidson Bank, around the Shumagin Islands, in Shelikof Strait, and over marine canyons on the southeastern side of Kodiak Island. The BSAI Pacific cod fishery occurs primarily in the EBS with an additional 10% (or less) of the annual catch from the Aleutian Islands subarea (Thompson and Dorn 1997). The fishery is concentrated over the southeastern Bering Sea shelf and then follows the 200-m contour northwest to the U.S.-Russia Convention Line. The trawl part of this fishery tends to be concentrated in the north of Unimak Pass and Island, whereas the longline portion of the fishery extends over a significantly greater distance along the shelf break (Fig. 8). In the GOA, the distribution of the cod fishery is essentially the same as the pollock fishery. The yellowfin sole catch has been predominantly from the central portion of the southeastern Bering Sea shelf (i.e., between the 50- and 100-m contour lines. Trawling for Greenland turbot occurs along the continental shelf and slope with concentrated effort from the horseshoe area north of the Aleutian Islands and near the U.S. Convention Line. Greenland turbot are also taken in deeper waters adjacent to the Aleutian Islands, particularly to the northwest of Adak Island and to the west of Petrel Bank. Longlining for Greenland turbot occurs in approximately the same areas. Arrowtooth flounder are taken on the southeastern Bering Sea shelf and along the continental shelf break to the Convention Line. They are also taken in the Aleutian Islands and the GOA, primarily along the shelf break but also around the Shumagins, and to the east and southeast of Kodiak Island. Rock sole are taken over the southeastern Bering Sea continental shelf, with lesser catch along the shelf break in the Bering Sea, Aleutian Islands, and GOA. Alaska plaice are taken primarily over the central portion of the Bering Sea continental shelf. Dover sole are taken primarily along the shelf break in the GOA. Rex sole area also taken in that area, and to a lesser extent in the southwestern region of the southeastern Bering Sea shelf. Flathead sole are caught over the southeastern Bering Sea shelf and up the continental shelf from the 200-m contour line as it extends to the Convention Line. They are also taken in lesser amounts around the canyons and 200-m contour east and southeast of Kodiak Island. Sablefish are taken along the continental shelf break in the GOA, and also along the southeastern shelf break in the Bering Sea. Virtually all rockfish are taken primarily along the shelf break or over adjacent deeper waters in the Bering Sea, Aleutian Islands, and GOA. The Atka mackerel fishery occurs primarily from in the Aleutian Islands from Seguam Island westward to Attu Island. Squid and octopus catches are primarily along the continental shelf or in deeper adjacent waters in the Bering Sea, Aleutian Islands, and

GOA. Sculpins are taken over the Bering Sea continental shelf, primarily in the middle domain between the 50- and 100-m contours, along the shelf break to the Convention Line, in the Aleutians, and primarily along the shelf break in the GOA. Skates are taken in approximately the same regions. Sharks are taken primarily north of Unimak Pass and over the shelf between the 100-m and 200-m contour lines.

2.6 Conservation measures associated with the groundfish fisheries

Groundfish fisheries are managed by NMFS and the Council in a manner intended to protect and conserve the integrity of these ecosystems. Fishery management tools include permits and limited entry, catch quotas (TACs), seasons, in-season adjustments, gear restrictions, closed waters, bycatch limits and rates, allocations, regulatory areas, record keeping and reporting requirements, and observer monitoring. Annual management efforts are detailed below in the section on Federal fishery management actions (in the section on the environmental baseline).

3.0 STATUS OF PROTECTED SPECIES

The following threatened and endangered species and designated critical habitat may be affected by the proposed actions:

Northern right whale	*Balaena glacialis*	Endangered
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Chinook salmon (Snake River spring/summer)	*Oncorhynchus tshawytscha*	Threatened
Chinook salmon (Snake River fall)		Threatened
Sockeye salmon (Snake River)	*Oncorhynchus nerka*	Endangered
Steller sea lion (western population)	*Eumetopias jubatus*	Endangered
Steller sea lion (eastern population)		Threatened

In the action areas, critical habitat has been designated only for the western and eastern populations of Steller sea lions (50 CFR 227.12).

The endangered short-tailed albatross (*Diomedea albatrus*), threatened spectacled eider (*Somateria fisheri*), and threatened Steller's eider (*Polysticta stelleri*) occur in the action areas for the three proposed actions; these species are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). A letter dated December 2, 1998 from the USFWS to Steven Pennoyer, NMFS, Administrator, Alaska region, extends the USFWS's 1997-1998 Biological Opinion covering these species until it is superseded by a subsequent amendment to that opinion. The listed salmon species are managed by the Northwest Region, NMFS, and will not be addressed further in this document as they are addressed in a separate consultation from that office.

3.1 Northern right whale

The following description of the northern right whale is summarized primarily from the Final Recovery Plan for the Northern Right Whale, *Eubalaena glacialis* (NMFS 1991a).

Species description and distribution

The northern right whale (*Eubalaena glacialis*) is a member of the order Cetacea, suborder Mysticeti, family Balaenidae. Stock structure in the North Pacific is unknown, although several different stocks have been hypothesized. Scarff (1986) suggests the possibility of a stock in the GOA.

Whaling records (Maury 1852, Townsend 1935) indicate the northern right whale ranged across the North Pacific above 35°N lat. In summer, they have been sighted north of the Bering Strait (Omura et al. 1969) and their distribution may have been continuous across the North Pacific south of the Aleutian Islands (Scarff 1986). The recovery plan for this species describes their distribution in the eastern North Pacific as follows:

> ". . . right whales historically summered in Alaska waters, mostly between 50° and 60°N from April or May to September, with a peak in sightings in coastal waters in June and July (Maury, 1852; Townsend, 1935; Omura, 1958; Klumov, 1962; Omura et al., 1969). Important historical concentration areas in Alaska appear to have been located in the Gulf of Alaska, especially south of Kodiak Islands (Rice and Wolman, 1982),

and in the Eastern Aleutian Islands and southern Bering Sea shelf waters (Braham and Rice, 1984). They were particularly abundant in the Gulf of Alaska from 145° to 151°W (Berzin and Rovnin, 1966)."

Winter distribution patterns are unknown, but limited sightings have been made as far south as 27°N in the eastern North Pacific and near Hawaii. Migration patterns are essentially unknown, but presumably include southern movements to winter habitat and northern movements to summer habitat. Most recent sightings include observations of a group of 3-4 right whales (apparently including a juvenile animal) in western Bristol Bay on July 30, 1996 (Goddard and Rugh 1998). During July 1997, a group of 5-9 whales were observed in approximately the same location (C. Tynan, pers. comm., reported in Hill and DeMaster 1998), and aerial surveys in 1998 observed six whales in the same area (Marine Mammal Commission 1999).

Life history information

Essentially no information exists on reproduction or calving grounds in the eastern North Pacific. Based on the lack of sightings along the west coast of North America and around Hawaii, calving grounds may be offshore. Age distribution, mortality rates and sources of mortality (e.g., disease) are essentially unknown. Killer whales are suspected as possible predators, but no data are available to support this speculation (Scarff 1986).

Northern right whales feed at the surface on zooplankton (mainly copepods). They may compete with sympatric sei whales and many other predators or consumers of zooplankton in the eastern North Pacific and Bering Sea.

Population status and trends

Population dynamics of the northern right whale are unknown. The recovery plan for this species suggests that its pre-exploitation abundance was higher than 11,000, based on a known harvest of over 11,000 by U.S. whalers with additional numbers struck and lost (Brownell et al., 1986). Estimate of current population range from a low of 100-200 (Braham and Rice 1984) to a high of 220-500 (Berzin and Yablokov 1978 [in Berzin and Vladimirov 1981]), but Hill and DeMaster (1998) suggest a reliable estimate of abundance or trends is currently not possible. Population variability and stability are unknown, but population trends in the North Pacific may be influenced by factors affecting small populations (e.g., allee effects). No population projections have been made.

Listing status

Since 1949, the northern right whale has been protected from commercial whaling by the International Whaling Commission. In the U.S., northern right whales are listed as depleted under the Marine Mammal Protection Act and endangered under the Endangered Species Act. They are also listed in Appendix I of the Conservation on International Trade in Endangered Species of Wild Fauna and Flora. Critical habitat has not been designated for the northern right whale in the North Pacific.

3.2 Blue whale

The majority of the following description of blue whales comes from the Recovery Plan for the Blue Whale (*Balaenoptera musculus*) (NMFS 1998a).

Species description and distribution

Blue whales (*Balaenoptera musculus*) are members of the order Cetacea, suborder Mysticeti, family Balaenopteridae. The blue whale is essentially cosmopolitan in distribution (i.e., found in all major oceans). At least three subspecies have been designated, but only one of those (*B. m. musculus*) occurs in the northern hemisphere. The recovery plan for this species states:

> "It is assumed that blue whale distribution is governed largely by food requirements and that populations are seasonally migratory. Poleward movements in spring allow the whales to take advantage of high zooplankton production in summer. Movement toward the subtropics in the fall allows blue whales to reduce their energy expenditure while fasting, avoid ice entrapment in some areas, and engage in reproductive activities in warmer waters of lower latitudes."

Within the North Pacific, the species is considered by the International Whaling Commission to be panmictic (Donovan 1991, Best 1993), but recent evidence suggests that blue whales in Alaskan waters are of a different stock than blue whales off California and Mexico (Rice 1992, Calambokidis et al. 1995, Gilpatrick et al. 1996, Barlow 1995, Calambokidis and Steiger 1995, NMFS 1998a). Again, from the recovery plan:

> "Whaling catch data indicate that animals believed to belong to the central stock (as defined by Gambell 1979) feed off the Aleutian Islands in summer. The prime period for blue whale catches (made in various years between 1912 and 1939) was June through August (Reeves et al. 1985). 'Discovery' tag returns indicate that this population ranges further to the east, with movements from the Gulf of Alaska to the Aleutian Islands, and from Vancouver Island to the Gulf of Alaska (Omura and Ohsumi 1964; Ohsumi and Masaki 1975; Ivashin and Rovnin 1967)."

In addition, analysis of catch records from 1929 to 1965 indicate separate western (off Kamchatka and the Kuril Islands) and central (the Aleutian Islands area) stocks (Forney and Brownell 1997). The recovery plan for the species concludes that there are five stocks in the North Pacific, two of which are relevant to this analysis: the central stock near the Aleutian Islands, and the eastern GOA stock. The north-south limits of these stocks appears to range from as far north as the Chukchi Sea (Yochem and Leatherwood 1985, Rice 1986a) to as far south as waters near Hawaii. They are found both over the continental shelf in coastal waters and far offshore in pelagic environments.

Life history information

Reproductive activities occur primarily in winter months. Gestation is 10-12 months, followed by a nursing period of about 6-7 months. Age of sexual maturity is unknown, but may be from 5 to 15 years (Mizroch et al. 1984a, Yochem and Leatherwood 1985). Age distribution is unknown, as are natural sources of mortality and mortality rates. Killer whales are known to attack blue whales, but the rate or significance of such attacks are unknown.

Euphausiids (*Euphasia pacifica* and *Thysanoëssa spinifera*) are thought to be the primary prey of blue whales in the North Pacific, but other prey have been reported including copepods and amphipods (Nemoto 1957, Nemoto and Kawamura 1977), pelagic red crabs (Rice 1974), small schooling fish, and squid (Mizue 1951, Sleptsov 1955).

Nemoto (1970) suggests that all sympatric baleen whales that consume euphausiids are potential competitors with blue whales. However, Clapham and Brownell (1996) suggest that little direct evidence exists for such competition and that the highly migratory behavior of blue whales would help them avoid such competition by allowing them to take advantage of widely dispersed prey resources.

Population status and trends

The recovery plan for this species indicates that the abundance of blue whales in the North Pacific can not be estimated reliably. The plan does include an estimate of about 3500 whales for the eastern North Pacific south of Oregon. It also notes evidence that the stocks in Aleutian waters and the GOA appear to remain depleted. In surveys of former Akutan whaling grounds in 1984 (Stewart et al. 1987) and south of the Aleutians in 1994 (Forney and Brownell 1997), no blue whales were sighted.

Listing status

Blue whales are listed as endangered under the ESA and depleted under the Marine Mammal Protection Act. The North Pacific stock is also listed as "low risk, conservation dependent" under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for the species.

3.3 Fin whale

The majority of the following descriptive information for the fin whale comes from the Draft Recovery Plan for the Fin Whale, *Balaenoptera physalus,* and Sei Whale, *Balaenoptera borealis* (NMFS 1998b).

Species description and distribution

Fin whales (*Balaenoptera physalus*) are members of the order Cetacea, suborder Mysticeti, family Balaenopteridae. They are cosmopolitan, or distributed widely in the world's oceans. Depending on food supply, fin whale groups may exhibit seasonal migration patterns to high latitudes in summer for feeding, and to low latitudes in winter, when they may be fasting. Other groups may remain in a particular area, depending on food supply. Mizroch et al. (1984b) described five feeding aggregations in the North Pacific. At present, however, NMFS considers stock structure in the North Pacific to be equivocal, and recognizes three stocks: 1) Alaska (Northeast Pacific), 2) California/Oregon/ Washington, and 3) Hawaii (Hill and DeMaster 1998).

The draft recovery plan for fin whales provided the following description of their distribution in the North Pacific:

> "Rice (1974) reported that the summer distribution of whales included 'immediate offshore waters' throughout the North Pacific from central Baja California to Japan and to as far north as the Chukchi Sea. They occurred in high densities in the northern Gulf of Alaska and southeastern Bering Sea from May to October, with some movement through the Aleutian passes into and out of the Bering Sea (Reeves et al. 1985). Fin whales were observed and taken by Japanese and Soviet whalers off eastern Kamchatka and Cape Navarin, both north and south of the eastern Aleutians, and in the northern Bering and southern Chukchi seas (Berzin and Rovnin 1966, Nasu 1974). . . . In recent years, fin whales have been observed . . . in summer and fall in the Gulf of Alaska (including Shelikof Strait) and southeastern Bering Sea (Leatherwood et al. 1986; Brueggeman et al. 1990). Their regular occurrence has also been noted in recent years around the Pribilof Islands in the northern Bering Sea (Baretta and Hunt 1994). . . . Fin whale concentrations in the northern North Pacific and Bering Sea generally form along frontal boundaries, or mixing zones between coastal and oceanic waters, which themselves correspond roughly to the 200-m isobath (shelf edge)(Nasu 1974)."

Life history information

Reproductive activities occur primarily in winter months. Gestation is thought to be somewhat less than one year, followed by a nursing period of about 6-7 months. Age of sexual maturity may vary from six or seven to ten or more, depending on density-dependent factors (Gambell 1985b). Average calving interval is two or more years (Christensen et al. 1992). Pregnancy rates of adult females may range between 0.36 and 0.47 (Sigurjónsson 1995). Age distribution is unknown, but fin whale populations in the Gulf of Maine apparently included about 8% calves (as a percentage of total population; Agler et al. 1993). Sources and rates of natural mortality are largely underscribed, but Aguilar and Lockyer (1987) suggest annual natural mortality may range between 0.04 and 0.06. Killer whales are known to attack fin whales, and sharks are suspected of attacking young and sick whales.

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

Population status and trends

The current status and trends of fin whales in the North Pacific, either in absolute terms or relative to pre-exploitation abundance, are unknown. Surveys in 1984 (Akutan whaling grounds, Stewart et al. 1987) and 1994 (south of the Aleutian Islands, Forney and Brownell 1996) observed no or few fin whales, respectively. In contrast, seabird surveys around the Pribilof Islands indicated an increase in local abundance of fin whales between 1975-78 and 1987-89 (Baretta and Hunt 1994).

Listing status

In the North Pacific, the IWC began management of commercial taking of fin whales in 1969, and fin whales were given full protection in 1976 (Allen 1980). The fin whale is listed as endangered under the ESA, depleted under the MMPA, and endangered under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). The fin whale is also listed in Appendix I of CITES. Critical habitat has not been designated for the species.

3.4 Sei whale

The majority of the following descriptive information for the sei whale comes from the Draft Recovery Plan for the Fin Whale, *Balaenoptera physalus*, and Sei Whale, *Balaenoptera borealis* (NMFS 1998b).

Species description and distribution

Sei whales (*Balaenoptera borealis*) are members of the order Cetacea, suborder Mysticeti, family Balaenopteridae. They are cosmopolitan (Gambell 1985a, Horwood 1987), but tend to occur more over the deeper water of the continental slope and rarely enter inshore waters. They are relatively fast-moving and mobile, thought to be non-resident, and exhibit pole-ward seasonal migrations for feeding in summer and wintering in temperate or subtropical waters. Sei whales in the North Atlantic, North Pacific, and Southern Ocean are considered separate stocks. In the North Pacific, three stocks have been proposed, divided by longitudes 175°W and 155°W (Masaki 1977). The draft recovery plan for the species states:

> "In the North Pacific as a whole, the sei whale has been said to occur mainly south of the Aleutian Islands (Nasu 1974, Leatherwood et al. 1982) although Japanese sighting records presented by Masaki (1977) indicate concentrations in the northern and western Bering Sea from July through September. These data have never been confirmed and must be considered doubtful, as no other authority has ever reported them in the areas indicated. Horwood's (1987) synoptic evaluation of the Japanese sighting data led him to conclude that sei whales 'rarely penetrate deep into the Bering Sea.'"

Life history information

Reproductive activities occur primarily in winter. Rice (1977) estimated a gestation period of 12.7 months, an average calving interval of 3 years, and a mean age of sexual maturity of 10 years. These results differ somewhat from those proposed for the North Atlantic sei whale. Age structure is unknown. Rice (1977) also estimated total annual mortality for adult females as 0.088 and adult males as 0.103. Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas.

Sei whales in the North Pacific are known to feed on euphausiids and copepods. The also feed higher up the food chain on squid and schooling fish, including Atka mackerel (Nemoto and Kawamura 1977). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries.

Population status and trends

Tillman (1977) suggested that the North Pacific population of sei whales declined from about 42,000 to 8,600 between 1963 and 1974. Current abundance or trends are not known.

Listing status

In the North Pacific, the IWC began management of commercial taking of sei whales in 1970, and fin whales were given full protection in 1976 (Allen 1980). The sei whale is listed as endangered under the ESA, depleted under the MMPA, and endangered under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). The sei whale is also listed in Appendix I of CITES. Critical habitat has not been designated for the species.

3.5 Humpback whale

The majority of the following descriptive information for the humpback whale comes from the Final Recovery Plan for the Humpback Whale, *Megatera novaeangliae* (NMFS 1991b).

Species description and distribution

Humpback whales (*Megaptera novaeangliae*) are members of the order Cetacea, suborder Mysticeti, family Balaenopteridae. They are cosmopolitan in distribution, but less common in Arctic waters. They generally occur over continental shelves, shelf breaks, and around some oceanic islands (Balcomb and Nichols 1978, Whitehead 1987). They exhibit seasonal migrations between warmer temperate and tropical waters in winter and cooler waters of high productivity in summer. Summer ranges include “coastal and inland waters . . . from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk” (Tomlin 1967, Nemoto 1957, Johnson and Wolman 1984; all cited in NMFS 1991b).

In southeast Alaska, humpback whales are seen year-round, but are most common in May through December with peaks in late August and September. Distribution of whales in these inland waters appears to be determined primarily by distribution of their main prey, including herring and euphausiids. Individual whales may use the same feeding areas over many years.

Humpbacks also summer throughout the central and western portions of the GOA, including Prince William Sound, around Kodiak Island (including Shelikof Strait and the Barren Islands), and along the southern coastline of the Alaska Peninsula. The following description is taken directly from the recovery plan for this species.

> “In the 1960's, the waters south of the Alaska Peninsula were considered to be the center of the summer distribution of humpback whales in the North Pacific (Berzin and Rovnin 1966). Japanese scouting vessels continued to observe high densities of humpback whales near Kodiak Island during 1965-1974 (Wada 1980). In Prince William Sound, during recent years [i.e., prior to 1991], humpback whales have congregated near

> naked Islands, in Perry Passage, near Cheega island, in Jackpot, Icy and Whale Bays, in Port Bainbridge and north of Montague Islands between Green Island and the Needle (Hall 1979, 1982; von Ziegesar 1984; von Ziegesar and Matkin 1986). The few sighting of humpbacks in offshore waters of the centra Gulf of Alaska are usually attributed to animals migrating into coastal waters (Morris et al. 1983), although use of offshore banks for feeding is also suggested (Brueggeman et al. 1987)."

For the Aleutian Islands region and Bering Sea, the recovery plan states:

> "The waters along the continental shelf of the central Aleutian Islands were once considered the center of the North Pacific humpback whale population (Berzin and Rovnin 1966; Nishiwaki 1966). . . . Nikulin (1946) and Berzin and Rovnin (1966) described the northern Bering Sea, Bering Strait, and the southern Chukchi Sea along the Chukchi Peninsula as the northern extreme of the humpback's range. Within the Bering Sea, humpback whales were sighted with greatest frequency south of Nunivak Island and east of the Pribilof Islands (Berzin and Rovnin 1966; Braham et al. 1977; Nemoto 1978; Braham et al. 1982; Leatherwood et al. 1983)."

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

Life history information

Reproductive activities occur primarily in winter months. Sexual maturity occurs at age four to six, and the birth interval for mature females is every two to three years. Nursing occurs for up to 12 months. Annual pregnancy rates have been estimated at about 0.40-0.42 (NMFS unpublished and Nishiwaki 1959). Age distribution is unknown, but the portion of calves in various populations has been estimated at about 4-12% (Chittleborough 1965, Whitehead 1982, Bauer 1986, Herman et al. 1980, and Clapham and Mayo 1987). Sources and rates of natural mortality are generally unstudied, but potential sources of mortality include parasites, disease, predation (killer whales, false killer whales, and sharks), biotoxins, and ice entrapment.

Humpbacks exhibit a wide range of foraging behaviors, and feed on a range of prey types including small schooling fishes, euphausiids, and other large zooplankton. Fish prey in the North Pacific include herring, anchovy, capelin, pollock, Atka mackerel, eulachon, sand lance, pollack, Pacific cod, saffron cod, arctic cod, juvenile salmon, and rockfish. Invertebrate prey include euphausiids, mysids, amphipods, shrimps, and copepods.

Population status and trends

The best available estimate of population size for the western North Pacific unit is based on photo-identification studies conducted in 1991-93 (Calambokidis et al. 1997), and indicates an abundance of 394 (coefficient of variation = 0.084). Reliable information on trends are not available for this management unit. The best available estimate of population size for the central North Pacific management unit is based on the same photo-identification study during 1991-93, and indicates an abundance of 4,005 (coefficient of variation = 0.095) (Calambokidis et al. 1997).

The existing data are not sufficient to estimate trends for the western North Pacific management unit (Hill and DeMaster 1998). For the central North Pacific unit, the data are suggestive of an increasing trend, but are not sufficient to reliably estimate a rate of increase (Hill and DeMaster 1998).

For southcentral Alaska, the recovery plan states:

> “. . . recent [i.e., prior to 1991] studies suggest a dramatic reduction in the number and distribution of humpback whales in comparison to early records of commercial catches (Rice and Wolman 1982; Brueggeman et al. 1987; Hall 1979; von Ziegesar and Matkin 1986]. In Prince William Sound . . . annual use is variable and less than 100 individuals use this area during any given year (von Ziegesar and Matkin 1986). In the Shumagin Island region . . . Brueggeman et al. (1987) reported that humpback whales were generally found along shallow shelf breaks near islands and offshore banks. Although this distribution was similar to that reported in commercial whaling records, Brueggeman et al. (1987) reported some interesting exceptions. Extensive aerial surveys failed to find any humpback whales over the Davidson Bank, an area that was harvested regularly by the Akutan Whaling Station. a similar absence of humpback whales in the eastern Aleutian Islands is reported by Stewart et al. (1987). Brueggeman et al. (1987) attributed those absences to intensive exploitation of local herds and their failure to recover.”

For the BSAI, the plan states:

> “Existing information on distribution in the Bering Sea and along the Aleutian Islands indicates a dramatic decline since commercial whaling commenced, but little evidence of any marked recovery since protection. Brueggeman et al. (1987) reported no sightings of humpback whales in the North Aleutian and St. George Basin OCS [Outer Continental Shelf] planning zones to the north and west of the Alaska Peninsula. Similarly, Stewart et al. (1987) reported that no humpback whales were observed during aerial surveys on or near areas hunted by vessels from the Akutan whaling station in the eastern Aleutians. Braham et al. (1977) saw 14 humpbacks in the northern Bering Sea in August 1976, and Braham et al. (1982) documented 25 humpbacks between 1958-1978 in the southern Bering Sea between Unimak Pass and the Pribilof Islands.”

Listing status

The humpback whale in the North Pacific was first protected by the IWC in 1965. The humpback was classified as endangered when the ESA was passed in 1973. Critical habitat has not been designated for the species.

3.6 Sperm whale

Species description and distribution

The sperm whale (*Physeter macrocephalus*) is a member of the order Cetacea, suborder Odontoceti, family Physeteridae. The species has a cosmopolitan distribution. In the North Pacific, they are distributed broadly from tropical and temperate waters to the Bering Sea as far north as Cape Navarin. As they inhabit deeper pelagic waters, their distribution does not include the broad continental shelf of the EBS, and these whales generally remain offshore in the eastern Aleutian Islands and GOA. Distribution also varies as a function of sex and social status, with females and young remaining further south in temperate and tropical waters, and males moving north in summer to feed in the Bering Sea, around the Aleutian Islands, and in the GOA. During winter, their distribution is generally south of 40°N latitude (Gosho et al. 1984), but seasonal movements are have not been described (Hill and DeMaster 1998). For stock assessment purposes, NMFS has divided the North Pacific population into three stocks, only one (the Alaska or North Pacific stock) of which is considered relevant to this consultation.

Life history information

Both males and females are thought to reach sexual maturity at approximately 10 years of age. However, males may not reach social maturity (i.e., sufficient size to compete for breeding rights) for another decade. The gestation period is about 15 months, and nursing continues for two to three years. The interbirth interval is, therefore, on the order of three to four years. Age distribution is unknown; longevity may be seventy years or more. Sources and rates of mortality are unknown.

Sperm whales are known for their deep foraging dives (in excess of 3 km). The feed primarily on mesopelagic squid, but also consume octopus, other invertebrates, and fish (Tomilin 1967, Tarasevich 1968, Berzin 1971). Perez (1990) estimated that their diet in the Bering Sea was 82% cephalopods (mostly squid) and 18% fish. Fish eaten in the North Pacific included salmon, lantern fishes, lancetfish, Pacific cod, pollock, saffron cod, rockfishes, sablefish, Atka mackerel, sculpins, lumpsuckers, lamprey, skates, and rattails (Tomilin 1967, Kawakami 1980, Rice 1986b).

Population status and trends

Current estimates for population abundance, status, and trends for the North Pacific stock are not available or are considered unreliable (Hill and DeMaster 1998).

Listing status

Sperm whales are listed as endangered under the ESA and depleted under the MMPA. They have been protected from commercial harvest by the IWC since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). A recovery plan has not been prepared for the species; nor has critical habitat been designated. The primary threat to the species has been commercial whaling.

3.7 Steller sea lion

3.7.1 Species description

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

3.7.2 Distribution

The Steller sea lion is distributed around the North Pacific rim from the Channel Islands off Southern California to northern Hokkaido, Japan. The species' distribution extends northward into the Bering Sea and along the eastern shore of the Kamchatka Peninsula. The center of distribution has been considered to be in the GOA and the Aleutian Islands (NMFS 1992).

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

The movement patterns of Steller sea lions are not yet well understood. Their movement patterns from a land base (rookery or haulout) might be categorized into at least three types. First, sea lions move on and offshore for feeding excursions. Limited data are available to describe these movements (e.g., Gentry 1970, Sandgren 1970, Merrick and Loughlin 1997), but such descriptions are essential for understanding foraging patterns, nursing strategies, and energetics. Second, at the end of the reproductive season, some females may move with their pups to other haulout sites and males may "migrate" to distant foraging locations [Spaulding 1964, Mate 1973, Porter 1997]). Limited data are available indicating that animals do shift from rookeries to haulouts, but the timing and nature of these movements need further description (i.e., what distances are involved, are movements relatively predictable for individuals, do movements vary with foraging conditions, etc.). Description of these types of movements are essential for understanding seasonal distribution changes, foraging ecology, and apparent trends as a function of season. Third, sea lions may make semi-permanent or permanent one-way movements from one site to another (Chumbley *et al.* 1997, their Table 8; Burkanov *et al.* unpubl. report [cited in Loughlin 1997]). Calkins and Pitcher (1982) reported movements in Alaska of up to1500 km. They also describe wide dispersion of young animals after weaning, with the majority of those animals returning to the site of birth as they reach reproductive age.

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

3.7.3 Reproduction

Steller sea lions have a polygynous reproductive system where a single male may mate with multiple females. As mating occurs on land (or in the surf or intertidal zones), males are able to defend territories and thereby exert at least partial control over access to adult females and mating privileges. The pupping and mating season is relatively short and synchronous, probably due to the strong seasonality of the sea lions' environment and the need to balance aggregation for reproductive purposes with dispersion to take advantage of distant food resources (Bartholomew 1970). In May, adult males compete for rookery territories. In late May and early July, adult females arrive at the rookeries, where pregnant females give birth to a single pup. The sex ratio of pups at birth is assumed to be approximately 1:1 (e.g., York 1994) or biased toward slightly greater production of males (e.g., Pike and Maxwell 1958, Lowry *et al.* 1982, NMFS 1992).

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

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

Relatively little is known about the life history of sea lions during the juvenile years between weaning and maturity. Pitcher and Calkins (1981) reported that females sampled in the late 1970s reached reproductive maturity between ages 2 and 8, and the average age of first pregnancy was 4.9 ±1.2 years. These results suggest a mean age of first birth of about 6 years. The available literature indicates an overall reproductive (birth) rate on the order of 55% to 70% or greater (Pike and Maxwell 1958, Gentry 1970, Pitcher and Calkins 1981, Pitcher *et al.* in review). York (1994) derived the age-specific fecundity rates in Table 4 based on data from Calkins and Pitcher (1982). Those rates illustrate a number of important points and assumptions. First, the probability of pupping is rare (about 10%) for animals 4 years of age or younger. Second, maturation of 100% of a cohort of females occurs over a prolonged period which may be as long as 4 years. Third, the reported constancy of fecundity extending from age 6 to 30 indicates that either senescence has no effect on fecundity, or our information on fecundity rates is not sufficiently detailed to allow confident estimation of age-specific rates for animals older than age 6. Given the small size of the sample taken, the latter is a more likely explanation for such constancy.

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

The reproductive cycle includes mating, gestation, parturition, and nursing or post-natal care. The reproductive success of an adult female is determined by a number of factors within a cycle and over time through multiple cycles (Fig. 12). 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 the decline may also be due, in part, to decreased reproductive success.

- Younger females collected in the 1970s were larger than females of the same age collected in the 1980s (Calkins *et al.* 1998). As maturity is likely related to size, 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.* (in review) provide data from the 1970s and 1980s that suggests a much higher 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 large fetal mortality rate 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.

! Statistically, the observed late pregnancy rates (67% in the 1970s and 55% in the 1980s) were not significantly different. The direction of the difference is consistent with the hypothesis that reproductive effort in the 1980s was compromised.

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

Males appear to reach sexual maturity at about the same time as females (i.e., 3 and 7 years of age; Perlov 1971 reported in Loughlin *et al.* 1987), but generally do not reach physical maturity and participate in breeding until about 8 to 10 years of age (Pitcher and Calkins 1981). A sample of 185 harem bulls from the Marmot, Atkins, Ugamak, Jude, and Chowiet Islands in 1959 included animals 6 to 17 years of age, with 90% from 9 to 13 years old (Thorsteinson and Lensink 1962).

3.7.4 Survival

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

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

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

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

3.7.5 Age distribution

Two life tables have been published with age-specific rates (Table 4). The first was from Calkins and Pitcher (1982) and was based on sea lions killed in the late 1970s. York (1994) created a second life table using a Weibull model and the data from Calkins and Pitcher (1982) and Calkins and Goodwin (1988). York's analysis of these two data sets suggests a shift from the 1970s to the 1980s in the mean age of females older than 3 years of age. The shift was about 1.55 years, and provided the basis for her determination that increased juvenile mortality may have been an important proximate factor in the decline of Steller sea lions. That is, such a shift in mean age would occur as the adult population aged without expected replacement by recruiting young females.

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

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

3.7.6 Foraging patterns

The foraging patterns of the Steller sea lion are clearly central to any discussion of the potential for interaction between this species and fisheries. A partial list of foraging studies is provided in Table 5, together with notes on the sample sizes, locations, years, and primary findings of those studies.

Methods for researching sea lion foraging behavior

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

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

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

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

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

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

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

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

Fatty acid analysis: Fish species vary in fatty acid composition and therefore carry their own "fatty acid signature." Removal of small tissue (blubber) plugs from Steller sea lions and analysis for fatty acid composition can be used to identify prey types. This method of prey analysis is relatively new (e.g., Iverson 1993), but has been used successfully to identify prey types of harbor seals in different regions of

Prince William Sound (Iverson *et al.* 1997). The NMFS laboratory at Auk Bay has developed the capability to conduct such analyses and, in the future, this approach to prey determination will likely prove useful for providing a longer-term view of sea lion diets.

Isotope analysis: Isotope ratios for various elements differ in prey types in a manner that allows estimation of general prey category and trophic level. These analyses can be conducted using small amounts of tissue (e.g., vibrissae or whiskers) and may provide evidence of long term changes in general prey type, trophic level, or feeding strategy.

Foraging distributions

At present, our understanding of Steller sea lion foraging distribution is based on sightings at sea or observations of foraging behavior (or presumed foraging behavior) in areas such as the southeastern Bering Sea (Fiscus and Baines 1966, Kajimura and Loughlin 1988, NMFS unpublished data from the Platform-of-Opportunity Program [POP]), records of incidental take in fisheries (Perez and Loughlin 1991), and satellite telemetry studies (e.g. Merrick *et al.* 1994, Merrick and Loughlin 1997). Observations and incidental take of sea lions (Loughlin and Nelson 1986, Perez and Loughlin 1991) in the vicinity of Seguam Pass, the southeastern Bering Sea, and Shelikof Strait provided a basis for establishment of those areas as critical habitat (FR 58:45269-45285).

The POP database provides our best overall view of the foraging range or distribution of Steller sea lions (Fig. 13). However, this database should be viewed with some caution. The sightings in this database were collected over a period of four decades and do not reflect any natural changes that may have occurred in sea lion foraging patterns during that period. Similarly, foraging range, as indicated by such sightings, would be expected to change over time due to the severe decline of the species in the last two decades. In addition, the database is biased as a reflection of overall foraging dispersion by the location of sighting effort. That is, a sighting at a particular location indicates sea lion presence at that site, but the lack of sightings at a site could mean that the site is not important for foraging or it could mean that there was insufficient sighting effort in that area. Also, it is not clear that each sighting represents a different animal, and it is possible that some sightings were of the same animal. Finally, the sighting database does not include information on the age and sex of the sighted animal. Nevertheless, this database and the locations of sea lions taken incidentally in groundfish fisheries (1973-1988, Perez and Loughlin 1991), indicate that sea lions disperse widely to forage throughout much of the Bering Sea and the GOA, at least as far out as the continental shelf break. Such broad dispersal may be essential to sea lion populations to take advantage of distant food resources and, as a consequence, limit intra-specific competition near rookeries and haulouts.

The results of limited telemetry studies suggest that foraging distributions vary by individual, size or age, season, site, and reproductive status (i.e., is the female still supporting a pup; Merrick and Loughlin 1997). The foraging patterns of adult females differed during summer months when females were with pups versus winter periods when considerable individual variation was observed, but may be attributable to the lactation condition of the females. Trip duration for females (n = 14) in summer was approximately 18 to 25 hours. For five of those females that could be tracked, trip length averaged 17 km and they dove approximately 4.7 hours per day. For five females tracked in winter months, mean trip duration was 204 hours, mean trip length was 133 km, and they dove 5.3 hours per day. The patterns exhibited by females in winter varied considerably, from which the investigators inferred that two of them may still have been supporting a pup. Those two females continued to make relatively shorter trips (mean of 53 km over 18 hours) and dove 8.1 hours per day, whereas the other three ranged further, dove 3.5 hours per day, and spent up to 24 days at sea. Five winter young-of-the-year exhibited foraging patterns intermediate between summer and winter females in trip distance (mean of 30 km), but shorter in duration (mean of 15 hours), and with less effort devoted to diving (mean of 1.9 hours per day). Estimated home ranges (mean ± 1 SE) were

319 ± 61.9 km^2 for adult females in summer, 47,579 ± 26,704 km^2 for adult females in winter, and 9,196 ± 6799 km^2 for winter young-of-the-year. The sea lions used in Merrick and Loughlin's (1997) study were from the GOA (Sugarloaf Island, Latax Rocks, Marmot Island, Long Island, Chirikof Island, Atkins Island, and Pinnacle Rock), and the BSAI region (Ugamak Island and Akun Island). This information is, therefore, directly pertinent to the action areas for both the GOA and BSAI fisheries, although it is perhaps most relevant to the GOA action area.

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

Foraging depths

The sea lions in the Merrick and Loughlin (1997) study tended to make relatively shallow dives, with few dives recorded at greater than 250 m (Fig. 14). Maximum depth recorded for the five summer adult females were in the range from 100 to 250 m, and maximum depth for the five winter adult females was greater than 250 m. The maximum depth measured for winter young-of-the-year was 72 m. These results suggest that sea lions are generally shallow divers, but are capable of deeper dives (i.e., greater than 250 m).

The instruments used to record diving depths do not determine the purpose of a dive, and many of the recorded dives (Fig. 14) may not be indicative of foraging effort. Dives between 4 and 10 m depth may be for foraging, or they may be related to other behaviors such as social interactions or transiting between locations. For example, animals transiting to and from foraging locations during rough sea surface conditions may transit in a series of long, shallow dives to avoid such conditions. The relatively large number of dives recorded between 4 and 10 m may therefore bias the assessment of "foraging" depths for these sea lions.

The results from this study also may not be indicative of diving depths and patterns for other sea lions at other times of year or in other locations. The winter young-of-the-year were instrumented in the period from November to March, when they were probably about five to nine months old and may have still been nursing. At this age, they are just beginning to develop foraging skills, which may take years to learn. The diving depths and patterns exhibited by these young-of-the-year are likely poor indicators of the foraging patterns of older juveniles (one- to three-year-olds). For example, Swain and Calkins (1997) report dives of a 2-year-old male sea lion to 252 m, and regular dives of this animal and a yearling female to 150 m to 250 m (Fig. 15). Clearly, if young-of-the-year are limited to relatively shallow depths, and older animals are capable of diving to much greater depths, then those younger animals are just beginning to develop the diving and foraging skills necessary to survive. The rate at which they develop those skills and, for example, begin to dive to greater depths or take prey at greater depths, is unknown, but probably occurs rapidly after weaning to take advantage of otherwise unavailable prey resources.

Prey, energetics and nutrition, and diversity

At the least, an understanding of Steller sea lion foraging requires a listing of their prey species, a qualitative or (preferably) quantitative measure of the relative importance of different prey types, descriptions of prey characteristics and predator-prey dynamics, and an assessment of diet diversity. A (partial) listing of Steller sea lion prey species or prey types would include (not in order of priority): Atka mackerel, capelin, crabs, dogfish sharks, eulachon, flatfish, greenling, hake, halibut, herring, lamprey, lingcod, molluscs, octopus, Pacific cod, pollock, ratfish, rockfishes, salmon, sand lance, sculpins, shrimps, smelt, squid, and yellowfin sole.

Qualitative or quantitative indices of prey importance might be developed on the basis of prey "selection" or "preference." However, we rarely have information on the distribution or availability of different prey types, and therefore don't have a basis for inferring "selection" or "preference" (Lowry *et al.* 1982, Frost and Lowry 1986). In most studies of Steller sea lion prey, rank frequency of occurrence is used as a qualitative (or semi-quantitative) index of relative importance. More quantitative estimation of the importance of different prey types is considerably more difficult. The value of a prey type should be quantified on the basis of the observed net gain in calories and nutrients resulting from predation on that prey type versus other prey types. Such a determination would require information on biomass consumed, caloric and nutrient content of that biomass, energy and nutrients gained, and energy and nutrients expended (i.e., the costs of predation). Caloric and nutrient content of different prey types are relatively easy to determine using proximate analysis, although Stansby (1976) cautioned that individuals of the same prey type may vary considerably as a function of season, site, reproductive condition, and other factors. Assimilation efficiency has also been studied (Fadely *et al.* 1994, Rosen and Trites *in press*) and appears to be relatively straightforward. Biomass consumed and costs of predation are more difficult to quantify, particularly with respect to any particular prey type. Many of the studies on Steller sea lion foraging patterns (Table 5) provide information on frequency of occurrence, but such information cannot be readily converted into biomass consumed unless additional data are provided. Biomass estimates are more readily determined from volumetric measurements of stomach contents, but can also be estimated from length-weight relationships combined with measured lengths of prey or estimated length at age (with age based on otoliths; e.g., Frost and Lowry 1986). Costs of predation may also vary considerably by prey type, depending on the distribution, life history characteristics, and behavior of the prey.

Important prey characteristics include their tissue or body composition, individual size (mass), availability, depth in the water column, their degree of association with the bottom, their reproductive behaviors, their degree of aggregation (e.g., solitary versus schooling), and their temporal and spatial distribution patterns. To date, the limited telemetry information available indicates that sea lions generally forage at depths less than 250 m. However, the available evidence from the POP database indicates that sea lions are commonly sighted (and presumably foraging) in the vicinity of the continental shelf break. If sea lions in the vicinity of the shelf break are diving to depths near the bottom, then depths of 200 m to 250 m may be more indicative of common or modal dives than extremes of their diving range. And many sea lion prey are, at one life stage or another, associated with the bottom. Predation on prey associated with the bottom is a common pinniped strategy, perhaps because the bottom limits the spatial dimensionality of the predator-prey arena and thereby limits the prey's alternatives for escape. Male Atka mackerel, for example, may be susceptible to predation because they fertilize and then guard eggs laid by the female on the bottom. Schooling behavior of prey probably enhances their value, as such schooling may increase sea lion consumption relative to costs associated with searching and capture.

The spatial and temporal distributions of prey types is a critical determinant of their availability to sea lions. The consistent pattern of the Atka mackerel fishery over time indicates that aggregations of Atka mackerel are distributed in patches that are relatively predictable. Aggregations of pollock are less predictable in time and space than aggregations of Atka mackerel, but also demonstrate considerable predictability, particularly for winter and spring spawning aggregations. The availability and characteristics of prey patches (pollock, Atka mackerel, Pacific cod, or other prey) may be essential to the foraging success of sea lions. Important patch characteristics may include their size, location, persistence, composition (e.g., prey sizes) and density (number of patches per area). Unfortunately, the information available to characterize such prey patches (and evaluate their potential importance to sea lions) is limited to trawl and hydroacoustic surveys that generally provide a single broad-scale snapshot of prey distribution on an annual or less frequent basis.

The quality of the sea lion diet appears to be determined not only by the individual components (species) of the diet, but also by the mix or diversity of prey in the diet. Merrick *et al.* (1997) found a correlation between a measure of diet diversity in different geographic regions of the western population and population trends in those regions. Their conclusions were that reliance on a single prey type may not be conducive to population growth; a diversity of prey may be necessary for recovery of the western population. Trites (unpubl. data) evaluated the diet and population growth data for Steller sea lions in southeast Alaska and found results consistent with those of Merrick *et al.* (1997). Unfortunately, diet diversity is a function not only of prey selection, but of the diversity of prey available. Regardless of the diversity of the prey field available, sea lions must survive on those prey.

Foraging - integration and synthesis

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

- Steller sea lions are land-based predators but their attachment to land and foraging patterns/distribution may vary considerably as a function of age, sex, site, season, reproductive status, prey availability, and environmental conditions;
- 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);
- at present, pollock and Atka mackerel appear to be their most common or dominant prey, but Steller sea lions consume a variety of demersal, semi-demersal, and pelagic prey;
- 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;
- 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; and
- the broad distribution of sea lions sighted in the POP database indicates that sea lions also forage at sites distant from rookeries and haulouts; the availability of prey at these sites may be crucial in that they allow sea lions to take advantage of distant food sources, thereby mitigating the potential for intraspecific competition for prey in the vicinity of rookeries and haulouts.

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

3.7.7 Natural predators

The Recovery Plan for the Steller Sea Lion (NMFS 1992) states: "Steller sea lions are probably eaten by killer whales and sharks, but the possible impact of these predators is unknown. The occurrence of shark predation on other North Pacific pinnipeds has been documented, but not well quantified (Ainley *et al.*, 1981)." The likelihood of shark attack is probably greater for Steller sea lions off the Washington, Oregon, and California coasts than in waters further north. A killer whale attack has been documented off the Oregon coast (Mate 1973), but killer whales are probably much more frequent predators in the waters of British Columbia and Alaska (Barrett-Lennard *et al.*, unpubl. rep.). Barrett-Lennard *et al.* surveyed 126 respondents to estimate the rate of observation of sea lion/killer whale interactions. Of 492 interactions witnessed, 32 (6.5%) reportedly involved sea lion mortality. The lethal interaction rate appeared to be greatest in the Aleutian Islands region, but those results were based on the "vague recollection" of one observer of 3 kills over a 24-year period. Perhaps the most noteworthy anecdotal observation of apparent killer whale predation on sea lions occurred in 1992, when flipper tags from 14 sea lions that were both tagged and branded were found in the stomach of a killer whale dead on the beach in Prince William Sound (NMFS 1995). Barrett-Lennard *et al.* (unpubl. rep.) model sea lion mortality due to killer whales, and suggest that while such predation may account for a significant portion of natural mortality at the current low size of the sea lion population, it was not likely to have been the cause of the decline. The most recent status report on Steller sea lions (NMFS 1995) concurs and points out that relative abundance of killer whales is likely greater off southeast Alaska, where sea lion populations have been slowly increasing.

Since the completion of the December 3, 1998 Biological Opinion on the possible effects of the pollock and Atka mackerel fisheries on the western population of Steller sea lions, a number of killer whale and sea lion interactions have been reported throughout the GOA and BSAI regions. Such interactions might reflect a true increase in such interactions, increased reporting of a relatively constant level of interactions, or some combination of the two. Without further scientific study of such interactions, the significance of killer whale predation to the status and trends sea lion populations can not be determined with confidence.

3.7.8 Natural competitors

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

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

3.7.9 Disease

Hoover (1988) lists parasites known to infect sea lions, including cestodes of the genera *Diplogonoporus, Diphyllobothrium, Anophryocephalus, Adenocephalus,* and *Pyramicocephalus*; trematodes of the genera *Pricetrema, Zalophotrema,* and *Phocitrema*; acanthocephalans of the genera *Bulbosoma* and

Corynosoma; and nematodes of the genera *Anisakis*, *Contracaecum*, *Parafilaroides*, *Uncinaria*, and *Phocanema* (Hill 1968, Dailey and Brownell 1972, Daily 1975, Fay *et al.* 1978, Geraci 1979, Dieterich 1981). In addition, Thorsteinson and Lensink (1962) reported two types of parasites: Body louse (*Antarctophthirus michrochir*) severely infesting pups and nose mites *(Orthohalarachne diminuta*) invariably found on adults. And Scheffer (1946) reported ascarid worms (*Porocaecum decipiens*) nearly always found in adult stomachs.

Hoover (1988) also lists evidence of exposure of sea lions to leptospirosis (Fay *et al.* 1978), chlamydiosis (Goodwin and Calkins 1985), and San Miguel sea lion virus (Goodwin and Calkins 1985, Barlough *et al.* 1987). Barlough *et al.* (1987) also present evidence of eight types of calici virus (including seven types of San Miguel sea lion virus and Tillamook [bovine] virus). And recent tests, indicate exposure to brucellosis (pers. comm., K. Pitcher, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518). Disease may have contributed to the *in utero* mortality rate observed in animals collected in 1975-1978 and 1985-1986 (Pitcher *et al.* in review) but, again, that hypothesis is not substantiated by any data.

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

3.7.10 Population dynamics

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

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

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

However, if the purpose is to study or understand the natural (i.e., without human influence) population structure of the Steller sea lion, then the biogeography of the species must be defined more narrowly.

Genetic studies may provide the best description of the result of biogeographic patterns, as they are likely the least influenced by human interaction. Demographic trends and foraging patterns may be influenced by human activities and, clearly, the artificial boundaries determined for political purposes should not have an influence on the natural biogeography of sea lions.

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

Without a better understanding of movement patterns of sea lions, the geographic extent of potential fisheries effects can not be estimated with confidence. For example, we can not, at this time, describe the geographic extent of fishing for Atka mackerel at Seguam pass because we can not confidently determine whether the sea lions foraging at that site are from just Seguam and Agligadak Island rookeries, or perhaps also from Yunaska and Kasatochi Island rookeries or sites more distant. Similarly, the pollock fisheries in Shelikof Strait may have influenced the dynamics of sea lion populations at Chirikof and Chowiet Islands, or may have even farther reaching effects if, for example, sea lions from the Shumagin Islands forage in Shelikof Strait. An understanding of the natural biogeography of the Steller sea lion is essential to describe their population size or status, trends, variability, and stability, and to identify the potential effects of human activities.

3.7.11 Population status and trends

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

For the western U.S. population (i.e., west of 144°W long.), counts of adults and juveniles fell from 109,880 animals in the late 1970s to 22,167 animals in 1996, a decline of 80% (Fig. 16; Hill and DeMaster 1998, based on NMFS 1995, Strick *et al.* 1997, Strick *et al. in press*). From the late 1970s to 1996, abundance estimates for the GOA dropped from 65,296 to 9,782 (85%), and for the BSAI region dropped from 44,584 to 12,385 (72%). Counts in Russian territories (to the west of the action area for the BSAI and GOA groundfish fisheries) have also declined and are currently estimated to be about one-third of historic levels (NMFS 1992). Counts in southeast Alaska (to the east of the action area for the GOA groundfish fisheries) are increasing slowly.

For the western population, the number of animals lost appears to have been far greater from the late 1970s to the early 1990s. Nevertheless, the rate of decline in the 1990s has remained relatively high: the 1996 count was 27% lower than the count in 1990. Counts conducted in 1998 suggest that the overall decline continues (Table 6; data from T. Loughlin, pers. comm. and from Sease and Loughlin 1999, their Tables 4 and 5). The counts reported in Table 6 are for rookery and haulout "trend sites" (top) and for rookery trend sites only (bottom). Counts at rookery trend sites declined from 1996 to 1998 in all major regions except the eastern GOA (Sease and Loughlin 1999, their Table 5). In addition, the portion of (nonpup) sea lions counted on rookeries versus haulouts appears to have declined considerably during the 1990s (Sease and Loughlin 1999, their Table 7). This drop could occur for a number of reasons: a decrease in reproductive rate for females, a decrease in number of males on the rookeries, a shift in the age distribution from relatively more mature animals to relatively fewer mature animals (such as might occur with greater juvenile survival), or a shift in the timing of reproduction relative to the timing of the counts. To the extent that this shift indicates a decrease in reproductive rate, then this trend bodes poorly for near future recovery.

Although the decline of the western population has occurred over extensive areas, site-by-site evaluation of the counts may be helpful for understanding the decline and anticipating the nature of threats to the species as local populations dwindle to extremely low numbers. However, changes observed at specific sites must be interpreted with caution because factors affecting counts at specific sites are generally unknown or poorly known. Perhaps more importantly, animals move between sites on temporary, seasonal, and permanent bases. Therefore, the extent to which the collection of animals at a given site represent an independent or meaningful population unit is not yet clear.

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

3.7.12 Population variability and stability

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

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

Vital rates and age structures may change as a function of factors either extrinsic or intrinsic to the population. This biological opinion addresses the question of potential effects of fishery actions (i.e., extrinsic factors) on the Steller sea lion. However, the potential effects will be determined, in part, by the sensitivity of the western population to extrinsic influence, its resilience, and its recovery rate. Steller sea lions fit the description of a "K-selected" species of large-bodied, long-lived individuals with delayed reproduction, low fecundity, and considerable postnatal maternal investment in the offspring. These characteristics should make sea lion populations relatively tolerant of large changes in their environment. Thus, the observed decline of the western population over the past two to three decades is not consistent with the description of the species as K-selected, and suggests that the combined effect of those factors causing the decline has been severe. The ability of the population to recover (i.e., its resilience) and the rate at which it recovers will be determined by the same K-selected characteristics (longevity, delayed reproduction, and low fecundity), as well as its metapopulation structure. Its maximum recovery rate will likely be limited to 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. The metapopulation structure of the western population may enhance or deter recovery. Dispersal of populations provides some measure of protection for the entire species against relatively localized threats of decline or extinction. And rookeries that go extinct may be more likely recolonized by seals migrating between sites. On the other hand, the division of the whole population into smaller demographic units may exacerbate factors that accelerate small populations toward extinction (e.g., unbalanced sex ratios, allee effects, inbreeding depression). Such acceleration has been referred to as an "extinction vortex" (Gilpin and Soulé 1986).

Finally, any description of population stability for the Steller sea lion should be written with caution. Over the past three decades (or perhaps longer), we have witnessed a severe decline of the western population throughout most of its range. Our inability to anticipate those declines before they occurred, our limited ability to explain them now, and our limited ability to predict the future suggests that we are not yet capable of describing the stability of Steller sea lion populations.

3.7.13 Population projections

Based on recent trends in southeast Alaska and British Columbia, prospects for recovery of the eastern population are encouraging. Population viability analyses have been conducted for the western population by Merrick and York (1994) and York *et al.* (1996). While such analyses require some assumptions, they provide a context for management and an indication of the severity and urgency of the sea lion dilemma.

The results of these analyses indicate that the next 20 years may be crucial for the western population of Steller sea lions, if the rates of decline observed in recent years continue. Within this time frame, it is possible that the number of adult females in the Kenai-to-Kiska region could drop to less than 5000. Extinction rates for rookeries or clusters of rookeries could increase sharply in 40 to 50 years, and extinction for the entire Kenai-to-Kiska region could occur in the next 100-120 years.

These projections are reasonable, given the severity of the overall decline (80% in about two decades) and the declines observed for specific time periods and regions. From 1985 to 1989, counts at trend sites in the central and western GOA declined by 55% and 39%, respectively. In the same time period, counts at trend sites in the eastern and central Aleutian Islands declined by 60% and 67%, respectively (data for 1985 are not available for the western Aleutian Islands). From 1989 to 1996, counts at trend sites in the eastern and central GOA dropped by 70%, and 61% respectively. These counts represent severe drops that argue that the above population projections are clearly feasible.

3.7.14 Listing Status

On 26 November 1990, the Steller sea lion was listed as threatened under the Endangered Species Act of 1973 (55 FR 49204). The listing followed a decline in the U.S. population of about 64% over the three decades prior to the listing. In 1997, the species was split into two separate stocks on the basis of demographic and genetic dissimilarities (Bickham *et al.* 1996, Loughlin 1997), the status of the western stock was changed to endangered, and the status of the eastern stock was left unchanged (62 FR 30772).

3.7.15 Critical habitat description

The term "critical habitat" is defined in the Endangered Species Act (16 U.S.C. 153) to mean:

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

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

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

Establishment of Critical Habitat

The areas designated as critical habitat for the Steller sea lion were determined on the basis of the available information on life history patterns of the species, with particular attention paid to land sites where animals haul out to rest, pup, nurse their pups, mate, and molt, and to marine sites considered to be essential foraging areas. The foraging areas were determined on the basis of sightings of sea lions at sea, incidental catch data (Loughlin and Nelson 1986, Perez and Loughlin 1991), and foraging studies using satellite-linked tracking systems. Critical habitat areas were determined with input from NMFS scientists and managers, the Steller Sea Lion Recovery Team, independent marine mammal scientists invited to participate in the discussion, and the public. The proposed rule for establishment of critical habitat for the Steller sea lion was published on 1 April 1993 (58 FR 17181), and the final rule was published on 27 August 1993 (58 FR 45269). The following areas have been designated as critical habitat in the action area of one or more of the proposed fisheries (Fig. 17).

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

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

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

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

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

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

Physical and biological features of Steller sea lion critical habitat

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

Prey resources are the most important feature of marine critical habitat. Marine areas may be used for a variety of other reasons (e.g., social interaction, rafting or resting), but foraging is the most important sea lion activity that occurs when the animals are at sea. Two kinds of marine habitat were designated as critical. First, areas around rookeries and haulouts were chosen based on evidence that 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). These young animals are just learning to feed on their own, and the availability of prey in the vicinity of rookeries and haulouts must be crucial to their transition to independent feeding after weaning. Similarly, areas around rookeries are likely to be important for juveniles. While the foraging patterns of juveniles have not been studied in the BSAI region, it is possible that they depend considerably on resources close to haulouts. Evidence indicates that decreased juvenile survival may be an important proximate cause of the sea lion decline (York 1994, Chumbley *et al.* 1997), and that the growth rate of individual young seals was depressed in the 1980s. These findings are consistent with the hypothesis that young animals are nutritionally stressed. Furthermore, young animals are almost certainly less efficient foragers and probably have relatively greater food requirements which, again, suggests that they may be more easily limited or affected by reduced prey resources or greater energetic requirements associated with foraging at distant locations. Therefore, the areas around rookeries and haulouts must contain essential prey resources for at least lactating adult females, young-of-the-year, and juveniles, and those areas were deemed essential to protect.

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

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

Critical habitat and environmental carrying capacity

Prey resources are not only the primary feature of Steller sea lion critical habitat, but they also appear to determine the carrying capacity of the environment for Steller sea lions. Therefore, the concepts of critical habitat and environmental carrying capacity are closely linked: critical habitat reflects the geographical extent of the environment needed to recover and conserve the species. The term “environmental carrying capacity” is generally defined as the number of individuals that can be supported by the resources available. The term has two main uses: first as a descriptive measure of the environment under any given set of circumstances, and the second as a reference point for the environment under “natural” conditions (i.e., unaltered by human activities). Thus, the definition can have markedly different implications depending on whether it is used as a reference point for the natural carrying capacity of the environment, or the carrying capacity of the environment as it may have been altered by human-related activities.

The changes observed in the 1970s and 1980s in Steller sea lion growth, reproduction, and survival are all consistent with limited availability of prey. At this time, the best scientific and commercial data available are not sufficient to distinguish the relative influences of natural (i.e., oceanographic) factors versus human-related activities (i.e., fisheries) on the availability of prey for sea lions. The notion that the observed changes in sea lion vital parameters are consistent with a change in “carrying capacity” does not necessarily mean that the changes are entirely natural. If carrying capacity is defined as a measure of the environment under any set of conditions, then that capacity could also have been reduced by fisheries. That is, natural and human-related changes to the carrying capacity are not mutually exclusive; both types of factors may have been operating at the same time. Natural and human-related factors that may have affected Steller sea lions or their environment in the past are described in the next section.

4.0 ENVIRONMENTAL BASELINE

4.1 Large whales

4.1.1 Status of the species within the action areas

Relatively little information is available on the status of the six large protected cetaceans considered in this opinion. Recent sightings suggest a small number of northern right whales are beginning to use the southeastern Bering Sea where many of the subject fisheries occur. The stock structure of the northern right whale in the action areas is unknown. Abundance is also unknown, but the species is clearly in a state of severe depletion. As virtually nothing is known of the abundance of these animals, their trends in the action area are also unknown.

The overall abundance of the blue whale is also unknown in the North Pacific, but abundance of blue whales in the eastern North Pacific has been estimated at 3500. Current information suggests that two blue whale stocks may occur in the action areas, but abundance and trends for those two stocks are unknown.

Only one stock of fin whale is recognized for the North Pacific. This stock occurs in the action area, but its abundance and trends are unknown.

The sei whale may be present only in the more southern portions of the action area, south of the Aleutian Islands. Abundance and trends are unknown.

Relatively more information is available for humpback whales in the North Pacific. Two stocks occur in the action areas, a western North Pacific stock and a central North Pacific stock. Abundance and trends of the western stock are unknown. The central stock was estimated at 4,005 for 1991 to 1993. Trends for the central stock are not well described, although some data suggest that it may be increasing.

Sperm whales occur in the action areas, but are generally limited to areas of greater depth (e.g., 200 m or deeper). Their abundance and trends are unknown.

4.1.2 Known or suspected factors contributing to the current status of the large cetaceans in the action areas

The dominant factor determining the status of the large protected cetaceans in the North Pacific is the historical commercial killing of these animals in the latter half of the last century and through the early and middle part of this century. Ship strikes, subsistence harvests, entanglement in fishing gear or gear related to other oceanic activities by humans have contributed to their declines, but probably to a trivial or negligible degree, particularly compared to the effects of commercial whaling. Other possible causes include disease, natural environmental changes, effects of contaminants, and disturbance.

4.2 Steller sea lions

4.2.1 Status of the species within the action areas

Total abundance for the western population of Steller sea lions in 1996 has been estimated as 39,500 animals (Hill and DeMaster 1998; based on 1996 counts [NMFS unpubl. data] and correction factors derived by

Loughlin *et al.* [1992]). Based on these counts (as an index of population abundance), the western population declined by 80% since the late 1970s.

The 1996 counts used to derive this estimate included 11,710 animals (nonpups) in the BSAI region and 9,782 animals (nonpups) in the GOA. These counts suggest that, in 1996, about 54% of the western population was in the BSAI region and 46% in the GOA. Counts in 1998 indicate that the number of sea lions in both the BSAI and GOA regions continue to decline (Sease and Loughlin 1999). These estimates should be used cautiously when assessing the potential effects of a fishery. Due to mobility of both the fish stocks and sea lions, the effects of a fishery may extend beyond the distribution of fishing effort. Critical habitat for the western population (west of 144°W long.) has been designated around 40 rookeries and 82 haulouts (approximate, overlapping circles with a radius of 20 nm; Fig. 17) and special foraging areas at Seguam Pass, in the southeastern Bering Sea, and in Shelikof Strait.

Total abundance of the eastern population of Steller sea lions in 1996 has been estimated as ca. 30,400 (Hill and DeMaster 1998). This number is a minimum estimate not corrected for animals at sea during the counts. Based on counts in 1994 (20,176) and 1982 (14,895), the eastern population increased by 35% during that period (suggesting an annual growth rate of about 2.5%).

The total abundance estimate of ca. 30,400 for the eastern population was derived by summing counts of animals from southeast Alaska (14,571), California, Oregon and Washington (6,555), and British Columbia (9,277), and includes both nonpups (adults and juveniles) and pups. These counts suggest that, in 1996, about 48% of the eastern population was in southeast Alaska, 22% in California, Oregon, and Washington, and 31% in British Columbia (with rounding error). Counts in southeast Alaska during 1998 indicate a continued increase in that area (Sease and Loughlin 1999). Critical habitat for the eastern population (east of 144°W long.) has been designated around 3 rookeries and 22 haulouts in the eastern GOA or southeast Alaska and 6 rookeries in California or Oregon. For the eastern population, critical habitat extends 0.9 km seaward from these rookeries and haulouts. No special foraging areas have been included in critical habitat for the eastern population.

The potential effects of the groundfish fisheries on both the western and eastern populations include either operational effects (incidental kill, gear conflict, entanglement, destruction of catch) or biological effects (competition for prey, changes to the community composition, changes in the age/size structure of prey populations). Operational effects could result in injury or death of sea lions. Biological effects could result in decreases in condition, growth, reproduction, or survival.

4.2.2 Known or suspected factors contributing to the current status of Steller sea lions or their critical habitat

Predation

As noted in the above section on status of the species, killer whales and sharks prey on Steller sea lions. Anecdotal evidence of such predation is available, but the rate of predation and the potential impact on population trends can not be determined with any measure of confidence. Given the reduced abundance of sea lions at multiple sites (rookeries and haulouts), predation by killer whales and other sources of natural mortality may exacerbate the decline or impede recovery in local areas (e.g., Barrett-Lennard *et al.* unpubl. rep.). Killer whale predation likely occurs in the ranges occupied by both the western and eastern populations of sea lions, and may be more common in southeast Alaska, where the sea lion population is growing slowly.

Disease

Disease and parasitism may also impede population growth, and evidence is available indicating that animals have been exposed to diseases and carry parasites. However, none of the evidence available at this time provides any indication that disease or parasitism caused the decline of the western population or are impeding the recovery of the eastern population. Disease and parasitism are common in all pinniped populations and have been responsible for major die-offs (e.g., Osterhaus and Vedder 1988), but such events are usually relatively short-lived and provide more evidence of morbidity or mortality. The ramifications of disease and parasitism remain of concern, both as primary and secondary problems, but do not appear to be significant factors at this time or on the basis of the information currently available.

Toxic substances

Several studies indicate that organochlorine pollutant residues in the tissues of California sea lions and harbor seals have been associated with reproductive failure (NMFS 1992). A number of studies (Varanasi *et al.* 1992, Lee *et al.* 1996, Krahn 1997, Krone 1997) have also indicated relatively high concentrations of organochlorine compounds in Steller sea lions in Alaska, although these levels have not yet been associated with any changes in health or vital rates. Steller sea lions were undoubtedly exposed to oil after the Exxon Valdez oil spill, but no significant adverse effects of the oil were confirmed (Calkins *et al.* 1994; see the next section). At the present time, the available information does not support the hypothesis that contaminants are a significant contributor to the decline of sea lions, or an impediment to their recovery.

Oil and gas or mineral development

Previous NMFS biological opinions for both the BSAI and the GOA analyzed this factor under the heading of “human development.” In each case it was noted that human development activities that result in aquatic habitat destruction or the release of contaminants and pathogens (e.g., mineral exploration and extraction, effluent discharges into the marine environment) could directly diminish the health and reproductive success of Steller sea lions or cause them to abandon feeding, breeding, or resting sites. Development and discharge proposals typically undergo ESA section 7 consultation during the Federal permitting process.

On October 15, 1993, NMFS completed a biological opinion on the leasing and exploration activities of the Minerals Management Service in the Cook Inlet/Shelikof Strait region (lease sale Number 149). The opinion concluded that such 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. The biological opinion noted that “Shelikof Strait was designated as critical habitat based on its proximity to major rookeries and important haulouts, its use by foraging sea lions, and its value as an area of high forage fish production. Any impacts attributable to oil and gas development that adversely affect the forage fish resource within Shelikof Strait may also adversely modify this critical habitat.” However, NMFS also noted that “the probability of an oil spill during exploration is low, and the forage resource base within Cook Inlet/Shelikof Strait is unlikely to be impacted to the point of adversely affecting this critical habitat.”

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.

Oil spills are expected to result in adverse effects if they contact Steller sea lions, haulouts, or rookeries when occupied, or large proportions of major prey. 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 nonpup 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 GOA after the Exxon Valdez oil spill did not appear to avoid oiled areas. 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).

Steller sea lions are probably most vulnerable to acute oil spills during mid-May through mid-July, the period of time they are on rookeries (Calkins and Pitcher 1982). An oil spill near any rookery during this time could cause abandonment of pups and interrupt the normal breeding cycle. Loss of a majority of pups from one of the large rookeries plus failure to impregnate females from that rookery could have serious implications for the western population of sea lions. Loss of prey species may pose the most serious, long term threats to sea lions in the GOA (Calkins and Pitcher 1982).

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 GOA. 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 recently concluded, therefore, that oil and gas activities in the Bering Sea have not significantly affected the Bering Sea ecosystem (National Research Council 1996).

Disturbance by activities unrelated to fishing

Several studies investigating the potential effects of oil and gas exploration and development on the Steller sea lion have noted human disturbance as a potential factor. 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 contributed to or exacerbated the decline of the western population, although it is not likely to have been a major factor. Disturbance may also impede the recovery of the eastern population, which occupies an area where small vessel traffic is far greater than occurs in the GOA and BSAI. At present, concern is focused on disturbance as an impediment to the study of sea lions and other potential causes of the decline.

Research

Steller sea lions have been taken for scientific research (Thorsteinson and Lensink 1962, Calkins and Pitcher 1982, Calkins and Goodwin 1988, and Calkins *et al.* 1994):

- Experimental commercial harvest of 630 sea lion bulls in 1959. Life history information (age, size, reproductive condition, food habits) was collected.

- Between 1975 and 1978, 250 sea lions were collected by shooting in nearshore waters and on rookeries and hauling areas of the GOA. 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 collected in the GOA and Southeastern 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.

- Sixteen animals were collected under the Natural Resources Damage Assessment study conducted on Steller sea lions in 1989 following the Exxon Valdez oil spill.

Entanglement in marine debris

Observations of Steller sea lions entangled in marine debris have been made throughout the GOA and in southeast Alaska (Calkins 1985), typically incidental to other sea lion studies. Two categories of debris, closed plastic packing bands and net material, accounted for the majority of entanglements. Loughlin *et al.* (1986) surveyed numerous rookeries and haulout sites to evaluate the nature and magnitude of entanglement in debris on Steller sea lions in the Aleutian Islands. Of 30,117 animals counted (15,957 adults; 14,160 pups) only 11 adults showed evidence of entanglement with debris, specifically, net or twine, not packing bands or other materials. Entanglement rates of pups and juveniles appear to be even lower than those observed for adults (Loughlin *et al.* 1986). It is possible that pups were too young during the survey to have encountered debris in the water or that pups and juveniles were unable to swim to shore once entangled and died at sea. Trites and Larkin (1992) assumed that mortalities from entanglement in marine debris were not a major factor in the observed declines of Steller sea lions and estimated that perhaps fewer than 100 animals are killed each year.

Commercial harvest of Steller sea lions

In 1959, the Bureau of Commercial Fisheries awarded a contract to a commercial fishing company to develop techniques for harvesting sea lions in Alaskan waters. The two-fold purpose of the contract was to reduce the sea lion herds (because of alleged depredations on salmon and halibut fisheries) and to provide an economical source of protein for fur farms, fish hatcheries, and similar purposes (Thorsteinson and Lensink 1962). In 1959, 630 sea lion bulls were killed in an experimental harvest, but the harvest proved to be uneconomical. Another study was contracted by the Bureau of Indian Affairs of the Department of Interior to analyze the feasibility of a commercial sea lion harvest in Alaska. A total of 45,178 pups of both sexes were killed in the eastern Aleutian Islands and GOA between 1963 and 1972 (Merrick *et al.* 1987). Such harvests could have depressed recruitment in the short term and may have explained declines noted at some sites in the eastern Aleutian Islands or the GOA. These harvests do not appear to explain declines in other regions. Bigg (1988) lists the numbers of animals culled at rookeries and haulouts in British Columbia from 1912 to 1968. The impact of such culls on numbers of sea lions in southeast Alaska is not clear, but through migration, may well have affected the distribution and numbers of sea lions throughout the entire region.

Subsistence harvest of Steller sea lions

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

Subsistence harvest of Steller sea lions from 1960 to 1990 has been estimated at 150 animals per year (Alverson 1992), but the estimate was subjective and not based on any referenced data. This estimate is well below the levels observed in the 1990s (Hill and DeMaster 1998), which seems inconsistent with the fact that sea lion populations are at their lowest recorded levels. In 1986, a working group organized by NMML suggested that subsistence harvest had a potentially low impact on recent Steller sea lion population declines in Alaska (Loughlin 1987). More recent estimates (Wolfe and Mishler 1993, 1994, 1995, 1996, 1999) indicate a mean annual subsistence take of 448 animals from the Western U.S. stock (i.e., the endangered population) from 1992 to 1995, declining to 178 (with 95% confidence limits of 137 to 257) in 1998. The majority of sea lions have been taken by Aleut hunters in the Aleutian and Pribilof Islands. The great majority (99%) of the statewide subsistence take was from west of 144°W long. (i.e., the range of the western population). Therefore, the expected effect of subsistence harvesting on the eastern population is expected to be negligible with respect to population trends.

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

Natural environmental change

Discrimination between the relative influence of natural environmental factors versus human activities is controversial in both a scientific and management context. The distinction between natural and human-related impacts gets to the heart of management responsibilities under both the Marine Mammal Protection

Act (MMPA) and the Endangered Species Act (ESA). At the time these acts were passed, our conceptual model of natural ecosystems was built largely on the notion of a balance and persistence in nature, or a stable point of ecosystem equilibrium. In the past three decades, we are discovering that the term "stable" may not be such a good descriptor of ecosystems; that is, we are learning that ecosystems vary naturally. At the same time, ecosystems may be seriously perturbed by human activities (e.g., global warming, global pollution, and ever increasing demands for natural products to satisfy growing human populations), and often we can not distinguish natural variation from changes wrought by human activities.

Studies of atmospheric and oceanic circulation and physical properties indicate that the BSAI and GOA ecosystems shift between at least two types of climatic regimes (Ebbesmeyer *et al.* 1991, Trenberth 1990, Brodeur and Ware 1992, Beamish 1993, Francis and Hare 1994, Miller *et al.* 1994, Trenberth and Hurrell 1994; Ingraham *et al.* 1998). While these regimes differ in many ways, they can be simply categorized as "warm" and "cold" depending on atmospheric and oceanic temperatures. One factor inducing the shift between regimes is changes in the position of the Aleutian Low Pressure system, which leads to changes in atmospheric temperature, storm tracks, ice cover, and wind direction (Wyllie-Echeverria and Wooster 1998). Shifts between regimes can be reflected in such indices as the Southern Oscillation Index, Pacific Decadal Oscillation, and the North Pacific Index. Historical studies suggest that over the last 500 years, the system has oscillated between the two distinct regimes every 10-30 years (Ingraham *et al.* 1998).

A well-documented shift from a cold to a warm regime in 1976-77 was associated with dramatic changes in the structure and composition of the invertebrate and fish communities as well as the distribution of individual species in the North Pacific ocean and Bering Sea (Brodeur and Ware 1992, Beamish 1993, Francis and Hare 1994, Miller *et al.* 1994, Hollowed and Wooster 1992; 1995; Wyllie-Echeverria and Wooster 1998). For instance, many groundfish stocks, particularly pollock, Atka mackerel, cod and various flatfish species increased in abundance as a result of strong yearclasses spawned in the mid to late 1970s. Many of the long-lived flatfish species (e.g., arrowtooth flounder, Pacific halibut, yellowfin sole, and rock sole) remained in high abundance since then, while other shorter lived groundfish species (pollock, Atka mackerel, and Pacific cod) have oscillated in abundance. Based on these patterns, researchers have associated "warm" years (and other related environmental conditions, such as southwest winds in April [Wyllie-Echeverria and Wooster 1998]), with the production of strong yearclasses of gadids (Hollowed and Wooster 1992; 1995; Wespestad *et al.* 1997a).

Increases in many broadly distributed benthic (e.g., arrowtooth flounder, Pacific halibut) and semi-demersal (e.g., pollock and Pacific cod) piscivorous groundfish species since the late 1970s have been associated with either (or both) a decline in abundance (at least in nearshore environments; Anderson *et al.* 1997) or a change in distribution of short-lived pelagic species such as capelin. Anderson and Piatt (*in prep*) describe an almost complete disappearance of capelin from bays and the nearshore environment of the western and central GOA beginning in the late 1970s and early 1980s, and increases in cod and flatfish. During this time, the prevalence of capelin in the diets of many piscivorous birds and pinnipeds in the GOA also declined. However, Livingston (*in prep*) estimated that capelin consumption in 1990 in the GOA by the groundfish species was at least 300,000 mt. This suggests that capelin didn't necessarily disappear from the GOA (since so much was eaten), but changed its vertical distribution (went deeper), possibly in response to the warm conditions. If this change occurred, capelin would have been more susceptible to predation by piscivorous groundfish and less available to birds and pinnipeds that begin their foraging excursions from the water's surface.

As in the GOA, the prevalence of capelin in the diets of puffins, kittiwakes and other birds on the Pribilof Islands in the BSAI also declined in the mid-1980s. Furthermore, the prevalence of juvenile pollock tended to increase during this time period (Byrd *et al.* 1992, Springer 1992). Further north in the EBS, capelin remains a dominant feature of the kittiwake diet on St. Lawrence Island. This suggests that capelin distribution contracted to the north in response to warming conditions in the EBS in the 1980s and 1990s. Thus, capelin in the EBS may have redistributed horizontally (or geographically) in response to warming, while in the GOA, the redistribution may have been more in the vertical dimension. Regardless, these changes in prey distribution in response to changes in environmental conditions may have reduced the availability of capelin to Steller sea lions in the SE Bering Sea and GOA. During warm regimes, Steller sea lions may then depend on the availability and abundance of other resident prey in these areas for their survival.

Sea lions may have lived through many regime shifts in the few million years that they have existed. What may be different about this most recent shift 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 GOA 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 effect. The cause of the sea lion decline need not be a single factor. To the contrary, strong environmental influences on BSAI and GOA ecosystems could increase the sensitivity of sea lions to fisheries or changes in those ecosystems resulting from fisheries.

Prey quality

Alverson (1992) proposed that the changes in trophic structure observed in the BSAI and GOA regions resulted in the dominance of pollock, and he further proposed that the shift to ecosystems dominated by pollock has been the overriding factor in the decline of Steller sea lions. That is, Alverson (1992) suggested a link between the changes in trophic structure of these ecosystems and the decline of sea lions based on the notion that pollock are a low quality prey for sea lions and the western population has not been able to sustain itself with this low quality prey. This suggestion has become known as the “junk food hypothesis.”

The notion that pollock are of low quality is based on the fact that, on average, pollock have a lower fat content (per kilogram) than many of the other species in the sea lion’s diet. To illustrate this difference, pollock are frequently compared with herring, which has a higher fat content than other prey species in the sea lion diet. The difference has been used to argue the pollock are a bad prey item for sea lions.

Pollock might not be the preferred prey of sea lions if they had a wide selection from which to choose. But as Alverson (1992) suggested, the observed change in the trophic structure of these ecosystems indicates that they do not have a wide selection. Further, sea lions in the wild are not completely limited to a single prey type. Diet studies conducted to date indicate that sea lions feed on a number of prey. The amount of diversity has varied considerably and may be an important factor (Merrick *et al.* 1997), but clearly sea lions are not limited to the extreme of only one prey type. In addition, the value of any particular prey type is not determined solely by its fatty content, but also by factors such as individual size, total biomass, availability, behavior, degree of aggregation, temporal and spatial distribution, and so on. That is, the value of any particular prey type depends on the net gain to a sea lion from foraging on that prey, and net gain is a function of multiple factors of which fat content is an important, but not the only, determinant.

Fishery impacts

This consultation considers the potential effects of the BSAI and GOA groundfish fisheries. These fisheries may interact with Steller sea lions in a wide variety of ways, including operational conflicts (e.g., incidental kill, gear conflicts, sea lion removal of catch) and biological conflicts (e.g., competition for prey). Operational conflicts are assessed by observers and have been reduced to low levels (Hill and DeMaster

1998) that are considered to be negligible at a sea lion population level. Therefore, the discussion of fishery effects will focus on biological effects and, particularly, competition.

Assessing past competition --- The issue of competition between fisheries and sea lions is central to this biological opinion and a determination of whether these fisheries jeopardize the survival and recovery of the Steller sea lion or adversely modify its critical habitat. Competition occurs when two potential competitors use the same resource, the use of the resource by one potential competitor limits the availability or use by a second competitor, and the restriction in availability or use of the resource constrains or limits the second competitor in some manner.

Two approaches have been suggested to assess the potential for competition between sea lions and fisheries. The first approach involves establishment or demonstration of a direct causal link. The second approach does not require establishment of a direct link, but rather searches for correlations between observed changes in sea lion vital rates or population trends and patterns in the fishery or fished stock. This second approach, therefore, assumes a link may occur if a correlation can be demonstrated.

The first approach was suggested by Lowry *et al.* (1982), who provide the following series of questions for assessing a direct causal link between fisheries and Steller sea lion: (a) does the subject fishery affect the diet of Steller sea lions? (b) do any changes in diet compromise the condition of individual animals? (c) are any changes in condition sufficient to reduce growth, reproduction or survival? and (d) are any changes in reproduction and/or survival sufficient to have significant population effects? Unfortunately, the data required to answer these questions are either unavailable or equivocal.

The second approach uses the observation of potential relations (correlations) to indicate that a fishery may have had a significant impact on Steller sea lions. Most examples of this approach include investigations of correlations between indices of the pollock or other fisheries in the BSAI and GOA regions and indices of Steller sea lion populations (Loughlin and Merrick 1989, Alverson 1992, Trites and Larkin 1992, Ferrero and Fritz 1994). The question is whether the removal of fish biomass by the fishery reduces the availability of prey for Steller sea lions to the extent that the condition and vital rates of sea lions are compromised and local populations of sea lions are detrimentally affected. This approach is also severely confounded.

! The most plausible relation would be between the amount of prey available in the area where sea lions forage (the *X* or independent variable) and some localized measure of sea lion "well-being" such as condition, growth, reproduction, survival, or abundance (the *Y* or dependent variable). Importantly, the amount of prey available is rarely known in the areas where sea lions forage, and measures of harvest or total biomass for a larger area (i.e., total biomass in the BSAI region) may or may not be good indicators of prey available. For example, a large catch in a small area may indicate that the prey available was severely reduced (creating poor conditions for sea lions), or it may indicate that large amounts of prey were available (good conditions). In most cases, the data currently available do not allow a distinction between these two scenarios, so the X variable cannot be determined. 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. If the problem is starvation-induced mortality, then an individual sea lion will survive or starve on the basis of the prey it encounters and consumes. It is, therefore, crucial to understand the distribution of prey, as well as its abundance. Without additional survey information at the appropriate spatial and temporal scales (i.e., those that pertain to sea lion foraging), we can not confidently characterize the magnitude or significance of the *X* or independent variable (prey availability) in these attempted correlations.

! The concept of prey availability is often defined in a univariate context; that is, the amount of prey available is estimated for a single species of prey (i.e., pollock). If starvation is the problem, then sea lions will starve not so much on the basis of the availability of a single prey, but on the availability of all prey types combined (e.g., a multivariate context). Clearly, diet studies indicate that sea lions consume more than one prey type (e.g., NMFS 1995). Certain species (e.g., pollock) may constitute the primary prey available but, on the basis of the current information, we can not quantify the absolute or relative abundance of all prey types. Thus, we can not characterize the multi-species nature of "prey availability," which may be better symbolized as $\{X_{pollock} + X_{Atka\ mackerel} + X_{cod} + X_{herring} + \textit{and so on}\}$.

! Similarly, the testing of fishery effects may be confounded by factors unrelated to fisheries. Considerable evidence indicates that environmental conditions and trophic structure have shifted within the action areas (see the section on environmental changes). The effects of such shifts may be similar to fisheries-related effects and, at present, the effects of environmental or ecological factors can not be distinguished from potential fishery effects. In addition, we know that harvesting of sea lions, intentional illegal kill, incidental kill in trawl nets, and other factors were operating to the detriment of sea lions during the same period. So in addition to prey availability (all the *X* variables), the analysis is also confounded by other factors, say $W_{environment} + W_{trophic\ structure} + W_{harvesting} + W_{incidental\ kill} + W_{intentional\ kill} + \textit{and so on}$.

! If food availability has affected population trends (i.e., counts), and counts are used as the measure of sea lion "well-being," then the response in counts may not be observed for some years. That is, the relation may involve a considerable time lag. For example, changes in pup counts on rookeries might follow declines in juvenile survival by five years or more, when deceased juvenile females would have been recruited and started producing their own pups. Similarly, counts of nonpups on rookeries will also be time-lagged as rookeries are occupied by adult males and females and pups. Juveniles are generally not present on rookeries. So the relationship between our *Y* variable and the *X* and *W* variables may be complicated further by potential time lags.

! The time series used to evaluate possible correlations may simply be inadequate. For some rookeries in the central and western Aleutian Islands, count data are highly variable and not available in the years when abundance of sea lions in these regions was thought to decline the most, based on a limited number of trend sites (i.e., before 1990). Counts after 1990 may not indicate a link because the main effects occurred earlier. So the analysis may again be confounded because certain variables can not be quantified with confidence.

As a result of these confounding factors, the power of this second approach is also low. That is, an effect (or effects) may occur, but attempts to isolate simple correlations from a complex situation severely confounded by measurement error, multiple varying factors, and time lags may not be a feasible approach. The fact that the situation is so complex does not mean that competition is not possible, it simple means that the effects of competition may not be separable from the effects of additional factors, particularly given the data at hand.

In essence, the potential for competition between the Steller sea lion and these fisheries cannot (at this time) be assessed using the direct or the simple correlative approaches described above. Such assessments will be possible only when data are available to describe the foraging distribution of sea lions, the availability of prey within that distribution, and the effects of fisheries on the availability of prey in those regions.

Finally, any analysis of potential competition in the past is clearly pertinent to this consultation. However, the question of whether competition occurred in the past is not the question to be addressed in the consultation. That question is whether the actions (fisheries) may compete with the Steller sea lion in the future.

Competition and selection of prey by size --- Size selection of prey by fisheries and by sea lions may have significant bearing on the question of whether or not competitive interactions occur. Fisheries may compete with sea lions if they remove the same size of prey from the same areas. Fisheries may also reduce the spawning biomass of prey to the extent that the reproductive capacity of the fish stock is reduced and, over time, fewer fish become available for sea lions.

The degree of overlap in the sizes of groundfish taken by Steller sea lions and by the various groundfish fisheries is not known for most species, but it is reasonable to assume at least some overlap occurs. The December 3, 1998 Biological Opinion provided evidence that the size of pollock taken by the fishery and by sea lions overlaps. Evaluation of the overlap is confounded by a number of factors. First, the sizes consumed by sea lions are determined by the available prey and any preferential selection of prey by size. In the majority of cases, scientists do not have sufficient information to characterize the available prey and therefore can measure only what was consumed, not necessarily what was preferred. Second, much of the information presented in the scientific literature on sizes of prey taken by sea lions or fisheries has been based on numbers taken by length. Inferences on relative importance of prey by numbers taken by length are, however, misleading, as dietary value is determined by biomass consumed by length, rather than number. That is, sea lions may gain a great deal more nutrition from consumption of a single large prey item than from the consumption of multiple small prey items and, therefore, number, is not the best indicator of dietary value.

Competition and depth of prey --- The possibility of competition between groundfish fisheries and the Steller sea lion has been argued on the basis of depth of fishing, and depth of diving by sea lions. Overlap by depth may occur for any of the species that occur and are taken by fisheries on the shelf or shelf break. Competition may be less likely for species that tend to be found deeper in the water column.

The extent to which competition between fisheries and sea lions may be avoided through partitioning of resources by depth can be difficult to judge using the available information. Scientific studies of sea lion foraging patterns are just beginning to characterize the diving depths and patterns of sea lions, and they are likely capable of foraging patterns not yet understood or anticipated. In addition, prey for sea lions and fisheries move vertically in the water column as a function of life history traits, geography, light levels, temperature gradients, and perhaps a range of other factors.

Competition and the winter season --- Changes in behavior, foraging patterns, distribution, and metabolic/physiologic requirements during the annual cycle are all pertinent to consideration of the potential impact of prey removal by commercial fisheries. Steller sea lions, at least adult females and immature animals, are not like some marine mammals that store large amounts of fat to allow periods of fasting. They need more or less continuous access to food resources throughout the year. Nevertheless, the sensitivity of sea lions to competition from fisheries may be exaggerated during certain times of the year. Reproduction likely places a considerable physiological or metabolic burden on adult females throughout their annual cycle. Following birth of a pup, the female must acquire sufficient nutrients and energy to support both herself and her pup. The added demand may persist until the next reproductive season, or longer, and is exaggerated by the rigors and requirements of winter conditions. The metabolic requirements of a female that has given birth and then become pregnant again are increased further to the extent that lactation and pregnancy overlap and the female must support her young-of-the-year, the developing fetus, and herself. And again, she must do so through the winter season when metabolic requirements are likely to be exaggerated by harsh environmental conditions.

Nursing pups are still dependent, at least to some extent, on their mother. If the mother is able to satisfy all the pup's nutritional needs through the winter, then at least from a nutritional point of view, winter may not be a time of added nutritional risk to the pup. If, on the other hand, the pup begins a gradual transition to independence before or during the winter season, then the challenge of survival may be greater for the pup through the winter.

Weaned pups are independent of their mothers, but may not have developed adequate foraging skills. They must learn those skills, and their ability to do so determines, at least in part, whether they will survive to reproductive maturity. This transition to nutritional independence is likely confounded by a number of seasonal factors. Seasonal changes may severely confound foraging conditions and requirements; winter months bring harsher environmental conditions (lower temperatures, rougher sea surface states) and may be accompanied by changing prey concentrations and distributions (Merrick and Loughlin 1997). Weaned pups' lack of experience may result in greater energetic costs associated with searching for prey. Their smaller size and undeveloped foraging skills may limit the prey available to them, while at the same time, their small size results in relatively greater metabolic and growth requirements.

Diet studies of captive sea lions indicated that they adjust their intake levels seasonally, with increases in fall and early winter months (Kastelein *et al.* 1990). These adjustments varied with age and sex of the studied animals, and the extent to which the patterns observed are reflective of foraging patterns in sea lions in the BSAI or GOA regions is not known. Nonetheless, such studies support the contention that the winter period is a time of greater metabolic demands and prey requirements.

Changes in condition, availability, and behavior of prey may also be essential to successful foraging by all sea lions in winter. For example, pollock in reproductive condition (i.e., bearing roe—toward the end of the winter) are presumably of greater nutritional value to sea lions (for the same reasons that the fisheries would rather take roe-bearing pollock than pollock spent after the spawning season). Also, the relative value of any prey type must also depend on the energetic costs of capturing, consuming, and digesting the prey. Prey spawning aggregations may lead to a reduction in sea lion energetic costs associated with foraging. The characteristics of such aggregations may determine their significance to foraging sea lions. Such characteristics likely include their size, depth, location, composition, density, persistence, and predictability.

Nonetheless, the information that suggests that winter may be a crucial season for Steller sea lions does not lessen the importance of available prey year-round. The observed increases in consumption by captive animals in the fall months indicates that preparation for winter months may also be essential. Spring may also be important as pregnant females will be attempting to maximize their physical condition to increase the likelihood of a large, healthy pup (which may be an important determinant of the subsequent growth and survival of that pup). Similarly, those females that have been nursing a pup for the previous year and are about to give birth may wean the first pup completely, leaving that pup to survive solely on the basis of its own foraging skills. Thus, food availability is surely crucial year-round, although it may be particularly important for young animals and pregnant-lactating females in the winter.

Interactive competition versus exploitative competition --- Much of the preceding discussion on the potential for competition between the Steller sea lion and BSAI and GOA groundfish fisheries has focused on exploitative competition; that is, competition that occurs when fisheries remove prey and thereby reduce prey availability to sea lions. In addition to exploitative competition, fisheries may affect sea lions through interactive competition. Examples of interactive competition include disruption of normal sea lion foraging patterns by the presence and movements of vessels and gear in the water, abandonment of prime foraging areas by sea lions because of fishing activities, and disruption of prey schools in a manner that reduces the effectiveness of sea lion foraging.

The hypothesis that these types of interactive competition occur can not be evaluated with the information currently available. The only data are from the POP database, and are not sufficient to describe the response of sea lions to fishing or other vessels. For example, few observations of sea lions from fishing vessels could mean that a) sea lions are present and tolerant of fishing but rarely sighted, or b) that sea lions are disturbed by fishing vessels and therefore abandon areas that are being fished. Incidental catch of sea lions in the 1970s and 1980s indicates that at least some sea lions were relatively tolerant of vessels and fishing activities. On the other hand, such interactions are relatively rare today, and it is possible there has been some selection for sea lions that avoid vessels and fishing activities.

The effects of fishing on groundfish schools are not understood. Vessels fishing for Atka mackerel trawl the same locations repeatedly, as they are unable to search for schools (Atka mackerel don't have a swim bladder and therefore are not evident on fish-finders). Analyses (Fritz , unpubl. manusc.) have shown that this repeated trawling can lead to severe localized depletion. The number of schools affected and the effects on schooling dynamics are not known, but these factors will be important in understanding the overall impact of trawling for Atka mackerel on Steller sea lions.

Vessels trawling for other targets can use fish finders and are therefore able to search for prey until they have found schools or aggregations of suitable density. The strategy used is to continue to trawl that school (or set of schools) until such time as their size or density is no longer sufficient to justify further trawling, and then to resume searching until another aggregation of suitable density is located.

The strategies used by fishing vessels likely alter schooling dynamics and important features of target schools: their number, density, size, and persistence. If sea lion foraging strategies are adapted to take advantage of prey aggregations or schools, then trawling may result not only in exploitative competition through removal of prey, but also in interactive competition through disruption of schools or aggregations and their normal dynamics. For example, the removal of a portion of a fish school by a trawl net must create at least a temporary localized depletion (i.e., a gap in the prey school). How long that gap persists and the responses of the remainder of the schooling prey to trawling are unknown. The school may aggregate again, either quickly or over time, or it may disperse. The short-term effects may be prolonged when trawling is repeated. Hypothetically, it is possible that sea lions in the immediate vicinity of the trawled school are able to take advantage of the disruption to isolate and capture prey. On the other hand, sea lion foraging patterns are more likely adapted to normal schooling behavior of prey, and trawling may disadvantage sea lions not only because it results in removal of potential prey (exploitative competition), but also because it may disrupt normal aggregation of the school.

Thus, the overall effect of interactive competition between fisheries and sea lions is unstudied and unknown, but could exaggerate the effects of exploitative competition or removal of prey.

Changes in community composition and prey diversity --- Fisheries could alter the composition of the BSAI and GOA ecosystems in a number of ways, including enhancement of a prey species by removal of a predator, enhancement of one competitor by removal of another, and suppression of a predator by removal of prey. Examples of such effects may be more common for terrestrial species, but such effects are also observed in aquatic ecosystems (e.g., Paine 1966, Power and Gregoire 1978). In addition to direct removal or reduction of a species, indirect consequences may accrue depending on the role of the species removed (e.g., keystone predator) and the method of removal (e.g., bottom trawling).

The groundfish under consideration in this opinion must assume a variety of ecological roles in the ecosystems of the BSAI, GOA, and southeast Alaska regions. Those roles and their relative importance to ecosystem structure must depend, in part, on the abundance, distribution, and age composition of the various species included in such biological communities. Those roles may change as a result of multiple factors, both natural and anthropogenic. Our current ability to assess the significance of any particular factor is severely confounded by the complexity of those systems, our poor understanding of their temporal patterns, and our inability to characterize their natural state. Fisheries-related effects may occur as a result of direct removal of components of these ecosystems, or as a result of indirect impacts such as disruption of benthic communities by bottom trawling.

The status and trends of Steller sea lion populations may depend heavily on the health of the ecosystems of which they are a part. Merrick *et al.* (1997) suggested that diet diversity was correlated to population growth in different parts of the Steller sea lion's range. Diversity may be necessary to ensure that sea lions are getting sufficient amounts of calories and essential nutrients, or to ensure that total available prey is adequate even if the availability of certain prey is variable and sometimes inadequate. Prey diversity has also been discussed in the context of changes in the trophic structure in the BSAI and GOA (e.g., Alverson 1992, Anderson *et al.* 1997), which resulted in a biological (prey) community dominated by pollock and flatfish rather than a variety of forage fish. The general consensus seems to be that a more diverse prey assemblage is likely better for sea lions.

The relevance of fisheries to the issue of diversity is based on two questions: (1) did the expansion of fisheries over the past four decades contribute significantly to changes in the trophic structure of the fish community and (2) can the changes in trophic structure be reversed (to a more diverse state) by intense fishing of pollock (e.g., Merrick 1995)? The answer to the first question appears to be "yes" based on, for example, observed declines in Pacific ocean perch or yellowfin sole. But the role of fisheries in contributing to the shift from forage fish to a pollock-dominated system is not clear. As described previously, important physical changes in the BSAI and GOA ecosystems have occurred and likely contributed to the shift in community composition. However, current information is not sufficient to distinguish between the effects of fisheries and natural physical or oceanographic changes.

The answer to the second question is equally unclear. Can a fishery, acting as a predator, alter the structure of an ecosystem by controlling a dominant competitor (e.g., pollock)? The concept of predatory control of a dominant competitor is well established in the ecological literature (e.g., Paine 1966). Springer (1992) suggested that pollock may maintain their dominance in the trophic structure both by out-competing some forage fish for zooplankton prey, and by preying on others. Skud (1982) suggested that environmental factors are important determinants of the abundance of dominant competitors, but abundance of subordinate competitors is also determined by interspecific interactions. He also suggested that if the abundance of the dominant competitor is reduced, then the subordinate competitor might increase even if climate factors are not wholly favorable. If BSAI and GOA relationships are, in fact, that simple, then greater removal of pollock may lead to a reversal of the recent changes in community composition and a greater abundance of, for example, forage fish.

The contention that increased fishing of pollock will reverse observed changes in the BSAI and GOA biological communities is, however, questionable. First, if the changes in the 1970s were due, in large part, to changes in physical conditions, then the structure of these ecosystems may be determined primarily by bottom-up processes (i.e., relations between environmental characteristics and biological processes such as primary production) rather than top-down processes (i.e., predator-prey-competitor relations). (As Skud

(1982) suggested, both bottom-up and top-down factors may be operating.) Second, certain areas (Donut Hole, Bogoslof, and Shelikof Strait) have been intensely fished for pollock and such fishing may have contributed to significant reductions of pollock in those regions. To date, however, the trophic structure in those regions has not returned to state more consistent with that observed prior to the mid to late 1970s. At present, the primary factors responsible for determining the structure of ecosystems in the BSAI and GOA regions are unclear. Third, the notion that human activities can alter these ecosystems seems reasonable (given the extent of our interaction with them), but the question of whether we can predict the direction of our effect seems presumptuous, at least at present. A review of the Steller sea lion decline, the history of human activities in these ecosystems, and the changes observed in the ecosystems suggests that we are far from a working understanding of these systems, and therefore our ability to predict even the near future is limited, at best.

Incidental take of Steller sea lions --- Steller sea lions have been caught incidentally in the foreign commercial trawl fisheries in the BSAI and GOA since those fisheries developed in the 1950s (Loughlin and Nelson 1986, Perez and Loughlin 1991). Alverson (1992) suggested that from 1960 to 1990, incidental take may have accounted for over 50,000 animals, or almost 40% of his estimated total mortality due to various fishery and subsistence activities. Perez and Loughlin (1991) reviewed fisheries and observer data and reported that from 1973 to 1988, sea lions comprised 87% (over 3000) of the marine mammal incidental take reported by observers. They extrapolated the take rate to unobserved fishing activities and suggested that the incidental take during 1978 to 1988 was over 6,500 animals. Using the average observed incidental rates during 1973 to 1977, they also estimated that an additional 14,830 animals were incidentally taken in the trawl fisheries in Alaska during 1966 to 1977. Finally, they concluded that incidental take was a contributing cause of the population decline of Steller sea lions in Alaska, accounting for a decline of 16% in the BSAI and 6% in the GOA. However, because the actual decline has exceeded 80% since 1960, incidental take does not appear to be the only or principal factor in the decline.

Estimates for more recent years indicate a reduction in the incidental take levels. The mean estimated annual (total) mortality for the BSAI and GOA groundfish trawl and longline fisheries for 1990 to 1996 is 11.4 animals and the estimate from the Prince William Sound salmon drift gillnet fishery is 14.5 animals; resulting in a total estimated mean mortality rate in observed fisheries of 25.9 sea lions per year from the endangered western stock (Hill and DeMaster 1998). Similarly, estimates of operational take by fisheries in southeast Alaska are less than 10 animals from the eastern population (Hill and DeMaster 1998).

Satellite tracking studies suggest that Steller sea lions rarely go beyond the U.S. EEZ into international waters. Given that the high-seas gillnet fisheries have ended and other net fisheries in international waters are minimal, the probability that significant numbers of Steller sea lions are taken incidentally in commercial fisheries in international waters may be low. NMFS has concluded that the number of Steller sea lions taken incidental to commercial fisheries in international waters is insignificant (Hill and DeMaster 1998).

Intentional take of Steller sea lions --- Historically, Steller sea lions and other pinnipeds were seen as nuisances to the fishing industry and management agencies because they damaged catch and fishing gear and were thought to compete for fish (Mathisen *et al.* 1962). Sea lion numbers were reduced through bounty programs, controlled hunts, and indiscriminate shooting. As noted above, they were also killed for bait in the crab fishery. Government sanctioned control measures and harvests stopped in 1972 with the introduction of the MMPA.

The total number of sea lions killed since the early part of this century is unknown. Alverson (1992) suggested that intentional take may have reached or exceeded 34,000 animals from 1960 to 1990. Fishermen were seen killing adult animals at rookeries, haulout sites, and in the water near boats. The loss of that many animals would have an appreciable effect on the population dynamics of sea lions, but the effect would not account for the total decline of the western population. The effect was likely concentrated in areas closer to fishing communities and less important in more isolated areas (e.g., central and western Aleutian Islands).

Sea lion populations appear to be growing slowly in southeast Alaska, where considerable commercial fishing occurs. Expanded observer coverage in the domestic groundfish fishery after 1989 and increased public awareness of the potential economic and conservation impacts of continued sea lion declines have probably reduced the amount of shooting.

Nevertheless, anecdotal reports of shootings continue and a small number of prosecutions have occurred in recent years. The full extent of incidental killing is undetermined and therefore should be considered a potential factor in the decline of sea lions at some locations.

Alaska State fisheries --- The Alaska Department of Fish and Game (ADF&G) manages fisheries out to three miles and oversees crab fisheries in federal waters (EEZ) under the FMP adopted by the Council. With the exception of the Alaska state sablefish fishery, ADF&G coordinates their fishery openings and in-season adjustments with federal fisheries.

Herring: Herring have been fished in Alaska since 1878. At present, the state fishery is located in the following areas: Prince William Sound, Cook Inlet, Kodiak, Alaska Peninsula, Bristol Bay, Kuskokwim, Norton Sound, Southeast, and Port Clarence. Fisheries in the Southeast and Port Clarence regions are not likely to affect the western population of Steller sea lions and are not considered further. 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. Harvest levels for 1998 are expected to be about 36,000 mt, similar to the last few years. Figure 18a shows herring catches by season and by region, and also shows the effort level depicted by the number of landings. Bristol Bay is the primary producer with recent catches of about 23,000 mt annually. Effort over the last two decades has decreased in Prince William Sound and Cook Inlet, but increased in Kuskokwim, Kodiak, and Bristol Bay. Since the early 1980s, the total state catch of herring has been relatively constant, with some variability in the late 1980s and early 1990s, but then constant again through 1997 (Figure 18b).

Miscellaneous Shellfish (Invertebrates): Clam, abalone, octopus, squid, snail, scallop, geoduck clams, sea urchins, and sea cucumbers have been harvested throughout the state (Fig. 19a). Of these, octopus and squid are the most likely prey of sea lions. Most of the catch of shellfish is taken from April to September, and they are taken by hand-picking, shovel, trawl, pot, and dredge gear. Harvest levels were relatively consistent through the 1980s, but have increased dramatically in amount and annual variation in the 1990s (Fig. 19b). The variability has been due, in large part, to recent but sporadic catches in Bristol Bay and the Bering Sea, areas not usually fished for shellfish (Fig. 19a). With the exception of the recent large catches in these areas, most of the shellfish fisheries have traditionally taken place in the Kodiak and Cook Inlet areas.

Crab: The state manages all crab fisheries in the BSAI and GOA. King (brown, red, blue), Dungeness, and Tanner crabs are taken by hand-picking, shovel, trawl, pot, and dredge gear. Crab fisheries began in the early 1960s when the stocks were abundant, then declined due to the King Crab recession in the early 1980s. State crab fisheries occur in Bristol Bay, Dutch Harbor, Alaska Peninsula, Kodiak, Cook Inlet, Adak and W. Aleutian Islands, and Prince William Sound (Fig. 20a). This fishery primarily occurs during the winter season. In the past ten years, the industry has focused on Alaska snow crab (*C. opilio*), and the catch exceeded historical levels of king crab in the early 1990s (Fig. 20b). The Bering Sea fishery produces the vast majority of crab that is harvested in Alaska but has also been declining since 1993. Catch per landing has been greatest in the Bering Sea, and worst in the Kodiak and Cook Inlet areas (Fig. 20a). In the 1970s, the crab fleet purportedly killed sea lions for bait; the numbers killed is not known.

Shrimp: The shrimp fishery occurs primarily in the southeast and Yakutat areas, and to a lesser extent in Prince William Sound, Kodiak, Dutch Harbor, Cook Inlet, and the Alaska Peninsula. Shrimp are harvested by pot gear and often sold to floating processors. In 1995, over 45,000 mt of shrimp were harvested by 351 vessels. In the last ten years, effort has increased in the southeast due, in part, to the availability of floating processors, which allow fishing vessels to devote more of their time to fishing. Figures 21a and b show the decline in shrimp fisheries in areas other than southeast and Yakutat. Effort was highest during the late 1970s and 1980s, but has since ceased in most areas.

Groundfish: The state manages groundfish within the 3-mile limit for lingcod, Pacific Ocean perch, flathead sole, rex sole, arrowtooth flounder, sablefish, black rockfish, and pollock. Fisheries occur in the Alaska Peninsula, Kodiak, Bering Sea, Dutch Harbor, Adak and W. Aleutian Islands, Cook Inlet, Prince William Sound, and Southeast areas.

Pacific Cod: The Pacific cod fishery is undergoing a change in management from federal to state authorities. A total TAC is set for Pacific cod, and that TAC is divided into federal and state shares. In 1997 and 1998, the state assumed management responsibility of 15% of the total TAC for cod, and 20% in 1999. Under current regulations, the state portion of the total TAC can not exceed 25%. The state fishery is limited to pot and jig gear only. The Pacific Cod fishing season is primarily in the winter.

Salmon: 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 (Fig. 22a). The state has a long history of salmon fishing. Salmon are taken by purse seines, gill nets, trolling, and beach seining. The catch in 1974 was just over 60,000 mt, then increased four-fold by 1981, was relatively constant through the 1980s, and then increased in the early 1990s to a record catch of over 450,000 mt (Fig. 22b). In 1997, 123 million salmon were caught in Alaska, amounting to about 280,000 mt. The 1998 catch was expected to be higher than 1997, but has been low due to poor returns in Bristol Bay. Bristol Bay harvest levels have historically been the highest with Kuskokwim and Chignik being the lowest (Fig. 22a). In 1997, 26% of the commercial catch was from hatcheries. Economically, the salmon fishery is worth more than all other state fisheries combined.

Federal fishery management actions affecting the Steller sea lion or its critical habitat

In 1989, the Environmental Defense Fund and 17 other environmental organizations petitioned NMFS to list all populations of Steller sea lions in Alaska as endangered. Justification was based on evidence of a major decline in their abundance throughout most of their range, but most acutely in the core region from the Kenai Peninsula to Kiska Island (Braham *et al.* 1980, Merrick *et al.* 1987). In this region, counts of adult and juvenile Steller sea lions had declined by about 80% since the late 1950s. Since 1990, the decline, while continuing, has slowed to an average of about 5 percent per year.

Concurrent with the sea lion decline, Alaskan groundfish fisheries underwent a period of unprecedented growth. Between the late 1950s and the early 1990s, the total annual removal of groundfish from Alaskan waters increased from about 27,000 mt to about 2.1 million metric tons (mmt). The fishing fleets of Japan and the Soviet Union were the first to exploit the region's groundfish resources in the 1950s, targeting Pacific ocean perch and yellowfin sole. By the early 1960s, trawl fisheries for walleye pollock and Pacific cod were established. By the late 1970s, American catcher boats had formed joint ventures with foreign processing vessels, beginning the domestication of Alaska groundfish fishing. Growth of the fishery and decline of the sea lion coincided in time and space, and the two overlapped in target (or prey) species. The following chronology describes management efforts protect the Steller sea lion, and to evaluate and mitigate the potential for competition between the sea lion and fisheries in the BSAI and GOA.

1990 --- 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 emergency interim measures to begin the population recovery process. NMFS implemented the following emergency conservation measures.

Management Actions:

1. Monitoring of incidental take and monthly estimates of the level of incidental kill of Steller sea lions in observed fisheries.

2. Aggressive enforcement of protective regulations, especially as they relate to intentional, lethal takes of Steller sea lions.

3. Establishment of a Recovery Team to provide recommendations on further conservation measures.

Protective Regulations:

1. Prohibition of shooting at or within 100 yds of Steller sea lions (this did not apply to Alaska native subsistence hunting).

2. Establishment of 3 nm “no-approach” buffer zones around the principle Steller sea lion rookeries in the GOA and AI.

3. Reduction of incidental kill quota from 1,350 to no more than 675 Steller sea lions.

Fritz *et al.* (1995) summarized the rationale supporting these actions and reviewed their impact on the groundfish fishing industry. NMFS issued the final rule for the Steller sea lion listing as threatened under the ESA and for the above actions on November 26, 1990 (55 FR 49204). NMFS also appointed a Recovery Team in 1990.

1991 --- On January 7, 1991, NMFS issued a final rule to implement regulations for BSAI/GOA FMP amendments 14/19 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”. Also, given the recent listing of Steller sea lions as threatened under the ESA, a conservative course of action seemed prudent.

The listing of the Steller sea lion also prompted NMFS to initiate section 7 consultation on the GOA and BSAI FMPs. On April 5, 1991, NMFS issued biological opinions to evaluate the potential impacts of the pertinent fisheries on endangered and threatened species, including the Steller sea lion. The potential adverse effects to Steller sea lions of the GOA and BSAI groundfish fisheries include: 1) reduction of food availability (quantity and/or quality) due to harvest; 2) unintentional entanglement of marine mammals in fishing gear; 3) intentional harassment (including killing and wounding) of animals by fishermen; and 4) disturbance by vessels and fishing operations. Both biological opinions concluded that the fishery was not likely to jeopardize the continued existence and recovery of the Steller sea lion. The following conservation recommendations were made:

1. NMFS should expand its research effort and initiate projects specifically designed to assess the effects of fisheries on Steller sea lion, their prey, and their feeding efficiency.

2. Law enforcement efforts should be increased to ensure compliance with Steller sea lion rookery buffer zones and shooting prohibitions.

3. NMFS should continue the Steller sea lion public relations and fishery information effort to maintain awareness of the Steller sea lion decline and conservation prohibitions in place.

4. NMFS should work with the State of Alaska to obtain more accurate estimates of the subsistence take of Steller sea lions.

5. NMFS and the State of Alaska should initiate an outreach program to facilitate efficient taking, as well as to obtain biological data from harvested animals.

On June 5, 1991, NMFS issued a biological opinion that focused on the potential effects of the GOA pollock fishery, as specified in the 1991 TAC specification, on food availability to Steller sea lions. Although the opinion concluded that the GOA 1991 pollock TAC specification was not likely to jeopardize the continued existence of any endangered or threatened species under NMFS' jurisdiction, the opinion noted that changes in the temporal and spatial distribution of the pollock fishery may have contributed to the Steller sea lion decline. Specifically, the fishery operated more in fall and winter, caught the quota in less time, and fished more often in areas later designated (in 1993) as Steller sea lion critical habitat under the ESA (Fritz *et al.* 1995).

On June 19, 1991, NMFS issued an emergency interim rule (effective through September 17, 1991) to ensure that pollock fishing did not jeopardize the continued existence or recovery of the threatened Steller sea lion (56 FR 28112). The preamble to this rule referenced the April 19 and June 5, 1991 biological opinions. The rule contained measures to protect the Steller sea lion by:

1. allocating the pollock TAC for the combined W/C Regulatory Areas equally between two subareas located east and west of 154°W,

2. limiting the amount of unharvested pollock TAC that may be rolled over to subsequent quarters in a fishing year, and

3. prohibiting fishing with trawl gear in the EEZ within 10 nm of 14 Steller sea lion rookeries.

On September 19, 1991, NMFS extended the above measures through December 16, 1991 (56 FR 47425).

NMFS reinitiated Section 7 consultation on the GOA pollock fishery because the 1991 3rd quarter pollock TAC was exceeded by 26%. On September 20, 1991, NMFS concluded that because of the small size of the 4th quarter harvest (27,000 mt), a fishery-caused reduction in local abundance of pollock, and thus, availability to Steller sea lions, does not appear likely. This opinion concluded that the proposed 1991 4th quarter pollock harvest was not likely to jeopardize the continued existence or recovery of Steller sea lions.

Since 1991, NMFS has conducted numerous section 7 informal consultations on the effects of various GOA and/or BSAI groundfish fishery management actions on the Steller sea lion (Table 1). In these instances, NMFS determined that the action was not likely to affect listed species under NMFS' jurisdiction in a way that was not already considered in previous biological opinions, therefore, section 7 formal consultation was not required.

Section 4(f) of the ESA requires NMFS to develop and implement plans for the conservation and survival of endangered and threatened species. NMFS had appointed a Steller Sea Lion Recovery Team to draft a Recovery Plan, and the draft Recovery Plan was released for public review and comment on March 15, 1991.

1992 --- On January 21, 1992, NMFS issued a biological opinion that evaluated the potential adverse effects of the 1992 BSAI fishery on Steller sea lions and concluded that the 1992 TAC specifications and the BSAI groundfish fishery were not likely to jeopardize their continued existence and recovery. The biological opinion also included the following discretionary conservation recommendation:

> "NMFS should amend the BSAI FMP to provide a mechanism to spatially allocate TACs in the Aleutian Islands in the future. For example, Atka mackerel are abundant in shelf waters near AI Steller sea lion rookeries and are eaten by Steller sea lions. Presently, the Atka mackerel harvest is only a minor component of the exploitable biomass and spatial and/or temporal concentration of the fishery is not expected to have any biological significance. However, if yearly TACs increase, as appears likely, spatial distribution of the harvest may be warranted to prevent local depletion of fish stocks."

On January 23, 1992, NMFS issued a final rule to implement amendments 20/25 to the BSAI and GOA FMPs (57 FR 2683). The amendments authorized regulations to protect marine mammal populations as follows:

1. prohibited trawling year-round within 10 nm of 37 Steller sea lion rookeries in the GOA and BSAI;

2. expanded the prohibited zone to 20 nm for 5 of these rookeries from January 1 through April 15 each year;

3. established 3 GOA pollock management districts; and

4. imposed a limit on the amount of an excess pollock seasonal harvest that may be taken in a quarter in each district.

On March 4, 1992, NMFS issued a biological opinion that evaluated the likely effects of the proposed BSAI FMP amendment 18 to proportionately allocate the yearly available harvest of pollock to inshore, offshore, and western Alaska community sectors of the BSAI fishing industry. This biological opinion concluded that based on the available data and management measures currently in place, that adoption of the proposed FMP amendment was not likely to jeopardize the continued existence and recovery of Steller sea lions. The biological opinion continued that:

> "However, since the southeastern Bering Sea shelf is considered to be an important foraging habitat for Steller sea lions, concerns regarding fishery removals from this area remain. Therefore, NMFS will continue to evaluate the suitability of existing management measures for the BSAI fishery to ensure adequate protection of Steller sea lions and their essential habitats. Since knowledge regarding the relationship between Steller sea lions and the commercial fishery remains

very limited, it is essential that results from 1992 fisheries and Steller sea lion research efforts be factored into this analysis.

Additional management measures for the southeastern Bering Sea shelf fishery that will be evaluated during 1992 include: (1) limits on total harvest from the southeastern Bering Sea shelf; (2) modification of Steller sea lion rookery buffer zones; and (3) limits on available pollock TAC in the "A" season. Evaluation and selection of an appropriate management regime will be conducted in consultation with the Council and the concerned public, and be completed prior to the start of the 1993 fishery."

1993 --- NMFS provided notice on January 7, 1993 that the final Recovery Plan for the Steller sea lion was available (58 FR 3008).

On March 12, 1993, NMFS issued a final rule to implement an 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 zone 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.

On April 28, 1993, NMFS issued a biological opinion that evaluated the potential effects on Steller sea lions of delaying the start of the BSAI pollock fishery "B" season from June 1 to August 15. NMFS concluded that it would take appropriate steps to ensure that delaying the BSAI "B" season would not result in a concentration of the BSAI fishery into the winter months and the southeastern Bering Sea shelf. Therefore, the proposed action was not likely to jeopardize the continued existence and recovery of Steller sea lions. Possible management measures to mitigate any significant increase in the winter fishery could include: 1) establishing a directed pollock fishery closure date of November 1 to ensure no increase in winter harvests, or 2) seasonally expanding rookery trawl closure zones until the entire "B" season TAC has been harvested to provide additional protection to Steller sea lion foraging areas.

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 rule was implemented because of concerns that the concentration of fishery removals, particularly Atka mackerel, in the eastern Aleutian Islands could cause localized depletion of groundfish stocks. While dispersal of the Atka mackerel TAC was initiated to conserve fish, it was also consistent with the objectives of the fishery management measures enacted for Steller sea lion recovery.

On August 27, 1993, pursuant to the ESA, NMFS designated critical habitat for the Steller sea lion (58 FR 45269). The primary benefit of the designation is that it provides notice to Federal agencies that a listed species is dependent on these areas (and their features) for its continued existence and that any Federal action that may affect these areas (and their features) is subject to the consultation requirements of section 7 of the ESA.

On November 1, 1993, NMFS initiated a status review of the Steller sea lion to determine whether a change in classification to endangered is warranted (58 FR 58318). NMFS solicited comments and biological information concerning the status of the Steller sea lion to be used for consideration in its comprehensive review.

1994 --- On November 29-30, 1994, NMFS convened the Steller Sea Lion Recovery Team specifically to consider the appropriate ESA listing status for the Steller sea lion 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 also recommended that the western population segment be listed as endangered and the eastern population segment be listed as threatened.

1995 --- On February 22, 1995, NMFS Alaska Region (AKR) and the Alaska Fisheries Science Center AFSC) recommended to NMFS Headquarters that: 1) the U.S. Steller sea lion population should be managed as two distinct population segments under the ESA, split to the east and west of 144°W, and 2) that the listing status of the western population should be changed to endangered. The AKR/AFSC recommendation was supported by a draft proposed rule and a draft status review document.

1996 --- On January 26, 1996, NMFS reinitiated a section 7 formal consultation on the effects of the BSAI and GOA FMPs and the 1996 TAC specifications on the Steller sea lion. Although NMFS had evaluated the effects of proposed changes to both the BSAI groundfish fishery the GOA groundfish fishery since 1991, it had been over 4 years since the last formal consultation on either fishery. During this period, the Steller sea lion population had continued to decline. Furthermore, NMFS had also collected additional data on Steller sea lions and the GOA and BSAI groundfish fisheries.

NMFS 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. NMFS noted that "the reasons for the decline of Steller sea lion populations and the possible role of the fisheries in the decline remain poorly understood.

The biological opinion included the following conservation recommendations: (1) In consultation with the Steller Sea Lion Recovery Team, the Council, and other affected parties, NMFS should review the adequacy of existing buffer zones around Steller sea lion rookeries and the ecological consequences of various harvest strategies for groundfish; (2) In cooperation with the state of Alaska, NMFS should review the location, duration, and effects of state-managed herring and salmon fisheries; (3) NMFS should fund and/or undertake research to determine the local effects of fishing on sea lion prey resources.

The biological opinion also included an incidental take statement, in which NMFS specified an annual incidental take level of 15 sea lions for the GOA groundfish fishery and 30 for the BSAI groundfish fishery. NMFS also identified a (non-discretionary) reasonable and prudent measure necessary to minimize the impact of the incidental take: For both BSAI and GOA, NMFS must ensure that observers monitor the take of Steller sea lions incidental to the groundfish fisheries.

On March 12, 1996, NMFS issued a final rule to implement GOA FMP amendment 45 that combines the 3rd and 4th quarterly allowances for pollock in the 3 statistical areas of the combined W/C Regulatory Area into single seasonal allowances that will become available on September 1 of each fishing year (61 FR 9972).

1997 --- On January 17, 1997, NMFS issued a Decision Memorandum on the BSAI and GOA 1997 TAC Specifications with respect to Steller sea lion section 7 consultations. Based on available information on the fishery and Steller sea lions, NMFS determined that the GOA and the BSAI groundfish fisheries were not likely to affect Steller sea lions in a way or to an extent not already considered in previous section 7 consultations on these fisheries. Therefore, reinitiation of consultation under the ESA was not required.

On May 5, 1997, NMFS reclassified Steller sea lions as two distinct population segments under the ESA (62 FR 24345). The reclassification was based on biological information collected since the species was listed as threatened in 1990. The Steller sea lion population segment west of 144°W (a line near Cape Suckling, AK) was reclassified as endangered; the listing for the remainder of the U.S. Steller sea lion population remained as threatened.

1998 --- On February 26, 1998, NMFS noted a) the conclusion of the 1996 opinion that the BSAI groundfish fishery was not likely to jeopardize the continued existence of Steller sea lions or destroy or adversely modify their critical habitat, and b) NMFS had previously determined that reinitiation of consultation was not required for the 1997 fishery because none of the elements that would trigger reinitiation had occurred. NMFS also noted that the 1996 biological opinion remained valid for the 1998 BSAI groundfish fishery.

On March 2, 1998, NMFS issued a biological opinion that evaluated the effects of the GOA FMP and the 1998 pollock TAC specifications on the Steller sea lion. NMFS concluded that the 1998 GOA fishery was not likely to jeopardize the continued existence and recovery of Steller sea lions or to adversely modify critical habitat. NMFS noted that the biological opinion only addressed the 1998 fishery, not the continued implementation of the GOA FMP beyond 1998. The Alaska Region would need to reinitiate Section 7 consultation for the fishery in 1999 and beyond.

The March 2, 1998 opinion authorized the same incidental take level that was authorized in the 1996 opinion (15 Steller sea lions for the GOA). The authorization would be re-evaluated when additional data become available on the number of sea lions injured or killed annually by gear associated with this fishery. No reasonable and prudent measures were identified.

NMFS included the following conservation recommendations in this biological opinion: (1) Fritz and Ferrero (1998), in an analysis of options in Steller sea lion recovery and groundfish fishery management, suggest three general categories of management measures that could be employed to minimize the effects of fishing on Steller sea lion recovery: (a) gear modifications or restrictions, (b) reductions in total catch, and (c) further temporal and spatial distribution of the fisheries. NMFS should carefully analyze and consider the potential benefits of these options; (2) Initiate studies of the efficacy of buffer zones as soon as possible; (3) Continue studies to determine the foraging range of young-of-the-year Steller sea lions; (4) Continue to educate the fishing community about Steller sea lions and techniques to reduce or eliminate incidental take of the species; (5) Conduct studies of the site-by-site relation between fishing effort and trends in juvenile survival or counts at nearby rookeries.

On March 17, 1998, NMFS issued regulations for amendments 36/39 to the BSAI and GOA FMPs (63 FR 13009). This action created a forage fish species category in FMPs and implemented associated management measures. Directed fishing for forage fish would be prohibited at all times in the 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. The proposed rule (62 FR 65402, December 12, 1997) stated that a) forage fish are important prey for marine mammals, seabirds, and commercially important groundfish species, and b) decreases in the abundance of these predators may be related to declines in forage fish.

On June 11, 1998, NMFS issued a final rule to change the seasonal apportionment of the pollock TAC in the W/C Regulatory Areas of the GOA by moving 10% of the TAC from the 3rd fishing season (starting September 1) to the 2nd fishing season (starting June 1; 63 FR 31939). This seasonal shift of TAC was a precautionary measure intended to reduce the potential impacts of pollock fishing on Steller sea lions by reducing the percentage of the pollock TAC that is available to the fishery during the fall and winter months.

At its June 1998 meeting, the Council adopted a precautionary approach by approving a regulatory amendment to reduce the probability of localized depletion of Atka mackerel in critical habitat for Steller sea lions. The Council recommended both spatial and temporal redistribution of the BSAI Atka mackerel TAC as a further sea lion protective measure.

On December 3, 1998, NMFS issued a biological opinion on the authorization of the BSAI Atka mackerel fishery (1999-2002) and the BSAI and GOA pollock fisheries (1999-2002) under the respective fishery management plans. The opinion concluded that the BSAI and GOA pollock fisheries are likely to jeopardize the continued existence of the western population of Steller sea lions and adversely modify its designated critical habitat. The finding of jeopardy and adverse modification was based on 1) the major role of pollock in the diet of Steller sea lions, 2) the evidence that Steller sea lions are prey-limited, 3) the overlapping distributions of fishing and foraging by Steller sea lions, 4) the concentration of fishing effort in space (Steller sea lion critical habitat) and time (including during the winter period when sea lions may be more sensitive to competition for prey), and 5) the evidence of excessive local harvest rates in sea lion critical habitat in contrast to stock-wide harvest rates. Principles for a reasonable and prudent alternative and an example reasonable and prudent alternative were included in the December 3, 1998 opinion. The Council was asked to develop conservation measures to satisfy the principles of the reasonable and prudent alternative, and passed a motion consisting of a set of such conservation measures. NMFS incorporated that recommendation into the RPAs of the Biological Opinion (with some modification), and the resulting management measures were incorporated into an emergency rule to manage the pollock fisheries in the first half of 1999.

1999 --- In June 1999, NMFS returned to the Council for additional recommendations regarding management measure for the latter half of 1999 (an extension of the emergency rule) and for 2000 and beyond (a permanent rule). Again, the Council recommended a number of measures for avoiding jeopardy and adverse modification. On July 9, 1999, United States District Court for the Western District of Washington ruled that the RPAs developed in December 1998 were arbitrary and capricious for lack of sufficient explanation. The Court remanded the RPAs back to NMFS for preparation of Revised Final Reasonable and Prudent Alternatives (RFRPAs), which were issued on October 15, 1999, and submitted to the Court on October 18, 1999. Those RFRPAs have been further challenged by both Plaintiffs and Defendant-Intervenors, and remain the basis for ongoing litigation.

4.2.3 Integration and synthesis of the environmental baseline for Steller sea lions

The decline of the western population of Steller sea lions is not the result of a single factor, and to search for *the single cause* is a misleading oversimplification. Multiple factors have contributed to the decline, and multiple factors may still be preventing recovery. The identification of one such factor does not rule out the possibility that others are also acting, perhaps synergistically, to prolong the decline. Furthermore, the causes for the decline appear to include both natural and anthropogenic influences.

- Intentional take of sea lions has occurred coincident with fisheries. From the 1950s (and probably before) to the 1970s, such take was not only condoned, but in many cases encouraged or rewarded. The rate or magnitude of intentional take has been estimated (Alverson 1992), although reporting and documentation have not been sufficient to provide reliable estimates of total take. Intentional take has likely subsided considerably since the passage of the MMPA and other protective legislation, although anecdotal reports indicate that some level of intentional take may still continue.

- Incidental take in trawl fisheries included thousands or tens of thousands of animals (Loughlin and Nelson 1986, Perez and Loughlin 1991) through the 1980s, and contributed to the decline of the population in the 1970s and 1980s. Currently, however, incidental take has been reduced to negligible levels.

- Commercial harvest of adult males in 1959 likely had no significant effect on population trends. However, harvest of over 45,000 pups in 1963 to 1972 contributed to local population trends in the

1960s through the early 1980s in the GOA and the eastern Aleutian Islands. Similarly, subsistence harvests prior to the 1990s were not measured but may have contributed to population decline in localized areas where such harvests were concentrated.

- Pollutants and marine debris (entanglement) may have contributed to the decline by altering growth, reproduction, or survival of sea lions. The evidence available to date does not support the contention that these factors have played a significant role.

- Harassment has likely occurred in many areas and may have been very disruptive to sea lion colonies on rookeries or haulouts, thereby leading to redistribution or deaths of animals. Such harassment could have contributed to mortality if animals were shot, females were separated from their pups for long periods, or animals (especially pups) were trampled or crushed or otherwise injured in the stampedes that often accompany such harassment. Nevertheless, harassment is thought to be less common at present, and the data are not sufficient to demonstrate that harassment was a significant contributor to the decline. Harassment is also a less likely explanation in the remote areas of the sea lion range where declines have, nonetheless, been observed (e.g., central and western Aleutian Islands).

- Disease has the potential to cause a major decline but, to date, the available information does not support the contention that disease was a significant factor.

- Killer whales and sharks take Steller sea lions, but such predation is not thought to have caused the decline. The significance of predation may have increased with the decline of sea lions. That is, if the number of sea lions taken has remained relatively constant, then the rate of mortality due to predation would increase because the abundance of sea lions has declined so significantly. However, the number of sea lions taken by killer whales and sharks is not known, and it is also possible that the number of sea lions taken has decreased in proportion to the decline of sea lions.

- Major changes have occurred in the BSAI and GOA ecosystems. Variation in physical and biological factors, in combination, likely contributed to the observed shift in trophic structure, and the dominance of pollock and flatfish in these systems.

- At the same time, the BSAI and GOA ecosystems have experienced the development and expansion of major fisheries for essential sea lion prey. The fisheries have also contributed to changes in the trophic structure of these ecosystems, but as is the case with natural changes, the extent of fisheries-related effects on the ecosystems, at large, can not be determined. To date, neither our science nor our management regimes are structured to distinguish natural from fisheries related effects on these ecosystems. With respect to Steller sea lions, however, fisheries target important prey resources at times and in areas where sea lions forage.

In the face of all these changes and influencing factors, the western population of Steller sea lions has not been able to maintain itself. The available evidence suggests that a significant part of the problem is lack of available prey. Studies of animals collected in the GOA in 1975-1978 and 1985-1986 indicate that animals in the latter collection were smaller, took longer to reach reproductive maturity, produced fewer offspring, tended to be older, and exhibited signs of anemia --- all observations consistent with the hypothesis of nutritional stress (Calkins and Goodwin 1988, Pitcher *et al. in review*, York 1994). In addition, survival of juvenile animals appeared to have dropped in both the eastern Aleutian Islands (Ugamak Island; Merrick *et al.* 1987) and the GOA (Marmot Island; Chumbley *et al.* 1997). These results, the evidence of substantial changes in the physical and biological features of the BSAI and GOA ecosystems, and the expansion of fisheries in these regions all support the contention that lack of available prey has contributed significantly to the past decline of the western population, and may still be so contributing.

Trends of the eastern population likely reflect a change in human activities that contributed to their decline in the earlier part of this century. Since at least 1912, or earlier, sea lions were killed as pests and to reduce their supposed effect on commercial fish stocks. Growth and recovery in the latter part of this century may be due to reductions in both killing and disturbance in the waters of southeast Alaska and British Columbia. The relatively slow recovery (2-3% annually from 1982 to 1994) suggests that some factors may be acting to slow recovery, but recovery is still occurring for the eastern population.

5.0 EFFECTS OF THE ACTIONS

This biological opinion assesses the effects of three separate Federal actions on six endangered whale species, the threatened eastern population of Steller sea lions, the endangered western population of Steller sea lions, and the critical habitat designated for sea lions. The three actions are: (1) authorization of 2000 BSAI groundfish fisheries under the BSAI groundfish Fishery Management Plan and based on TAC specifications recommended by the Council; (2) authorization of 2000 GOA groundfish fisheries under the GOA Fishery Management Plan and based on TAC specifications recommended by the Council; and (3) authorization of both BSAI and GOA groundfish fisheries in 2000 under management measures implementing the American Fisheries Act. Based on this effects analysis and an analysis of cumulative effects, NMFS separately determines whether one or any of these proposed actions are likely to jeopardize the continued existence of a protected species or destroy or adversely modify designated critical habitat.

Analyses of jeopardy usually focus on the effects of an action on a species' population dynamics while analyses of adverse modification usually focus on the effects of an action on the physical, chemical, and biological resources that support a population. A conclusion of "jeopardy" for an action means that the action could reasonably be expected to reduce appreciably the likelihood of both the survival and recovery of a protected species. A conclusion of "adverse modification" means that the action could reasonably be expected to appreciably diminish the value of critical habitat for both the survival and recovery of a protected species. Such actions include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical (50 CFR 402.02).

In the action areas, critical habitat has not been designated for any of the large protected whales. Therefore, this section on the effects of the proposed actions will address only the jeopardy question for the large whales. Critical habitat has been designated for the Steller sea lion, and includes areas used by animals from both the eastern and western populations. Therefore, both standards of jeopardy and adverse modification will be addressed for these populations. However, unless stated otherwise, jeopardy and adverse modification will be analyzed together. As will become evident in the following discussion, the most important question in evaluating the effects of these three actions on populations of Steller sea lions is whether the fisheries conducted under these actions compete with Steller sea lions. Jeopardy could occur through competitive removal of prey. As prey are the primary biological constituent element of Steller sea lion critical habitat, it is reasonable to expect that, at some point, removal of such prey from critical habitat would appreciably reduce the value of the critical habitat for the survival and recovery of sea lions.

Fisheries interact with marine mammals either operationally or biologically (Lowry *et al.* 1982). Operational interactions between marine mammals and fishing gear (whether it is actively fishing or derelict; e.g., ghostfishing or entanglement in debris) occur when marine mammals remove or destroy catch from fishing gear or when marine mammals are injured or killed by fishing gear. Operational interactions may directly affect marine mammals populations, but are not likely to directly affect their habitat. The operational effects of the proposed fisheries can be assessed because fishery observer programs have generated substantial information on operational interactions between Steller sea lions and fisheries. Biological interactions result from disturbance of normal marine mammal foraging behavior, competition with marine mammals for prey, changes in prey size/age structure, and changes in the composition of the marine community. This Biological Opinion assesses the effects of both forms of interaction between protected species and the groundfish fisheries as implemented under the 2000 TAC specifications and the AFA.

For clarity, this analysis is organized around the three categories of protected species. The analysis will first address the effects of the three proposed actions on the large protected whales, then on the eastern population of sea lions, and finally on the western population of sea lions.

5.1 Large whales

5.1.1 Effects of 2000 TAC specifications for BSAI groundfish fisheries

Operational effects

For all six species of large whales considered here (northern right whale, blue whale, fin whale, sei whale, humpback whale, and sperm whale), plausible operational effects include ship strikes and gear entanglement. Gear interactions are perhaps most plausible for sperm whales that have been known to remove prey from longline fishing gear. Other whales may also become entangled by accident if their paths cross longline gear. However, no cases of such entanglement have been documented in BSAI fisheries. Similarly, ship strikes have not been reported for vessels in the BSAI fisheries. NMFS does not expect these patterns of entanglements or ship to change in the foreseeable future and, therefore, does not expect the proposed action to have adverse, operational effects on large whales.

Biological effects

Plausible biological interactions include competition for prey, changes in the composition and structure of the ecosystem, and disturbance. Here, too, while such interactions are plausible, the available evidence is not sufficient to argue persuasively that these hypothetical interactions do occur and limit the recovery of these species. Information on feeding habits indicates that northern right whales, blue whales, fin whales, sei whales, and humpbacks forage primarily on prey lower in the food chain (e.g., zooplankton). Fin, sei, and humpbacks also prey on small schooling fishes including several species taken by the groundfish fisheries. But, again, no evidence available to date indicates that these fisheries compete with these large whales or that the whales are limited by availability of prey. Sperm whales are deeper divers that rely primarily on mesopelagic prey (e.g., squid), and competition with the groundfish fisheries for prey is highly unlikely.

As discussed in previous biological opinions, the groundfish fisheries may have contributed to changes in the composition or structure of these ecosystems, but the nature of such hypothetical effects is not clear, if they occur. Furthermore, if such effects occur, they may be beneficial to large whales. One explanation for the observed trophic changes in the Bering Sea involves the cascade hypothesis, which suggests that the removal of large whales in the North Pacific may have contributed to the increased biomass and dominance of pollock. This hypothesis implies a level of competition between the large whales and pollock, and if such is the case, then the pollock fisheries may have beneficial effects for these large protected whales.

Finally, these fisheries may increase the level of disturbance to large whales simply as a function of the number of vessels and the amount of gear present in areas that large whales might otherwise use. Here, too, this effect is at least hypothetically feasible, but cannot be meaningfully measured, detected, or evaluated with the information available. NMFS does not expect these patterns of entanglements or ship to change in the foreseeable future and, therefore, does not expect the proposed action to have adverse, biological effects on large whales.[2]

[2] The Interagency Consultation Handbook defines "insignificant effects" as those that a person would not be able to meaningfully measures, detect, or evaluate. If an effect is "insignificant"

5.1.2 Effects of 2000 TAC specifications for GOA groundfish fisheries

Operational effects

Operational interactions could occur between these large whales and vessels from the GOA groundfish fleets. However, only one case has been documented where a sperm whale became entangled in longline fishing gear in the GOA. That interaction did not result in serious injury to the whale. As is the case for the BSAI, the available evidence suggests that operational interactions are rare and, consequently, are not likely to appreciably reduce the likelihood of both the survival and recovery of these endangered whale species in the wild.

Biological effects

The above discussion pertaining to potential biological interactions between the BSAI groundfish fisheries and large whales applies also to the GOA. Here, too, the existing information is not sufficient to demonstrate a biological effect of the GOA groundfish fisheries on these large whales.

5.1.3 Effects of the AFA

The effects of the AFA on the BSAI groundfish fisheries are largely related to ownership restrictions and restrictions on the number of vessels in the fishing fleet, allocation of pollock among the four sectors in Bering Sea, improving observer coverage and assessment of tons caught, restrictions in other fisheries (including fisheries in the GOA) of vessels benefitting from the AFA, and requirements for formation of cooperatives within sectors. These allocations are expected to alter the nature of the pollock fishery by avoiding the race for fish, and allowing for better temporal dispersion of catch. The formation of cooperatives may also facilitate spatial dispersion of the catch to the extent that vessels can be more deliberative about where and when they fish to maximize profit. At present, no evidence suggests that the implementation of the AFA will increase the likelihood of operational or biological interactions between the BSAI groundfish fisheries and these large protected whales.

5.2 The eastern population of Steller sea lions

At present, Steller sea lions from the eastern and western populations can be distinguished reliably only if they have been marked as pups at the rookery of their birth. The vast majority of sea lions are not marked, and are included in one population or the other on the basis of location. That is, animals found east of 144°W longitude are included in the eastern population and animals found west of that line are included in the western population. This distinction may be misleading in that animals found on one side of the line may, in fact, have migrated from the other side of the line. Therefore, a sea lion caught incidentally in a trawl net near Kodiak Island may have originated from the eastern population and migrated (either temporarily, seasonally, or permanently) to the range of the western population. As so few animals are marked, scientists and fisheries observers are unable to make such distinctions. Therefore, this analysis assumes that animals found on each side of the 144°W long. line are part of the corresponding population. This assumption is reasonable based on the large distance between the easternmost haulout of the western population and the westernmost haulout of the eastern population - a distance of about 900 km.

5.2.1 Effects of 2000 TAC specifications for BSAI groundfish fisheries

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according to this definition, it is appropriate to conclude that the proposed action is not likely to adversely affect a listed species or designated critical habitat [see Handbook, page xv]

Operational and biological effects

The groundfish fisheries of the BSAI region are not expected to have significant, operational effects on the eastern population of Steller sea lions. Operational interactions between sea lions and the BSAI groundfish fisheries are assumed to involve animals from the western population. With the exception of some undetermined number of animals that might migrate between to the BSAI regions from the eastern population, the fisheries in the BSAI are geographically separate from the eastern population. Such migration is assumed to be small, given that the distance from the eastern population to the BSAI region is on the order of 3000 km or more, and the largest documented movement of a Steller sea lion is about 1500 km. In addition, the number of operational interactions between sea lions and the BSAI groundfish fisheries is negligible (with respect to population status) when compared with the number of animals in either the eastern or western populations.

Similarly, any biological effects of the BSAI groundfish fisheries on the eastern population of Steller sea lions is expected to be small. Given the considerable distance between the BSAI region and haulouts of the eastern population, the assumption that migration is small, and the general discreteness of groundfish stocks between the BSAI and GOA regions, it is reasonable to assume that such biological effects are negligible if they exist. Any potential effects are not reasonably expected to appreciably reduce the likelihood of the survival and recovery of the eastern population or destroy or adversely modify its critical habitat.

5.2.2 Effects of 2000 TAC specifications for GOA groundfish fisheries

Operational effects

The existing information suggests that the GOA groundfish fisheries do not have a significant effect on the eastern population of Steller sea lions. As noted above, it is generally not possible to determine if sea lions involved in operational interactions are from the western or eastern population, although NMFS assumes that they are from the western population. However, even if all interactions in the GOA were assumed to involve sea lions from the eastern population, the number of interactions would have a negligible impact on population status. Hill and DeMaster (1998) reported an annual average of about two sea lion mortalities in these GOA groundfish fisheries from 1990 to 1996. Given the current size and growth rate of the eastern population of Steller sea lions, the death of two additional sea lions each year would not be expected to appreciably reduce that population’s likelihood of survival and recovery in the wild.

Biological effects

The combined TAC allocated to the GOA groundfish fisheries for 2000 is 299,650 mt. About 85% of the total will be taken in the western and central regions of the GOA — a minimum distance of about 1000 km from the nearest haulout of the eastern population. The distance does not rule out the possibility that biological interactions occur between the eastern population and fisheries in the central and western GOA, but suggests that such interactions are highly unlikely.

The remaining 15% of the combined TAC for the GOA groundfish fisheries in 2000 is allocated to the eastern region of the GOA. This 15% is dispersed among 17 species or species groups, but the catch for the majority of these species was well below TAC in 1999, and it is reasonable to expect that a considerable portion of the TAC to the eastern portion will not be taken (Table 3). In addition, the available evidence does not indicate that the eastern population in this region is limited by interactions (either biological or operational) with the GOA groundfish fisheries. On the whole, the eastern population has been growing slowly over the past several decades, and this growth is also observed in southeast Alaska (which comprises only a portion of the total range of the eastern population). Such growth does not rule out the fact that detrimental interactions might be occurring. But this growth does indicate that if such interactions are occurring, they are not of sufficient frequency, magnitude, or consequence to appreciably reduce the likelihood of both the survival and recovery of the eastern Steller sea lion population in the wild.

5.2.3 Effects of the AFA

As noted above, the principle elements of the AFA pertain primarily to the BSAI pollock fishery. In addition, the AFA includes provisions to restrict fishing vessels benefitting from the AFA from turning those benefits to their advantage by increasing their participation in other fisheries. In particular, the AFA prevents BSAI vessels from redirecting their attention toward the GOA groundfish fisheries. If anything, the benefits of the AFA should allow for slower paced, more rational fisheries in the GOA. The consequences of the AFA are, therefore, not expected to have any significant, measurable, adverse effect on the eastern population of Steller sea lions.

5.3 The western population of Steller sea lions

The remainder of this section focuses on potential effects of the actions on the western population of Steller sea lions. The proposed biological effects are more significant than current operational effects. The estimated annual incidental mortality of Steller sea lions in the BSAI and GOA groundfish fisheries was about 11 to 12 animals from 1990 to 1996. Although this pattern is not expected to change in the foreseeable future, the loss of these animals is within the background mortality rate of the western Steller sea lion population and should have no measurable effect on the species likelihood of survival and recovery in the wild. Therefore, the remainder of this section deals with potential biological effects only.

The potential biological effects of fisheries on Steller sea lions include competition for prey (i.e., exploitative competition), disturbance (i.e., interference competition), or changes in the composition or structure of the ecosystem. Undisputable changes have occurred in the composition or diversity of the biological communities inhabiting the BSAI and GOA ecosystems over the past few decades. The cause or causes of these changes is a matter of considerable debate. Both natural environmental changes (e.g., the regime shift) and fisheries have contributed to these changes. At present, scientists are unable to describe the relative roles of each of these contributing factors or distinguish between the effects of natural phenomena and fisheries on the status and trends of the western population of Steller sea lions (NRC 1996). The most obvious fisheries-related effects would occur through overfishing and the simple reduction or removal of a target species from participating in the ecological interactions comprising the ecosystem. Such changes could clearly affect Steller sea lions, as well as other predators/consumers in the ecosystem, including harbor seals, northern fur seals, other marine mammals, seabirds, and large fish predators. As the topic will be addressed there, this current biological opinion will narrow its focus further to the issue of whether the BSAI and GOA groundfish fisheries, under the proposed 2000 TAC specifications and management measures implementing the AFA, will appreciably reduce the likelihood of survival and recovery of the western population of Steller sea lions through competition.

By definition, competition occurs when two potential competitors use the same resource, the use of the resource by one potential competitor limits the availability to or use of the resource by a second potential competitor, and the restriction in availability or use of the resource constrains or limits the second competitor in some significant manner. Under ideal circumstances, the information available to evaluate potential competition between Steller sea lions and fisheries would include:

- The abundance and composition of a recovered population of Steller sea lions.

- The energetic and nutritional needs of such a recovered population.

- A detailed and reliable characterization of the prey field available in the areas and times where and when Steller sea lions forage.

- The foraging patterns of sea lions and their interaction with the prey field.

- The nutritional and energetic costs to sea lions foraging in an unperturbed (i.e., unfished) prey field.

- The direct and indirect effects of fishing on the prey field and on sea lion foraging behavior and success.

- Changes in vital rates resulting from greater energetic or nutritional costs associated with foraging in a prey field altered by fishing, and changes in sea lion population trends due to changes in vital rates.

- Changes in the above as may occur through interactions of fishery effects with the effects of other phenomenon that influence the prey field or Steller sea lion foraging.

With this information, scientists would be able to definitively characterize the effects of various levels of fishing effort on the energetic and nutritional budgets of sea lions, and determine what degree of change to the sea lion prey field is tolerable before the overall effect leads to diminished vital rates and population decline.

For the most part, this level of information is not available, and the conflict between sea lions and the fisheries can not be evaluated directly, as implied by the ideal information listed above. Therefore, in recent consultations, NMFS has used the best scientific and commercial data available to indirectly evaluate potential competition between the groundfish fisheries and Steller sea lions after considering the following three criteria:

- First, the analysis should establish that potential competitors use the same resource (Andrewartha and Birch 1954, Hutchinson 1957, Odum 1971). The resource must be the same not only by name (i.e., both sea lions and the fisheries take "pollock"), but also by size, depth, time, and area. To address this criterion for pollock fisheries in the BSAI and GOA, for example, NMFS considered whether the timing, spatial distribution, size of fish caught in the fishery, and depth range of the fishery overlapped with the foraging habitats of Steller sea lions. This evaluation essentially treated the pollock fishing fleet as a new population of predators that competes with other predators (such as Steller sea lions, harbor seals, spotted seals, and fur seals) for pollock. The answers to these questions helped establish that the fisheries and Steller sea lions probably competed for the "same" resource because their demands for the pollock resource were overlapping.

- Second, the use of a resource by one consumer should be expected to limit the availability of that resource to the second consumer (Andrewartha and Birch 1954, Hutchinson 1957, Odum 1971). That is, the resources must be depleted relative to the needs of the second consumer. Here, too, the data necessary to definitively answer this question was not available. To develop the RFRPAs for its 1998 Biological Opinion on the pollock fishery, NMFS used (1) a conceptual model expressing a hierarchy of concern about localized depletion and (2) available information on harvest rates in different areas where sea lions forage. The hierarchy expressed greatest concern around rookeries and haulouts, intermediate levels of concern in other critical habitat areas, and reduced concern in areas outside of critical habitat. (In effect, the approach taken by NMFS also reflected a temporal hierarchy of concern, with no pollock trawling allowed from November 1 to January 20, and limits on the TAC allocated to the winter spring period of 40% of the annual TAC.) Where sufficient data were available, NMFS then analyzed localized harvest rates to determine the potential for localized depletion of sea lion prey. As the available evidence is not sufficient to determine that level of availability, NMFS used the overall harvest rate for pollock as an indicator of a safe harvest level in local areas and time periods. The goal of the RFRPAs was to ensure that prey availability was not compromised in crucial areas or during crucial time periods.

! Third, the limitation placed on the availability of a resource (caused by one consumer) should have demographic consequences for the second consumer (Andrewartha and Birch 1954, Hutchinson 1957, Odum 1971). The best scientific and commercial data available suggests that the continued decline of the western population of Steller sea lions can be partially explained by lack of sufficient prey and nutrition. Studies of animals collected in the GOA in 1975-1978 and 1985-1986 indicate that animals in the latter collection were smaller, took longer to reach reproductive maturity, produced fewer offspring, tended to be older, and exhibited signs of anemia — all observations consistent with symptoms of a population experiencing nutritional stress (Calkins and Goodwin 1988, Pitcher et al. in review, York 1994). In addition, the survival of juvenile animals appears to have declined in both the eastern Aleutian Islands (Ugamak Island; Merrick et al. 1987) and the GOA (Marmot Island; Chumbley et al. 1997). These results, the evidence of substantial changes in the physical and biological features of the BSAI and GOA ecosystems, and the expansion of fisheries in these regions all suggest that it is reasonable to expect that that reductions in prey abundance or availability, at least partially resulting from competition with the fishery, reduces the likelihood of both survival and recovery of the western population of Steller sea lions in the wild.

The following analysis uses the same general approach for evaluating the potential effects of 2000 TAC specifications for the BSAI and GOA groundfish fisheries on the western population of Steller sea lions. The analysis addresses relevant questions pertaining to whether target species are important prey items of sea lions, are taken in similar sizes by the fishery and sea lions, are taken at similar depths, in the same areas, and during crucial time periods. Where possible, the analysis also considers the local harvest rates of the target species to determine the potential for localized depletion. Given the considerable overlap in target species in the BSAI and GOA, the analysis addresses each target species once, giving consideration to different potential effects in these areas where warranted.

5.3.1 Effects of 2000 TAC specifications for BSAI and GOA groundfish fisheries

Pollock

The potential effects of the BSAI and GOA pollock fisheries were addressed in the December 3, 1998 Biological Opinion evaluating these fisheries for the period from 1999 to 2002. The Opinion concluded that these fisheries, as proposed in 1998, were likely to jeopardize the continued survival of the western population of Steller sea lions and adversely modify its critical habitat. From December 1998 to October 1999, NMFS and the Council were involved in developing RPAs to avoid jeopardy and adverse modification. NMFS issued Revised Final Reasonable and Prudent Alternatives (RFRPAs) on October 15, 1999, and NMFS believes that these RFRPAs are sufficient to avoid jeopardy and adverse modification for this fishery through 2002 (assuming no triggers for re-initiation of consultation are reached). As explained in detail in that consultation, NMFS does not believe that the TACs for the BSAI and GOA pollock fisheries raised significant concerns. Rather, the concerns were related to the manner in which the pollock catches were dispersed temporally and spatially. NMFS maintains its belief that the TACs set for the 2000 BSAI and GOA pollock fisheries (1.139 mmt and 0.1 mmt, respectively) are conservative with respect to the well-being of the pollock stocks, and are protective of Steller sea lions based on the significant changes imposed on these fisheries as a result of the RFRPAs. That is, based on the implementation of the RFRPAs and the changes resulting from the AFA, NMFS does not believe that the BSAI and GOA pollock fisheries and the 2000 TAC specifications for these fisheries will appreciably reduce the likelihood of survival and recovery of the western population of Steller sea lions or appreciably reduce the value of critical habitat for it survival and recovery.

Atka mackerel

The potential effects of the BSAI Atka mackerel fishery were also addressed in the December 3, 1998 Biological Opinion. The Opinion concluded that the Atka mackerel fishery was not likely to jeopardize the continued existence of the western population of Steller sea lions nor adversely modify its critical habitat. The conclusion was based on significant changes imposed on the fishery to (among other things) increase its temporal dispersion (from one season to two) and its spatial dispersion (shifting the amount of Atka mackerel catch from levels greater than 80% in critical habitat to levels at or below 40% over the period from 1999 to 2002). These conservation measures were recommended by the Council and approved by NMFS before the December 3, 1998 Biological Opinion was concluded, and remain in place for 2000. The TAC recommended for the 2000 Atka mackerel is within the limits recommended by the stock assessment authors. Therefore, based on the ongoing management measures to disperse this fishery temporally and spatially, and the approximate consistency in TAC recommended by the stock assessment authors and the Council, the 2000 TAC for the Atka mackerel fishery is not expected to appreciably reduce the likelihood of survival and recovery of the western population of Steller sea lions in the wild or appreciably reduce the value of designated critical habitat for the survival and recovery of Steller sea lions.

Flatfish

The flatfish taken in the BSAI and GOA groundfish fisheries are listed above, and include: flathead sole, rock sole, Greenland turbot, yellowfin sole, arrowtooth flounder, and other flatfish (Alaska plaice, rex sole, Dover sole, starry flounder, English sole, butter sole, sand sole, and deep sea sole).

Importance in the sea lion diet --- The importance of any particular species of flatfish in the Steller sea lion diet is difficult to determine. In existing studies (Table 5), the occurrence of flatfish species in either stomach contents or scats is often reported in a single “flatfish” category, rather than by reference to individual species. As a group, flatfish may be important in particular areas. For example, flatfish were ranked in the five top groups of fish prey found in the stomachs of sea lions collected from different portions of the western population’s range (NMFS 1995). Calkins and Goodwin (1988) found that flatfish comprised about 25% of the volume of stomach contents taken from 88 sea lions (47 with only trace amounts) near Kodiak Island in 1985-1986, and these authors ranked flatfish (as a group) as third in importance (based on a combined rank index developed by Pitcher [1981]).

Potential for competition --- Nonetheless, competition for some of these species is highly unlikely based on their characteristics and the degree of overlap between depth and location of the fisheries and depth and location of sea lion foraging. Greenland turbot, Dover sole, and deep-sea sole are all species found and fished at greater depths than is characteristic of sea lion foraging. Flathead sole, rock sole, yellowfin sole, Alaska plaice are species taken largely outside of critical habitat, north and east of the southeastern Bering Sea foraging area in the Bering Sea. Rex sole is taken primarily in the GOA, is taken out along the continental shelf area and along canyons extending up toward the shelf, and is taken in total catches considerably smaller than the TAC for the species (i.e., 29% of the TAC was taken in 1998 and 33% in 1999). Arrowtooth flounder is present in large abundance in both the BSAI and the GOA (it is the most abundant species in the GOA), but only a fraction of the TAC is generally taken. For example, the 1999 BSAI TAC was 134,354 mt, of which only 10,679 mt (8%) were taken. The 1999 GOA TAC was 35,000 mt (16% of the ABC), and only 16,062 mt (46%) were taken as of November 6. The remaining species (starry flounder, English sole, butter sole, and sand sole) are all shallow-water species that are taken primarily as bycatch in amounts well below ABCs or TACs set for these species. For example, in the BSAI in 1999, the other flatfish TAC was 154,000 mt and the catch was 15,184 mt (10% of the TAC). In the GOA, the 1999 TAC for shallow water flatfish was 18,770 mt and the catch was 2,545 mt (14% of the TAC).

The information summarized above and the uncertainty regarding the importance of specific flatfish species in the sea lion diet does not indicate a strong case for competition between sea lions and the flatfish fisheries at this time. Therefore, NMFS believes at this time that BSAI and GOA flatfish fisheries and 2000 TAC specifications for those fisheries are not expected to appreciably reduce the likelihood of survival and recovery of the western population of Steller sea lions in the wild or appreciably reduce the value of designated critical habitat for the survival and recovery of Steller sea lions..

Sablefish

Sablefish are a deep-water fish that are not reported in the Steller sea lion diet. Therefore, the potential for competition between sea lions and the sablefish fishery is considered to be virtually nil. NMFS believes that BSAI and GOA sablefish fisheries and 2000 TAC specifications for those fisheries will neither appreciably reduce the likelihood of survival and recovery of the western population of Steller sea lions nor appreciably reduce the value of critical habitat for its survival and recovery.

Rockfish

The rockfish taken in BSAI and GOA groundfish fisheries are listed above in the section on the description of the actions. Main species and species groups include Pacific ocean perch, shortraker, rougheye, northern, sharpchin, pelagic shelf rockfish, demersal shelf rockfish, thornyheads, yelloweye, dusky, and other rockfish.

Importance in the sea lion diet --- As was the case with flatfish, studies of the sea lion diet lump rockfish species into the single category "rockfish." Based on the available evidence, then, it is not possible to determine the relative importance of each species of rockfish to sea lions, or the potential for competition with fisheries based on any single species. "Rockfish" is commonly listed as a prey type in studies of the sea lion diet (Table 5), but they are generally not a dominant prey item. For example, Pitcher (1981) listed rockfish as tenth in rank order based on his combined rank index. Spaulding (1964) listed rockfish as second in importance, but his study was based on stomach contents from sea lions taken off British Columbia (i.e., not the western population). Summary tables of the sea lion diet (NMFS 1992) indicate that rockfish are taken by sea lions from the western population, but that they are a relatively small part of the diet.

Potential for competition --- The above information suggests that the potential for competition between rockfish fisheries and Steller sea lions in the western population may vary by region, but is generally likely to be low. Rockfish do not appear to be a major component of the diet of sea lions in the western population. In addition, many of the rockfish species are taken by the fishery at greater depths than those where sea lions are currently thought to forage. For example, thornyheads and yelloweye (demersal shelf group) may be taken in the fisheries from shallow depths down to 1000 m, but are generally taken at depths greater than 500 m. Pacific ocean perch is taken from 100 to 200 m, but the majority of the catch is from depths between 200 m and 500 m. The same is true for rougheye and shortraker. Northern, sharpchin, and dusky (pelagic shelf group) rockfish are exceptions. Northern and sharpchin rockfish are taken in the BSAI at catch levels commensurate with the TAC. They are taken at depths well within the diving range of Steller sea lions. Nevertheless, the available information does not indicate that northern or sharpchin rockfish are important in the sea lion diet in these regions. Sharpchin are taken in the GOA as part of the "other slope rockfish" category, much of which is taken as bycatch and discarded. Because it is undesirable, only 789 mt were taken in the GOA in 1999, compared to a TAC of 5,270 mt. Dusky rockfish (the dominant species of the pelagic shelf group in the GOA), are also taken at catch levels commensurate with TACs, and are taken within the diving range of Steller sea lions. In the GOA, they are taken primarily outside of Steller sea lion critical habitat along the continental shelf break. And again, the available evidence does not indicate that dusky rockfish are a major component of the Steller sea lion diet.

The above information and the uncertainty regarding the importance of specific rockfish species in the sea lion diet does not indicate a strong case for competition between sea lions and the rockfish fisheries at this time. Therefore, NMFS believes that the BSAI and GOA rockfish fisheries and the 2000 TAC specifications for those fisheries will neither appreciably reduce the likelihood of survival and recovery of the western population of Steller sea lions nor appreciably reduce the value of critical habitat for its survival and recovery.

Squid and other species

Of the species taken by the fisheries in these categories, squid, octopus, and sculpins are also known to be taken regularly in the Steller sea lion diet. All three species are taken almost entirely as bycatch.

Importance in the sea lion diet --- Squid and octopus are common in the sea lion diet in both the GOA and the BSAI regions, and sculpins are common in the BSAI region (Table 5, NMFS 1992, 1995). In some areas, they may comprise a major portion of the diet. For example, octopus ranked second in the stomach contents of 88 sea lions taken in the GOA in 1985-1986 (Calkins and Goodwin 1988), and fifth in importance in a similar collection in the GOA in 1975-1978. Squid were second in importance in the 1975-1978 collection. Sculpins were third in importance in the stomachs of 86 sea lions collected in the Bering Sea in 1981 (NMFS 1992). Thus, the available data suggest that these species are of considerable importance to the Steller sea lion diet.

Potential for competition --- In both the BSAI and GOA regions, squid are taken as bycatch primarily down slope from the continental shelf break. The catch of octopus is similarly distributed, except that it tends to be in somewhat shallower waters up the slope from the continental shelf break. Within critical habitat, both species are more likely to be taken in the southeastern Bering Sea foraging area than in the vicinity of rookeries and haulouts. In the GOA, squid and octopus catches together comprise about 3% to 5% of the catch for the entire other species category. Sculpins are taken by fisheries over the southeastern Bering Sea shelf, but largely to the east and north of the southeastern Bering Sea foraging area of sea lion critical habitat. In the GOA, sculpins are taken primarily along the continental shelf break and over the shelf southeast of Kodiak Island. While ABCs and TACs are established for these categories, they are taken almost entirely as bycatch only. In the BSAI in 1999, 21% of the squid TAC and 56% of the other species category were taken. In the BSAI, skates and sculpins generally comprise the majority of the other species catch (Fritz, 1999), which represents only 1% to 4% of their respective biomasses (Fritz 1999). In the GOA in 1999, 26% of the other species TAC was taken. Generally, sharks and skates comprise 50% to 80% of the other species catch in the GOA (Gaichas et al. 1999).

While the squid and other species in these categories may contribute significantly to the diet of Steller sea lions, they are caught by fisheries almost entirely as bycatch (i.e., little directed fishing occurs for these species), caught primarily outside of critical habitat areas, managed conservatively, and caught at levels well below established TACs. The potential for competition appears to be relatively low at this time. Therefore, NMFS believes that the catch of squid and other species and the 2000 TAC specifications allowing such catch will neither appreciably reduce the likelihood of survival and recovery of the western population of Steller sea lions nor appreciably reduce the value of critical habitat for its survival and recovery.

Pacific cod

During the course of this consultation, evidence was available suggesting a potential for competition between the BSAI and GOA fisheries for Pacific cod and the western population of Steller sea lions. On that basis, the consultation focused particular attention on these fisheries, as is indicated by the more detailed information provided below.

Importance in the sea lion diet --- Pacific cod (cod) is clearly a common prey item of Steller sea lions, as can be discerned from its occurrence in previous studies of the sea lion diet (Table 5). Recent unpublished results from NMFS's National Marine Mammal Laboratory (NMML) indicate that cod is a significant or important prey item in the central and western GOA and the eastern Aleutian Islands, at least during winter months (Table 7). The data are from scats collected in 1995 through 1998, and indicate that 20% (BSAI) to 40% (GOA) of the scats collected in these regions during the period from December to March contained hard parts from cod. Similar results are reported for stomach contents from the central and western Bering Sea in March of 1981 (NMFS 1995; see their Table 4, page 54).

Size distributions of cod taken by sea lions and the fishery --- Table 7 indicates that the majority of cod taken are in the range of 35 cm to 60 cm in length. As observed in Figure 6, this size range is consistent with the lower end of the size distribution of cod taken by the fisheries. Unfortunately, the data are not yet available in sufficient detail to determine the extent of overlap. For example, if the cod identified in the study scats were primarily in the 35 cm to 45 cm range, then comparison with the fishery distributions in Figure 6 would suggest relatively little overlap in size distribution with the fishery taking larger fish than taken by sea lions. At present, the information available suggests the fishery targets Pacific cod larger than foraging Steller sea lions, in which case competition between the fishery and Steller sea lions might be limited, although some competition may exist.

Depth distribution of foraging sea lions and the cod fishery --- The fishery could also compete with sea lions if it takes cod from depths within the range of diving and foraging sea lions (or conversely, the fishery might avoid competition if takes cod from depths where the cod are not available to foraging sea lions). The depths of the cod fisheries in the BSAI and GOA are generally less than 150 m (Fig. 5), and are clearly within the diving capability of the Steller sea lion. Therefore, on the basis of depth, the fishery and the sea lions may be using the same resource.

Spatial distribution of the cod fishery relative to Steller sea lion critical habitat --- The cod catch from Steller sea lion critical habitat in the BSAI region has increased from less than 30,000 mt in the mid 1980s to over 120,000 mt in 1997. The percent of the BSAI cod catch from critical habitat has increased from 11% - 38% through 1987 to about 50% in 1998. In the GOA, the amount of cod catch from Steller sea lion critical habitat increased from less than 12,000 prior to 1988, and has subsequently increased to about 40,000 mt for 1995 to 1998. The percent of the GOA cod catch from critical habitat has increased from less than 20% in the late 1970s to almost 80% in 1992, and then has varied between about 60% to 67% from 1994 to 1998. The distributions of the cod catch in the BSAI and GOA regions are illustrated by gear type in Figure 8. These figures indicate greater concentration of the trawl and pot fisheries in critical habitat compared to the longline fisheries, particularly in the BSAI region where the longline effort extends up the shelf break to the U.S.- Russian Convention Line. In the Aleutian Islands region, both the trawl and longline cod fisheries are concentrated within Steller sea lion critical habitat. The actual catches and percent catches by area for the GOA and BSAI regions in 1997 and 1998 are listed in Table 8. These data are sufficient to demonstrate a considerable spatial overlap of the cod fisheries in the BSAI and GOA regions with Steller sea lion critical habitat. The overlap is most apparent with trawl and pot fisheries.

*Temporal distribution of the cod fishery relative to crucial periods of Steller sea lion foragin*g --- The previous biological opinion on the pollock and Atka mackerel fisheries emphasized the sensitivity of Steller sea lions to competition for prey during the winter period. This emphasis was based on the importance of successful foraging for adult females that may be nursing a pup and supporting a developing fetus, for pups and juveniles that are learning to foraging during a period of greater environmental challenges. Steller sea lions are likely sensitive to competition for prey throughout the year, but the life cycle of the species, combined with harsher environmental conditions, likely makes them especially sensitive during the winter period. This sensitivity is discussed in detail in the December 3, 1998 Biological Opinion and the RFRPA document issued October 15, 1999. The temporal distribution of the cod fishery in the BSAI varies considerably by gear type. The longline fishery is well dispersed throughout all but the summer months, when the fishery does not operate to avoid halibut bycatch (Fig. 7). The BSAI trawl fishery, and to a lesser extent, the BSAI pot fishery are more concentrated in the late winter/spring period to take advantage of aggregations of cod over the southeastern Bering Sea shelf. In the GOA, all three gear types tend to be concentrated in late winter and early spring, with considerably less trawling in the period from July to November (Fig. 7). Thus, in the BSAI region, the trawl and pot fisheries appear to be concentrated during the winter period, whereas in the GOA, all gear types tend to be concentrated in winter.

Summary of potential effects of the Pacific cod fisheries --- The above information on potential effects of the cod fisheries raises several questions about whether these fisheries compete with Steller sea lions in the BSAI and GOA. The information indicates that (1) cod are a common prey of Steller sea lions, particularly in the winter, (2) portions of the fisheries occur in Steller sea lion critical habitat, (3) the fisheries occur at relatively shallow depths well within the range of Steller sea lions, and (4) portions of the fisheries (trawl fishery in the BSAI and trawl and longline fisheries in the GOA) are temporally concentrated in the late winter/spring period when sea lions may be particularly sensitive to reductions in availability of prey.

However, the information available does not demonstrate that competition occurs in a way that would be expected to appreciably reduce the likelihood of survival and recovery of the Steller sea lion in the wild or diminish the value of critical habitat for the survival and recovery of the sea lions. Fish taken in the cod fisheries are considerably larger than those taken in the pollock fishery. In the 1998 Biological Opinion, the available information on sizes of pollock taken by sea lions was sufficient to demonstrate considerable overlap with those taken by the fishery, which led us to conclude that the pollock fishery competed with Steller sea lions. With respect to Pacific cod, the information is not sufficient to reach the same conclusion.

In addition, the definition of competition also requires that the removal of cod by the fishery reduces their availability to sea lions. In the pollock and Atka mackerel cases, this concept was referred to as localized depletion of the resource. For Atka mackerel, localized depletions were clearly demonstrated based on Leslie depletion analyses (Fritz, *in prep*). For pollock, the potential for localized depletions was based on evidence of excessive harvest rates in Steller sea lion critical habitat. Based on the information available, NMFS has no evidence of localized depletions associated with the Pacific cod fisheries.

In the BSAI, the trawl fishery for cod is concentrated in Steller sea lion critical habitat. However, the overall effects of the cod fishery are determined primarily by a balance between the trawl and longline fisheries, and the longline fishery is well dispersed both temporally and spatially. The end result in the BSAI is that about 50% of the cod fishery comes from critical habitat - approximately the same portion as from the pollock fishery in the A and B seasons when the distribution of pollock is also unknown. In the GOA, the cod fishery is concentrated in the winter. However, the fishery is dispersed spatially among three management regions (610, 620, and 630) on the basis of the best available information on stock distribution. Such spatial dispersion would reduce the likelihood of localized depletions or competition between the cod fishery and Steller sea lions. In addition, 25% of the cod TAC is distributed to the State for management in State waters; this State fishery is primarily a pot and jig fishery consisting of smaller vessels with smaller hold capacities and reduced fishing power. The slower-pace of the State fishery would also be expected to reduce the likelihood of localized depletions and competition.

Additional analyses and information are needed to resolve this issue, and those analyses are highlighted in the conservation recommendations. In particular, the conservation recommendations place emphasis on evaluation of the size distribution of cod taken by sea lions, and the potential for localized depletion based on catch-per-unit-effort or any other appropriate analysis. Results of the analyses listed under the conservation recommendations should better enable the agency to evaluate the potential for future competition between sea lions and the cod fisheries of the BSAI and GOA.

5.3.2 Effects of the AFA

As described in section 2.3 above, the main elements of the AFA:

(1) Establish a new allocation scheme for BSAI pollock,

(2) Provide for buyout and scrapping of nine BSAI pollock catcher/processors,

(3) List by name or provide qualifying criteria for non-CDQ BSAI pollock participants,

(4) Increase observer coverage and scale requirements for BSAI catcher/processors,

(5) Establish limits on BSAI pollock fishery cooperatives in the non-CDQ sectors,

(6) Require individual allocations of BSAI pollock TAC to inshore catcher-vessel cooperatives,

(7) Require restrictions on vessels benefitting from the AFA to protect vessels not participating in the AFA, and

(8) Establish excessive share caps.

In total, the AFA deals with rules and limits for participation in the BSAI pollock fishery, and allocation of the pollock among the participants. In general, issues related to allocation of TAC are resolved or managed in the Council arena, where the industry and the public at large have an opportunity to participate. These matters do not have direct effects (beneficial or adverse) on the western population of Steller sea lions, but they may have important indirect consequences. Of the above major elements of the AFA, items (2) through (8) should have beneficial indirect effects on sea lions

! Item (2) will reduce the fishing power of the catcher/processor sector of the BSAI pollock fleet and will therefore reduce the rate at which pollock can be taken. This element should, therefore, increase the temporal dispersion of the fishery and reduce the probability of localized depletion.

! Item (3) lists and limits participating non-CDQ vessels and should reduce over-capitalization of the fleet, thereby reducing the fishing power and increasing temporal dispersion.

! Item (4) will increase the amount and accuracy of fisheries data from the catcher/processor sector. Such data is essential for assessment of the pollock stock, fishing practices, and potential effects on Steller sea lions.

! Item (5) allows for the establishment of fishery cooperatives which, perhaps more than any other element of the AFA, will provide an opportunity to eliminate or reduce the race for fish, thereby increasing temporal dispersion of the catch. As participating vessels will not have to operate under the temporal constraints of a race for fish, they will likely also increase their spatial dispersion, spending more time searching for the optimal fishing conditions. This kind of dispersion has already been observed with the offshore fleet in 1999; the fleet slowed their fishing and dispersed more widely during the summer period.

! Item (6) provides a mechanism for allocation of TAC to multiple inshore cooperatives formed around specific inshore processors. Again, the development of cooperatives within this sector of the industry is expected to reduce or eliminate the race for fish, and disperse the fisheries temporally and spatially. The extent of such dispersion is determined by multiple factors in addition to the existence of cooperatives, and the amount of temporal/spatial dispersion remains to be seen, but the movement toward greater temporal/spatial dispersion in this fishery can only be viewed as positive with respect to Steller sea lions.

! Item (7) prevents AFA-benefitting vessels in the pollock fishery from gaining an unfair advantage in other fisheries or over other vessels not participating in the AFA. This element is essential to keep AFA vessels in the pollock fishery from, for example, redirecting their fishing power to the Atka mackerel fishery, securing a greater portion of the Atka mackerel catch and increasing the speed with which the Atka mackerel TAC is taken. Similarly, this element of the AFA prevents these vessels from moving into the GOA and disadvantaging GOA vessels in their pollock and other fisheries. In effect, this element of the AFA is beneficial because it mitigates the potential for greater temporal concentration of catch in fisheries other than the BSAI pollock fishery.

! Item (8) may also benefit Steller sea lions by preventing any single company from dominating the fishing strategy for pollock, which could lead to temporal or spatial concentration of the fishery.

! Item (1) shifts the allocation of pollock TAC from the previous 35%:65% inshore:offshore allocation to a new allocation giving 10% of the annual TAC to CDQ, removing another 5% for bycatch, and then partitioning the remaining 85% in the ratio of 50:10:40 to inshore catcher vessels, motherships, and catcher/processors, respectively. In effect, this new scheme represents a significant increase in the inshore sector portion of the catch. This shift in allocation has potential implications for both the temporal dispersion of the catch and spatial dispersion of the catch. Temporal dispersion should increase as a result of this shift. On average, inshore vessels have less catching power then offshore catcher/processors. Therefore, if the number of vessels is held constant, then the rate at which the TAC is taken should be reduced because a greater portion of the TAC is given to vessels with lower fishing power or capacity. This increase in temporal dispersion should be beneficial to Steller sea lions as it reduces the probability of localized depletion of pollock. On the other hand, the vessels comprising the inshore sector are also subject to greater restrictions due to the smaller sizes of their vessels. In particular, the range of inshore vessels is smaller than the range of catcher/processors. Therefore, the shift in allocation toward the inshore fleet may tend to increase spatial concentration of the catch. This expectation is consistent with the long-term pattern of the fishery from foreign to joint venture to domestic, which corresponding in a shift from the fishery from primarily offshore waters to far greater concentration inshore. The shift of allocation to inshore vessels may well represent a continuation of this spatial pattern, which lead to spatial concentration of the catch in Steller sea lion critical habitat. However, two factors may mitigate or even preclude this tendency toward greater spatial concentration inshore. First, under the AFA, the majority of inshore vessels are expected to participate in cooperatives. As noted above, these cooperatives eliminate the race for fish, and provide an opportunity for fishing vessels to optimize their fishing strategy, which could include an increase in fishing range for each vessel. Secondly, the tendency for spatial concentration of the pollock catch in Steller sea lion critical habitat is addressed and precluded in the RFRPAs, which set limits on the amount of catch that can be taken from critical habitat in the

BSAI region. The full effect of each of these factors, and the full extent of spatial dispersion in this fishery in the upcoming years remains to be seen, but results from 1999 indicate that fishing vessels from the inshore sector are capable of fishing successfully outside of the Steller sea lion critical habitat and the SCA.

In combination with the RFRPAs, the AFA should have primarily beneficial effects on the BSAI pollock fishery and the Steller sea lion.

6.0 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 considered in this biological opinion. 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.

As discussed in the Environmental Baseline, the Alaska Department of Fish and Game (ADF&G) manages fisheries out to three miles, and oversees crab fisheries in Federal waters (EEZ) under the FMP adopted by the Council. These fisheries are expected to continue into the foreseeable future. Generally, where target fisheries are managed by both Federal and State agencies, the State coordinates their fishery openings and in-season adjustments with Federal fisheries. At present, the State fishery for herring is located in the following areas: Prince William Sound, Cook Inlet, Kodiak, Alaska Peninsula, Bristol Bay, Kuskokwim, Norton Sound, Southeast, and Port Clarence. Harvest methods for herring consist of gillnet, purse seine, and handpicking of roe from kelp. Herring are primarily caught for their roe during the sac roe harvest in the spring. Harvest levels for 1998 are expected to be about 36,000 mt, similar to the last few years. Figure 18a shows herring catches by season and by region, and also shows the effort level depicted by the number of landings. Bristol Bay is the primary producer with recent catches of about 23,000 mt annually. Effort over the last two decades has decreased in Prince William Sound and Cook Inlet, but increased in Kuskokwim, Kodiak, and Bristol Bay. The potential adverse effects of the State of Alaska herring fishery on Steller sea lions is uncertain, although herring have higher caloric and nutritional value to Steller sea lions.

Clam, abalone, octopus, squid, snail, scallop, geoduck clams, sea urchins, and sea cucumbers have been harvested throughout the State (Fig. 19a). Of these, octopus and squid are the most likely prey of sea lions. Most of the catch of shellfish is taken from April to September, and they are taken by hand-picking, shovel, trawl, pot, and dredge gear. Harvest levels were relatively consistent through the 1980s, but have increased dramatically in amount and annual variation in the 1990s (Fig. 19b). The variability has been due, in large part, to recent but sporadic catches in Bristol Bay and the Bering Sea, areas not usually fished for shellfish (Fig. 19a). With the exception of the recent large catches in these areas, most of the shellfish fisheries have traditionally taken place in the Kodiak and Cook Inlet areas.

The State manages all crab fisheries in the BSAI and GOA. King (brown, red, blue), Dungeness, and Tanner crabs are taken by hand-picking, shovel, trawl, pot, and dredge gear. State of Alaska crab fisheries occur in Bristol Bay, Dutch Harbor, Alaska Peninsula, Kodiak, Cook Inlet, Adak and W. Aleutian Islands, and Prince William Sound (Fig. 20a). This fishery primarily occurs during the winter season. In the past ten years, the industry has focused on Alaska snow crab (*C. opilio*), and the catch exceeded historical levels of king crab in the early 1990s (Fig. 20b). The Bering Sea fishery produces the vast majority of crab that is harvested in Alaska but has also been declining since 1993. Catch per landing has been greatest in the Bering Sea, and worst in the Kodiak and Cook Inlet areas (Fig. 20a).

The State of Alaska shrimp fishery occurs primarily in the southeast and Yakutat areas, and to a lesser extent in Prince William Sound, Kodiak, Dutch Harbor, Cook Inlet, and the Alaska Peninsula. Shrimp are harvested by pot gear and often sold to floating processors. In 1995, over 45,000 mt of shrimp were harvested by 351 vessels. In the last ten years, effort has increased in the southeast due, in part, to the availability of floating processors, which allow fishing vessels to devote more of their time to fishing. Figures 21a and b show the decline in shrimp fisheries in areas other than southeast and Yakutat.

The State of Alaska manages groundfish within the 3-mile limit for lingcod, Pacific Ocean perch, flathead sole, rex sole, arrowtooth flounder, sablefish, black rockfish, Pacific cod, and pollock. Fisheries occur in the Alaska

Peninsula, Kodiak, Bering Sea, Dutch Harbor, Adak and W. Aleutian Islands, Cook Inlet, Prince William Sound, and Southeast areas.

The State of Alaska Pacific cod fishery is undergoing a change in management from Federal to State authorities. A total TAC is set for Pacific cod, and that TAC is divided into Federal and State shares. In 1997 and 1998, the State assumed management responsibility of 15% of the total TAC for cod, and 20% in 1999. In 2000, the State will assume management responsibility of 25% of the total TAC for cod, which is the highest percent allowed under current regulations. The State fishery is limited to pot and jig gear only. The Pacific cod fishing season is primarily in the winter.

The State of Alaska 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 Kotzbue management areas (Fig. 22a). The State has a long history of salmon fishing. Salmon are taken by purse seines, gill nets, trolling, and beach seining. The catch in 1974 was just over 60,000 mt, then increased four-fold by 1981, was relatively constant through the 1980s, and then increased in the early 1990s to a record catch of over 450,000 mt (Fig. 22b). In 1997, 123 million salmon were caught in Alaska, amounting to about 280,000 mt. The 1998 catch was expected to be higher than 1997, but has been low due to poor returns in Bristol Bay. Bristol Bay harvest levels have historically been the highest with Kuskokwim and Chignik being the lowest (Fig. 22a). In 1997, 26% of the commercial catch was from hatcheries. Salmon caught in these fisheries are seasonally important in the diet of Steller sea lions

The subsistence harvest of Steller sea lions by Alaska Natives is expected to continue into the foreseeable future. The number of sea lions harvested has declined in the past few years. It is not clear if the decline will continue. The majority of sea lions are taken by Aleut hunters in the Aleutian and Pribilof Islands. The great majority (99%) of the statewide subsistence take was from west of 144°W long. (i.e., the range of the western population). The overall impact of the subsistence harvest on the western population will be determined by the number of animals taken, their sex and age class, and the location where they are taken. As is the case for other sources of mortality, the significance of subsistence harvesting may increase as the western population decreases in size unless the harvesting rate is reduced accordingly. However, the subsistence harvest accounts for only a relatively small portion of the animals currently lost to the population each year.

7.0 CONCLUSIONS

After reviewing the current status of the northern right whale, the blue whale, the fin whale, the sei whale, the humpback whale, the sperm whale, the eastern population of Steller sea lions, the western population of Steller sea lions, the critical habitat designated for Steller sea lions, the environmental baseline for the action area (including the extensive changes occurring as part of the RFRPAs being implemented in the pollock fisheries in the action area), the effects of the Year 2000 BSAI and GOA groundfish fisheries with the TAC levels proposed, the effects of the American Fisheries Act, and the cumulative effects, it is NMFS's biological opinion that the three actions considered in this Biological Opinion, as proposed, are not likely to (1) jeopardize the continued existence of the six large protected whale species or the eastern or western populations of Steller sea lion, or (2) destroy or adversely modify designated Steller sea lion critical habitat.

Although these conclusions are based on the best scientific and commercial data available during this consultation, NMFS recognizes the uncertainty in these data with respect to potential competition between the western population of Steller sea lions and the BSAI and GOA fisheries for Pacific cod. NMFS also recognizes that it has a continuing responsibility to make a reasonable effort to develop additional data (51 FR 19952). To fulfill this responsibility, NMFS has identified crucial information necessary to address this question again in one year. That information will result from analyses listed in the Conservation Recommendations. At the completion of those studies, the issue of competition between Steller sea lions and the BSAI and GOA cod fisheries should be re-examined.

8.0 INCIDENTAL TAKE STATEMENT

8.1 Introduction

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the reasonable and prudent measures and terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the action agency, NMFS's Office of Sustainable Fisheries, so that they become binding conditions of any grant or permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. NMFS's Office of Sustainable Fisheries has a continuing duty to regulate the activity covered by this incidental take statement. If the Office of Sustainable Fisheries (1) fails to require any applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, NMFS's Office of Sustainable Fisheries must report the progress of the action and its impacts on the species as specified in this Incidental Take Statement.

NMFS is not including an incidental take authorization for marine mammals at this time because the incidental take of marine mammals has not been authorized under section 101(a)(5) of the Marine Mammal Protection Act and its 1994 amendments. Following issuance of such regulations or authorizations, NMFS may amend this Biological Opinion to include an incidental take statement for marine mammals, as appropriate.

9.0 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The conclusions of this Biological Opinion were based on the best scientific and commercial data available during this consultation, NMFS recognizes the uncertainty in these data with respect to potential competition between the western population of Steller sea lions and the BSAI and GOA fisheries for Pacific cod. NMFS also recognizes that it has a continuing responsibility to make a reasonable effort to develop additional data (51 FR 19952). NMFS has identified the following information that should be developed to fulfill this responsibility:

1. Increase survey effort in the BSAI and GOA to determine the distribution by season of all species of groundfish taken in commercial fisheries. At the least, this should include information on distribution during summer versus winter months. If the distribution of all species can not be determined, then emphasis should be placed on species that are known to be important or common prey items of Steller sea lions (e.g., pollock, Atka mackerel, and Pacific cod).

2. Better define Steller sea lion foraging patterns, including their foraging distribution, and prey taken by size and to the lowest possible taxonomic level. At a minimum, studies should include an assessment of differences in foraging by size, sex, season, region, and population status.

3. Analyze trends in catch per unit effort for the Pacific cod fisheries in the Steller sea lion conservation area of the southeastern Bering Sea and, where appropriate, in the GOA. Determine whether catch per unit effort can be used as an indicator of localized depletion of cod resources to Steller sea lions.

4. Assess the effects of other fisheries on Steller sea lions. Include fisheries managed by the Federal government and the State of Alaska. The assessment should give priority to State fisheries for herring, salmon, and Pacific cod.

5. Monitor and evaluate the effect of management measures intended to facilitate the recovery of Steller sea lions. In particular, this should include review of the distribution of fishery effort and catch as a function of the implementation of the American Fisheries Act.

6. Consider establishment of 3-nm no-entrance zones around haulout sites used by the western population of Steller sea lions.

7. Continue to educate the fishing community about Steller sea lions and techniques to reduce or eliminate incidental take of the species.

To keep NMFS informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, notification of the implementation of any conservation recommendations should be provided.

10.0 REINITIATION - CLOSING STATEMENT

This concludes formal consultation on the 2000 TAC specifications for the BSAI and GOA groundfish fisheries, and the American Fisheries Act. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or designated critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or designated critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation of consultation.

The conclusions of this Biological Opinion were based on the best scientific and commercial data available during this consultation, NMFS recognizes the uncertainty in these data with respect to potential competition between the western population of Steller sea lions and the BSAI and GOA fisheries for Pacific cod. NMFS also recognizes that it has a continuing responsibility to make a reasonable effort to develop additional data (51 FR 19952). To fulfill this responsibility, NMFS has identified crucial information necessary to address this question again in one year. That information will result from analyses listed in the Conservation Recommendations. NMFS will consider the results of these studies as new information that reveals effects of the agency action that may affect listed species or designated critical habitat in a manner or to an extent not considered in this opinion.

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12.0 TABLES AND FIGURES

Table 1. Consultation history on BSAI Groundfish Fishery Management Plan and GOA Groundfish Fishery Management Plans as they pertain to Steller sea lions and other protected species.

Region	Year	Date	Consultation	ACTION	CONCLUSION
BSAI					
	1998	22-Dec	Formal	1999 TAC	No jeopardy
	1998	3-Dec	Formal	1999 pollock, Atka mackerel fisheries	Jeopardy and adverse modification by pollock fishery
	1998	26-Feb	Informal	1998 TAC	Reinitiation not triggered
	1997	17-Jan	Informal	1997 TAC	No adverse affects not already considered, reinitiation not necessary
	1996	26-Jan	Formal	1996 TAC and BSAI FMP	No jeopardy
	1995	26-Sep	Informal	Effect of I/O (38/40) on SSL	No adverse affects not already considered, reinitiation not necessary
	1995	25-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
	1994	2-Feb	Informal	1994 TAC	No adverse affects not already considered, reinitiation not necessary
	1993	28-Apr	Formal	Delay of pollock "B" season	No jeopardy
	1993	20-Jan	Informal	1993 TAC	No adverse affects not already considered, reinitiation not necessary
	1992	9-Oct	Informal	Amendments 20/25	No adverse affects not already considered, reinitiation not necessary
	1992	11-Jun	Informal	IFQ fishery	No adverse affects likely, therefore further consultation not required
	1992	4-Mar	Formal	Amendment 18 inshore/offshore	No jeopardy
	1992	21-Jan	Formal	1992 TAC	No jeopardy
	1991	22-Oct	Informal	Amendments 17/22 & 20/25	No adverse affects not already considered, reinitiation not necessary
	1991	19-Apr	Formal	BSAI FMP	No jeopardy
	1990	30-Oct	Formal	Bering Sea snail fishery	No jeopardy
	1990	24-Oct	Formal	BSAI crab FMP	No jeopardy
	1989	5-Jul	Formal	Issue of MMPA exemptions	No jeopardy
	1979	14-Dec	Formal	BSAI FMP	No jeopardy (only whales listed under ESA at this time)

Table 1 cont.

Region	Year	Date	Consultation	ACTION	CONCLUSION
GOA					
	1998	22-Dec	Formal	1999 TAC	No jeopardy
	1998	3-Dec	Formal	1999 pollock fishery	Jeopardy and adverse modification
	1998	2-Mar	Formal	1998 TAC	No jeopardy
	1997	10-Sep	Informal	Amendment 46	Action will not adversely affect listed species
	1997	17-Jan	Informal	1997 TACs	No adverse affects not already considered, reinitiation not necessary
	1996	26-Jan	Formal	1996 TAC and GOA FMP	No jeopardy
	1995	26-Sep	Informal	Effect of I/O (38/40) on SSL	No adverse affects not already considered, reinitiation not necessary
	1995	25-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
	1994	31-Jan	Informal	1994 TAC	No adverse affects not already considered, reinitiation not necessary
	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	Action will not adversely affect listed species
	1992	11-Jun	Informal	IFQ fishery	No adverse affects likely, therefore further consultation not required
	1992	4-Mar	Informal	Season 2nd quarter delay	Action will not adversely affect listed species
	1991	23-Dec	Informal	1992 TAC	No adverse affects not already considered, reinitiation not necessary
	1991	12-Nov	Informal	Amendment 23	No adverse affects not already considered, reinitiation not necessary
	1991	22-Oct	Informal	Amendments 17/22 & 20/25	No adverse affects not already considered, reinitiation not necessary
	1991	20-Sep	Formal	4th quarter pollock fishery	No jeopardy
	1991	5-Jun	Formal	1991 pollock TAC	No jeopardy
	1991	19-Apr	Formal	GOA FMP	No jeopardy

Table 2. Interim and recommended final TAC specifications for 2000 BSAI groundfish fisheries.

Species	Area	2000 Biomass	2000 OFL	2000 ABC	2000 Interim TAC	2000 TAC	1999 TAC	1999 Catch
Pollock	EBS	7,700,000	1,680,000	1,139,000	428,940	1,139,000	992,000	884,133
	A+B seasons						40%	
	C+D seasons						60%	
	AI	106,000	31,700	23,800	2,000	2,000	2,000	1,003
	Bogoslof	475,000	30,400	22,300	1,000	1,000	1,000	21
Pacific cod	BS/AI	1,300,000	240,000	193,000	40,931	193,000	177,000	160,084
Yellowfin sole	BS/AI	2,820,000	226,000	191,000	48,096	123,262	207,980	67,392
Greenland turbot	BS/AI	233,000	42,000	9,300	2,195	9,300	9,000	
	BS			67%	1,451	67%	67%	5,315
	AI			33%	744	33%	33%	461
Arrowtooth	BS/AI	785,000	160,000	131,000	31,069	131,000	134,354	10,679
Rock sole	BS/AI	2,070,000	273,000	230,000	27,750	134,760	120,000	40,362
Flathead sole	BS/AI	611,000	90,000	73,500	17,875	52,652	77,300	17,777
Other flatfish	BS/AI	829,000	141,000	117,000	35,613	83,813	154,000	15,184
Sablefish	EBS	18,000	1,750	1,470	155	1,470	1,340	628
	AI	33,000	3,090	2,430	79	2,430	1,380	529
POP complex								
True POP	EBS	47,700	3,100	2,600	324	2,600	1,400	376
Other POP	EBS	8,200	259	194	62	194	267	217
True POP	AI	192,000	14,400	12,300	3,311	12,300	13,500	
	Eastern			3,120	801	3,120	3,430	2,416
	Central			3,510	935	3,510	3,850	2,815
	Western			5,670	1,575	5,670	6,220	6,545
Sharp/Northern	AI	115,000	6,870	5,150	978	5,150	4,230	5,181
Short/Rougheye	AI	41,500	1,180	885	223	885	965	474
Other rockfish	EBS	7,030	492	369	86	369	369	137
	AI	13,000	913	685	159	685	685	632
Atka mackerel	AI	565,000	119,000	70,800	36,690	70,800	66,400	
	Eastern			16,400	14,769	16,400	17,000	15,893
	Central			24,700	9,940	24,700	22,400	21,443
	Western			29,700	11,981	29,700	27,000	15,626
Squid	BS/AI	n/a	2,620	1,970	456	1,970	1,970	413
Other species	BS/AI	611,000	71,500	31,360	7,599	31,360	32,860	18,396
BS/AI TOTAL		**18,580,430**	**3,203,874**	**2,260,113**	**694,679**	**2,000,000**	**2,000,000**	**1,223,618**

EBS = eastern Bering Sea
BS/AI = Bering Sea & Aleutians
OFL = Overfishing Level
ABC = Acceptable Biological Level
* (A/B):(C/D) season split for CDQ is 45%:55%
** AI pollock TAC is for bycatch

only

BS = Bering Sea
AI = Aleutian Islands

TAC = Total Allowable Catch

1999 catch (excluding CDQ) as of 10/30/99

Table 3. Interim and recommended final TAC specifications for 2000 GOA groundfish fisheries.

Species	Area	2000 Biomass	2000 OFL	2000 ABC	2000 Interim TAC	2000 TAC	1999 TAC	1999 Catch
Pollock	W (61)			38,350		38,350	23,120	23,387
	C (62)	588,000	130,760	22,820	23,120	22,820	38,840	38,135
	C (63)		(EYAK/SEO)	30,030		30,030	30,520	30,095
	WYAK	28,710		2,340	528	2,340	2,110	1,759
	EYAK/SEO		8,610	6,460	1,582	6,460	6,330	4
	Total	616,710	139,370	100,000	25,230	100,000	100,920	93,380
Pacific Cod	W			27,500	4,726	20,625	23,630	23,154
	C			43,550	8,857	35,165	42,935	44,559
	E			5,350	254	4,010	1,270	857
	Total	567,000	102,000	76,400	13,567	59,800	67,835	68,570
Flatfish, Deep Water	W			280	60	280	240	22
	C			2,710	685	2,710	2,740	1,865
	WYAK			1,240	430	1,240	1,720	389
	EYAK/SEO			1,070	337	1,070	1,350	9
	Total	74,370	6,980	5,300	1,512	5,300	6,050	2,285
Rex Sole	W			1,230	298	1,230	1,190	603
	C			5,660	1,373	5,660	5,490	2,391
	WYAK			1,540	212	1,540	850	41
	EYAK/SEO			1,010	405	1,010	1,620	22
	Total	74,600	12,300	9,440	2,288	9,440	9,150	3,057
Shallow water flatfish	W			19,510	1,125	4,500	4,500	252
	C			16,400	3,237	12,950	12,950	2,282
	WYAK			790	62	790	250	6
	EYAK/SEO			1,160	268	1,160	1,070	5
	Total	299,100	45,330	37,860	4,692	19,400	18,770	2,545
Flathead Sole	W			8,490	500	2,000	2,000	184
	C			15,720	1,250	5,000	5,000	680
	WYAK			1,440	318	1,440	1,270	16
	EYAK/SEO			620	192	620	770	11
	Total	207,520	34,210	26,270	2,260	9,060	9,040	891
Arrowtooth	W			16,160	1,250	5,000	5,000	3,656
	C			97,710	6,250	25,000	25,000	11,787
	WYAK			23,770	625	2,500	2,500	383
	EYAK/SEO			7,720	625	2,500	2,500	236
	Total	1,571,670	173,910	145,360	8,750	35,000	35,000	16,062
Sablefish	W			1,840	455	1,840	1,820	1,487
	C			5,730	1,398	5,730	5,590	5,828
	E/WYAK			5,760	552	2,207	2,090	1,704
	EYAK/SEO				800	3,553	3,200	3,080
	Total	169,000	16,660	13,300	3,175	13,300	12,700	12,099
Other slope rockfish	W			20	5	20	20	40
	C			740	162	740	650	615
	WYAK			250	117	250	470	122
	EYAK/SEO			3,890	1,033	3,890	4,130	12
	Total	102,510	6,390	4,900	1,317	4,900	5,270	789
Northern rockfish	W			630	210	630	840	573
	C			4,490	1,037	4,490	4,150	4,825

E			0	0	0	0	0
Total	85,360	7,510	5,120	1,247	5,120	4,990	5,398

Table 3. cont.

Species	Area	2000 Biomass	2000 OFL	2000 ABC	2000 Interim TAC	2000 TAC	1999 TAC	1999 Catch
Pacific Ocean Perch	W		1,460	1,240	462	1,240	1,850	1,935
	C		10,930	9,240	1690	9,240	6,760	7,914
	WYAK			840	205	840	820	627
	EYAK/SEO		3,000	1,700	790	1,700	3,160	0
	Total	200,310	15,390	13,020	3,147	13,020	12,590	10,476
Shortraker/Rougheye	W			210	40	210	160	194
	C			930	242	930	970	577
	E			590	115	590	460	531
	Total	70,880	2,510	1,730	397	1,730	1,590	1,302
Pelagic shelf rockfish	W			550	132	550	530	130
	C			4,080	843	4,080	3,370	3,835
	WYAK			580	185	580	740	672
	EYAK/SEO			770	60	770	240	20
	Total	66,440	9,040	5,980	1,220	5,980	4,880	4,657
Demersal shelf rockfish		15,100	420	340	140	340	560	262
Atka Mackerel	Gulfwide	unknown	6,200	600	150	600	600	262
Thornyhead	W			430	65	430	260	282
	C			990	175	990	700	582
	E			940	257	940	1,030	410
	Total	52,950	2,820	2,360	497	2,360	1,990	1,274
Other Species	Gulfwide	NA	NA	NA	3,650	14,270	14,600	3,735
GULF OF ALASKA	**TOTAL**	4,173,520	581,040	431,410	73,239	299,650	306,535	227,044

WYAK = Western Yakutat
EYAK = Eastern Yakutat
SEO = Southeast Outside

OFL = Overfishing Level
ABC = Acceptable Biological Catch
TAC = Total Allowable Catch

1999 Catch as of 11/6/99

Table 4. Life history table for Steller sea lions based on Calkins and Pitcher (1982) and York (1994). (From York 1994.)

Ages			Calkins-Pitcher life table			York life table		
From	To	Fecundity	Cum. survival	Annual survival	Percent at age	Cum. survival	Annual survival	Percent at age
0	1	0.000	1.000	0.776	16.676	1.000	0.782	16.251
1	2	0.000	0.776	0.776	12.546	0.782	0.782	12.709
2	3	0.000	0.603	0.776	9.438	0.612	0.782	9.938
3	4	0.105	0.468	0.868	7.100	0.478	0.930	7.772
4	5	0.267	0.406	0.879	6.163	0.445	0.909	7.228
5	6	0.286	0.357	0.888	5.417	0.404	0.895	6.570
6	7	0.315	0.317	0.893	4.811	0.362	0.884	5.880
7	8	0.315	0.283	0.898	4.296	0.320	0.875	5.198
8	9	0.315	0.254	0.874	3.857	0.280	0.867	4.548
9	10	0.315	0.222	0.899	3.372	0.242	0.859	3.943
10	11	0.315	0.200	0.893	3.031	0.208	0.853	3.338
11	12	0.315	0.178	0.896	2.707	0.178	0.847	2.889
12	13	0.315	0.160	0.895	2.425	0.150	0.841	2.447
13	31	0.315	0.160	0.895	15.99	0.150	p(x)d	11.239

Table 5. A partial listing of studies on the prey of Steller sea lions. When prey are listed in order of frequency of occurrence reported, an asterisk (*) or dagger (†) indicate that rank of the marked prey item was tied with the similarly marked prey item listed before or after. Sample sizes (*n*) for studies of stomach contents are given only for the number of stomachs with contents; empty stomachs are not included. Note that some studies used the same data and results are therefore redundant (e.g., Merrick and Calkins [1996] present reanalysis of data reported in Pitcher [1981], Calkins and Pitcher [1982], and Calkins and Goodwin [1988]).

Study	Years	Location	Methods	Main findings
Imler and Sarber 1947	1945-1946	Sitka to Kodiak Island	Stomach contents (*n* = 15)	• Eight sea lions sampled in southeast Alaska; all but one fed principally on pollock, and exception contained a skate and an octopus. • Three sampled from Barren Islands contained pollock, starry flounder, tom cod, arrow-toothed halibut, common halibut, and octopus. • Two from Chiswell Island contained salmon. • Two from Kodiak Island contained pollock and arrow-toothed halibut.
Sleptsov 1950 (cited in Spaulding 1964)	Unknown	Kuril Islands	Unknown	• Reported sea lion feeding on octopus.
Wilke and Kenyon 1952	1949, 1951	St. Paul Island	Stomach contents (*n* = 3)	• One sea lion contained primarily sand lance but also starry flounder, one contained halibut, cod, pollock, and flounders, and one contained a large cephalopod beak.
Pike 1958	Summary, 1901-1958	Primarily BC, but also off California and Alaska	Stomach contents, (*n* = 19)	• Reports a range of fish and cephalopods for 12 time/area studies. • Disputes claim that studies provide evidence of serious commercial competition. • For his study (in British Columbia), prey (in order of frequency of occurrence) included squid, herring, rockfish, octopus, salmon*, skate*, and hake*. • For other studies in his table (except Imler and Sarber 1947), prey items listed were (in no particular order) rockfish, perch, herring, skate, shark, squid, octopus, lamprey, salmon, "cod," "bass," mussels, clam, crab, dogfish, flatfish, and sardines.
Mathisen *et al.* 1962	1958	Chernabura	Stomach contents (*n* = 94; 14 yearlings, 42 adult females, 18 harem bulls, 20 unattached bulls)	• Prey (in order of frequency of occurrence) included squid/octopus , common bivalves, smelts, greenlings, shrimp/crabs, rockfish, sculpins, isopods, unclassified crustaceans*, segmented worms*, and single occurrences of lamprey, salmon, sand lance, sand dollar, and coelenterate.

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Thorsteinson and Lensink 1962	1959	Marmot, Atkins, Ugamak, Jude, Chowiet	Stomach contents (*n* = 56); primarily adult males	• Prey (in order of frequency of occurrence) included squid/octopus, clam/mussel/snail, sand lance, rockfish, crab, greenling*, sculpins*, flatfish*, and single occurrences of halibut and lumpfish.
Spaulding 1964	1956-1963(?)	British Columbia	Stomach contents (*n* = 190; overlap with specimens reported in Pike [1958] above)	• Suggests sea lions prey mainly on one item per feeding period. • Some seen feeding at surface on lingcod, rockfish, salmon, or halibut (*n* = 8). • Feed primarily at night (*n* = 269 or 393 sampled). • Consumption of herring and salmon by sea lions, fur seals, and harbor seals estimated about 2% to 4% of commercial catch. • Prey (in order of frequency of occurrence) included octopus, rockfish, herring*, whiting*, salmon, dogfish, squid*, hake*, flatfish†, clam†, ratfish, shrimp*, sand lance*, graycod†, lingcod†, and single occurrences of lamprey, skate, eulachon, halibut, and mackereljack.
Tikhomirov 1964	1962	Bering Sea	Stomach contents *n* = unknown)	• Large numbers of sea lions in the southeastern Bering Sea, winter/spring of 1962. • Suggests herring "staple food" of sea lions during this period. • Suggests sea lion distribution was influenced by the distribution of herring.
Fiscus and Baines 1966	1958-1963	California to Bering Sea	Stomach contents (*n* = 22)	• Steller sea lions taken off central California and Oregon fed only on bottom fish. • Steller sea lions taken in Alaskan waters fed mainly on small, schooling fishes. • Near Unimak Pass in 1962, capelin was the major food species. • A Steller sea lion taken on the Fairweather Grounds in the eastern GOA in May 1958 had eaten three salmon. • Most of the food species (capelin, sand lance, sculpins, rockfishes and flatfishes) found in the stomachs of Steller sea lions suggest that they feed near land or in relatively shallow water (<100 fm, 180 m). • Steller sea lions were seen at distances of 70-85 miles from land by Fiscus and Kenyon in 1960 (Kenyon and Rice 1961).

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Jameson and Kenyon 1977	1973-1976	Rogue River, Oregon	Observations of sea lions feeding at surface (84 observations; number of sea lions unknown)	• Prey consisted of 73 lampreys, 2 salmonids, 9 unidentified.
Gentry and Johnson 1981	1974-1975	St. George Island (Pribilof Islands)	Observations (163 verified observations, number of sea lions unknown)	• Observed sea lions taking 163 fur seal pups. Estimated such predation may result in the mortality of about 3% to 7% of fur seal pups born at St. George Island.
Jones 1981	1968-73	North and Central California	Stomach contents (n = 9)	• Noted 9 stomachs with fish, and 7 with squid and octopus. • Grouped 127 identified fishes from northern sea lions according to schooling (open-water), bottom-dwelling (rocky), and inshore-schooling species (his Table 6), and suggested results indicate that the northern sea lion feeds mainly on bottom-dwelling fishes.

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Pitcher 1981	1975-78	GOA	Stomach contents (*n* = 153)	• Stomach contents were 95.7% fishes by volume, and included 14 species of fish in 11 families. • Gadids comprised 59.7% of total contents and occurred in 82.4% of stomachs with food. • Walleye pollock comprised 58.3% of the total volume and occurred in 66.7% of stomachs with food. • Cephalopods occurred in 36.6% of stomachs with contents but made up only 4.2% of total volume. • Predation on salmon and capelin appeared to be largely limited to spring and summer. • Prey (by combination rank index) included pollock, squids, herring, capelin, cod, salmon, octopus, sculpins, flatfishes, rockfishes. • Herring and squids were extensively used by sea lions in Prince William Sound but appeared to be relatively unimportant in other areas. • Results for sea lions similar to results for harbor seals. • Mean fork length of 2030 pollock otoliths was 29.8 cm (range 5.6 to 62.9 cm, SD = 11.6 cm)

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Calkins and Pitcher 1982 (note redundancy with previous results of Pitcher 1981)	1975-1978	GOA, including northeastern GOA, Prince William Sound, Kenai Coast, Kodiak Island, and the Alaska Peninsula region	Stomach contents (*n* = 153)	• Fishes comprised 72.8%, cephalopods (octopus and Gonatid squids) 21.5%, decapod crustaceans (shrimps, tanner and spider crabs) 4.2%, gastropods (marine snails) 0.8%, and mammals 0.4% of the prey occurrences. • Fishes included minimum of 14 species of 11 families. • Gadids composed nearly half of total occurrences and nearly 60% of total volume. • Harbor seal remains were found in two stomachs (see Pitcher and Fay 1982). • Seven top-ranked prey (in order of modified Index of Relative Importance) were pollock, herring, squids, capelin, salmon, Pacific cod, and sculpins. • Pollock was dominant prey accounting for about 39% of all occurrences and 58% of the total volume. • Pollock was top-ranked prey in all areas except Kodiak, where it was ranked second below capelin. • Herring and squid were used extensively in Prince William Sound, but not in other areas. • Predation on salmon and capelin was largely limited to spring and summer. • Geographic differences in use of salmon and capelin may have been due to sampling at different sites and seasons. • Comparison with previous studies (Imler and Sarber 1947, Mathisen *et al.* 1962, Thorsteinson and Lensink 1962, and Fiscus and Baines 1966) which had more invertebrates, no herring, but included sand lance. Noted differences in sampling for this study (throughout year at wide range of locations) versus earlier studies (near rookeries during breeding season). • Four of the five top-ranked prey were off-bottom schooling species.
Lowry *et al.* 1982	1976	Pribilof Islands	Stomach contents (*n* = 4)	• Prey (in order of frequency of occurrence) included pollock, squids, and single occurrences of octopus, flatfish, lamprey, and prickleback. • Based on otoliths, pollock consumed ranged from 34 cm to 57 cm in length. • Also mentions the following prey items from a preliminary examination of 111 stomach samples collected in the central and western Bering Sea (in no particular order): pollock, cod, Gonatid squids, herring, octopus, and sculpins.

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Frost and Lowry 1986			Stomach contents (*n* = 90; not stated how many had contents)	• Most pollock eaten by sea lions (76%) were 20 cm or longer. • Younger sea lions (#4 yr) collected in 1981 (all were males) ate significantly smaller fish (G = 22.4 cm, *n* = 37) than did older animals (G = 26.9 cm, *n* = 51). • A sea lion collected in 1976 and another collected in 1979 (both near the Pribilofs) had eaten pollock averaging 46.9 cm in length (range 18.4-61.4 cm), while those collected in 1981 to the west had eaten substantially smaller pollock averaging 25.2 cm in length (range 8.3-64.2 cm). • In 1981 sea lions collected in the central Bering Sea had eaten larger pollock than those off the Kamchatka Peninsula (G = 26.8 cm vs. 23.5 cm). • "It is unknown whether the consumption patterns described above are a result of actual size selection of prey or if they result from coincidental distribution of predators and prey size classes." • " . . . the size range of pollock eaten by both young and old sea lions was similar."

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Calkins and Goodwin 1988	1985-1986	GOA and southeast Alaska	Stomach contents (*n* = 88;47 had only trace amounts. Five with measurable contents and nine with trace amounts from southeast; remainder were from Kodiak area and adjacent portions of Alaska Peninsula.)	Southeast • Fishes comprised 98% of volume, mostly Pacific cod (57% of total volume) and pollock (32%). • Most frequently occurring were pollock (57%) and flatfishes (21%). • Only other prey observed were squid and octopus. • Mean fork length of 80 pollock otoliths from 8 sea lions in southeast was 25.5 cm (range 4.8 to 55.7 cm, SD = 10.4 cm) Kodiak area • Most important by volume were pollock (42%), octopus (26%), and flatfish (25%). • Most frequently occurring were pollock (58%) and octopus (32%). • Other prey (in no particular order) were other fishes, squid, decapod crustaceans, and clams. • Prey rank (based on combined rank index [Pitcher 1981]) in Kodiak area were pollock, octopus, flatfishes, sand lance, Pacific cod, and salmon. • Mean fork length of 1064 otoliths from 43 sea lions in Kodiak area was 25.4 cm (range 7.9 to 54.2 cm, SD = 12.4 cm). • Pollock was the most important prey item in both 1975-1978 collection (39% by frequency of occurrence in Kodiak area) and 1985-1986 collection (58%). • Capelin was most important in Kodiak area in 1975-1978. However, they suggest difference in capelin may be due to seasonal differences when animals collected (spring-summer 1975-1978 versus spring-autumn/early winter 1985-1986). Thus, comparisons may be compromised by potential seasonal bias. • Octopus ranked second in 1985-1986 collection near Kodiak, but fifth in 1975-1978. However, they suggest difference may be due to collection site. Thus comparisons may be compromised by potential location bias. • Sand lance occurred in 26% of sea lions from GOA in 1960s (Mathisen *et al.* 1962, Thorsteinson and Lensink 1962, Fiscus and Baines 1966), were not found in 1975-1978 sample, but were fourth in 1985-1986 sample.

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Byrnes and Hood 1994	1992	Año Nuevo, California	One observation	• Observed a territorial male Steller sea lion attack, kill, and consume what appeared to be a yearling California sea lion.
Merrick and Calkins 1996 (note redundancy with Pitcher 1981, Calkins and Pitcher 1982, and Calkins and Goodwin 1988)	1975-1978, 1985-1986	GOA	Stomach contents, (*n* = 178 in 1975-1978 and *n* = 85 in 1985-1986)	• Prey consumption was based on frequency of occurrence. • Most stomachs contained prey of only one kind. • Pollock were the most common prey of juvenile (#4 years old) and adult sea lions in virtually all seasons and areas during these two periods. • Juvenile pollock were a major part of the diet in both periods. • Juvenile sea lions ate smaller and relatively more juvenile pollock. • Small forage fish were consumed on a seasonal basis. • Temporal comparisons were possible only in the Kodiak region. • The proportion of sea lions eating pollock increased from 49% in 1975-1978 to 69% in 1985-1986 in the Kodiak area. • Small forage fish were the second most common prey in the 1970s, and flatfish were second in the 1980s. • Of the fish consumed, 73% were < 30 cm, but they accounted for only 26.8% of the biomass consumed. • Half (50.7%) of the pollock mass consumed by juvenile sea lions came from fish <30 cm, while only 21% of the pollock mass consumed by adult sea lions came from juvenile pollock. • Seasonal differences were observed in the consumption of all prey taxa, but differences were not found in 1980s. • Between 1970s and 1980s, the portion consuming pollock and cephalopods increased significantly and the portion consuming small forage fish and other demersal fish decreased. • The increase in pollock consumed was only evident in summer months (all ages combined), but was evident in all seasons for juveniles. • (Note that sampling was not consistent with respect to seasons or specific locations between the two sampling periods, which weakens the basis for comparisons.)

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Merrick *et al.* 1997	1990-93 (summer - last week June, first week July, or first week August)	Kodiak to Agattu and Alaid - 37 collections at 19 rookeries and 3 haulouts	Scat analysis and population trends. No. scats analyzed = 338. Suggests most scats from adult females. Prey pooled into seven categories, rookeries and haulouts pooled into six areas. Report on 40 and 52 scats from Bogoslof and Ugamak (1985-89 and 1990-93, respectively), and compared with stomach contents in Kodiak area for 1976-78 (20) and 1985-89 (28), and 54 scats in 1990-93.	• Scats contained at least 13 species. • Atka mackerel most common prey category (62%), gadids second (43%), salmon (20%) third, cephalopods (12%) fourth, small schooling fish (9%) fifth, then other demersal fish (7%) and flatfish (3%). • Pollock occurred in 29% of the scats and unidentified gadids (which the authors suggest were probably pollock) in 28%. • Pollock dominated in the GOA, was approximately equal in the eastern Aleutian Islands and the area they designated as central Aleutian Islands 1, and Atka mackerel dominated further west. • Salmon, small schooling fish, and flatfish were found more commonly in the eastern areas. • Diet diversity tended to be greater east to west and was correlated with rate of population change. • "The high correlation between area-specific diet diversity and population changes supports the hypothesis that diet is linked with the Steller sea lion population decline in Alaska." • If diet diversity (as measured in this study) is related to population trends, and the indices of diet are based on adult female foraging patterns, these results would indicate that juvenile survival is not the only vital rate being affected. • Emphasizes the importance of secondary prey.

Table 5. (cont.)

Study	Years	Location	Methods	Main findings
Merrick and Loughlin 1997	1990-1993	GOA to eastern Aleutian Islands	Very High Frequency radio transmitters (*n* = 10 adult females instrumented in June-July); Satellite-linked time-depth recorders (*n* = 5 adult females instrumented in June-July, *n* = 5 adult females instrumented in November-March, and *n* = 5 young-of-the-year instrumented in November-March).	• Mean trip duration for adult females instrumented (either radio transmitter or satellite-linked time-depth recorder) on the order of 18 to 25 hours, with time on shore on the order of 18 to 19 hours, so slightly more than half of the females' cycles were spent at sea. • Mean trip duration for adult females instrumented (satellite-linked time-depth recorder) in winter was 204 hours, but time on shore was approximately the same as for summer adult females. Adult females in winter spent approximately 90% of their time at sea. • Young-of-the-year animals spent a mean time of 15 hours at sea and 25 hours on land, therefore spending about 37% of their time at sea. • Summer adult females dove about 17 times per hour, winter adult females about 12 times per hour, and young-of-the-year about 12-13 times per hour. All groups dove most frequently in the late afternoon and night. • Maximum dive depths for summer adult females was between 150 m and 250 m, for winter adult females was > 250 m, and for young-of-the-year was 72 m. • Mean number of diving hours per day was 4.7 for summer adult females, 5.3 for winter adult females, and 1.9 for young-of-the-year. • Mean trip distance for summer adult females was 17.1 km, winter adult females 133 km, and young-of-the-year 31 km (but were skewed by one trip by a young-of-the-year of 320 km). • Two of the winter adult females foraged in a manner that suggested they still were nursing pups. These females relatively dove 8.1 hours per day, made short trips (mean 53 km over 18 hours), and returned to the same or nearby haulout at the end of each trip. The remaining three winter adult females was 3.5 hours per day and spent up to 24 days at sea before returning to land. • In general, winter adult females spent more time at sea, dove deeper, and had greater home ranges than summer adult females.

Table 6. Counts of adult and juvenile (non-pup) Steller sea lions at rookery and haulout trend sites by region (NMFS unpubl., Sease and Loughlin 1999). For the GOA, the eastern sector includes rookeries from Seal Rocks in Prince William Sound to Outer Island; the central sector extends from Sugarloaf and Marmot Islands to Chowiet Island; and the western sector extends from Atkins Island to Clubbing Rocks. For the Aleutian Islands, the eastern sector includes rookeries from Sea Lion Rock (near Amak Island) to Adugak Island; the central sector extends from Yunaska Island to Kiska Island; and the western sector extends from Buldir Island to Attu Island.

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

Table 7. Occurrence of Pacific cod in Steller sea lion scats collected in 1995 through 1998 (NMFS unpubl. data).

	Central GOA	Western GOA	Aleutian Islands	Combined
Summer				
Sample size	130	97	660	887
% Frequency of occurrence	**5**	**6**	**6**	**6**
% 35-60 cm	67	100	83	83
% 28-34 cm	0	0	10	8
% <28 cm	34	0	6	8
Winter				
Sample size	201	437	726	1364
% Frequency of occurrence	**40**	**40**	**20**	**30**
% 35-60 cm	65	74	85	76
% 28-34 cm	28	16	9	16
% <28 cm	13	10	7	8

Table 8. Spatial distribution of cod catch by quarter in the GOA and the BSAI.

GOA		Critical habitat							
1997 Quarter	Within RFRPA sites	Rookeries and major haulouts	Foraging area	Outside critical habitat	Total GOA	Total critical habitat	Percent within RFRPA sites	Percent within critical habitat	Percent by quarter
1	11,561	41,212	54	17,174	58,440	41,266	20	71	85
2	309	708	310	804	1,822	1,018	17	56	3
3	478	780	136	972	1,888	916	25	49	3
4	625	2,313	205	3,780	6,298	2,517	10	40	9
Total	12,973	45,013	704	22,731	68,447	45,717	19	67	

GOA		Critical habitat							
1998 Quarter	Within RFRPA sites	Rookeries and major haulouts	Foraging area	Outside critical habitat	Total GOA	Total critical habitat	Percent within RFRPA sites	Percent within critical habitat	Percent by quarter
1	5,837	32,467	1,832	18,077	52,376	34,299	11	65	84
2	397	1,290	26	1,341	2,657	1,315	15	50	4
3	187	449	194	3,153	3,795	643	5	17	6
4	225	1,105	84	2,089	3,277	1,188	7	36	5
Total	6,647	35,310	2,136	24,660	62,105	37,445	11	60	

Table 8. cont.

BSAI		Critical habitat							
1997 Quarter	Within RFRPA sites	Rookeries and major haulouts	Foraging area	Outside critical habitat	Total BSAI	Total critical habitat	Percent within RFRPA sites	Percent within critical habitat	Percent by quarter
1	21,369	24,852	45,993	53,451	124,296	70,845	17	57	48
2	23,561	17,502	25,240	26,574	69,316	42,742	34	62	27
3	1,172	1,465	1,486	13,718	16,669	2,951	7	18	6
4	3,598	4,700	5,319	37,201	47,220	10,019	8	21	18
Total	49,700	48,518	78,039	130,943	257,500	126,557	19	49	

BSAI		Critical habitat							
1998 Quarter	Within RFRPA sites	Rookeries and major haulouts	Foraging area	Outside critical habitat	Total BSAI	Total critical habitat	Percent within RFRPA sites	Percent within critical habitat	Percent by quarter
1	14,935	26,475	26,856	44,729	98,060	53,331	15	54	50
2	11,963	13,632	12,447	15,689	41,768	26,080	29	62	21
3	863	1,895	1,932	10,477	14,304	3,827	6	27	7
4	1,729	8,087	6,417	26,491	40,995	14,504	4	35	21
Total	29,490	50,090	47,652	97,385	195,127	97,742	15	50	

Figure 1. Bering Sea and Aleutian Islands statistical and reporting areas.

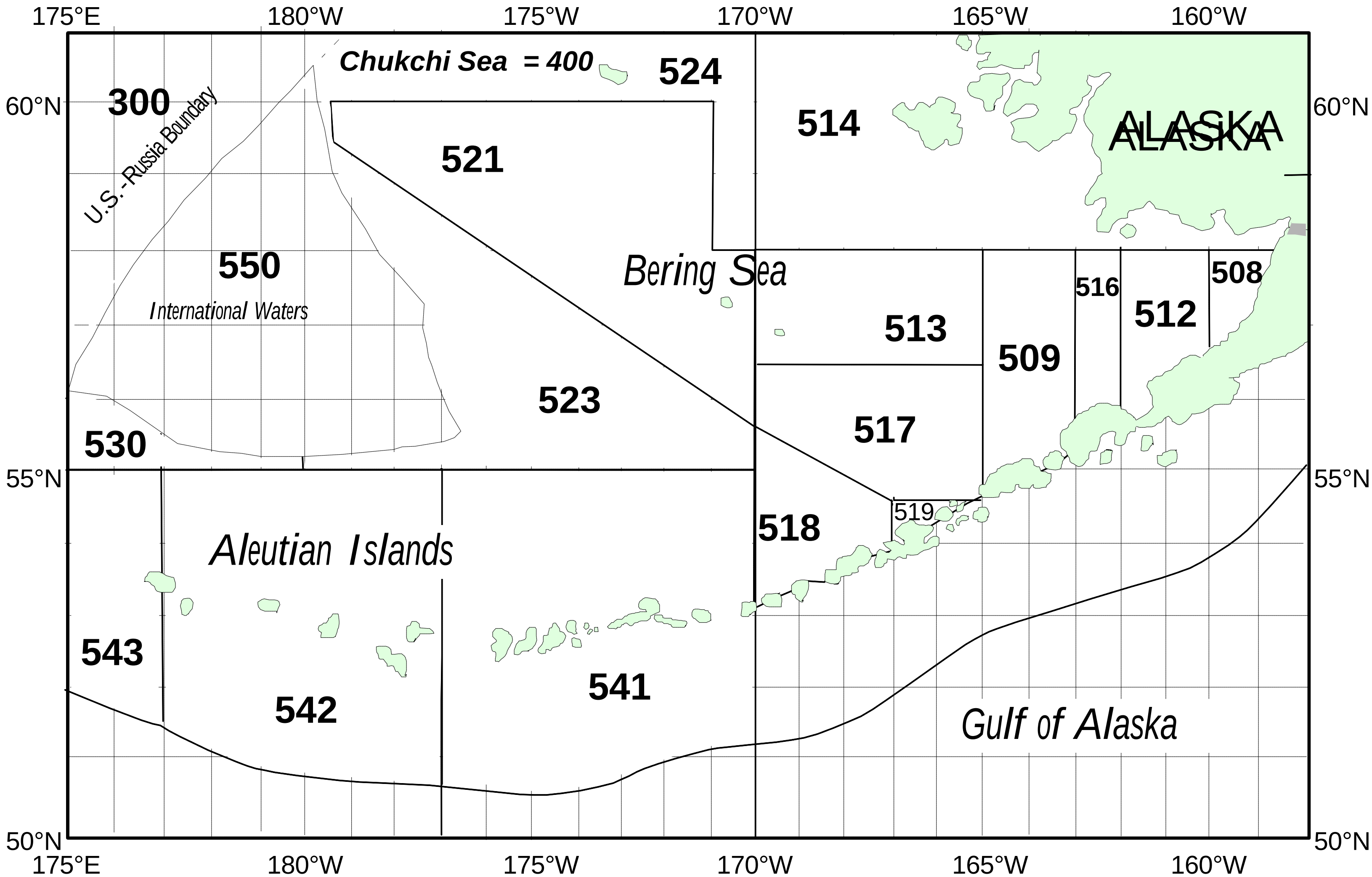


Figure 1 to Part 679. Bering Sea and Aleutian Islands statistical and reporting areas

a. Map

Figure 2. Gulf of Alaska statistical and reporting areas.

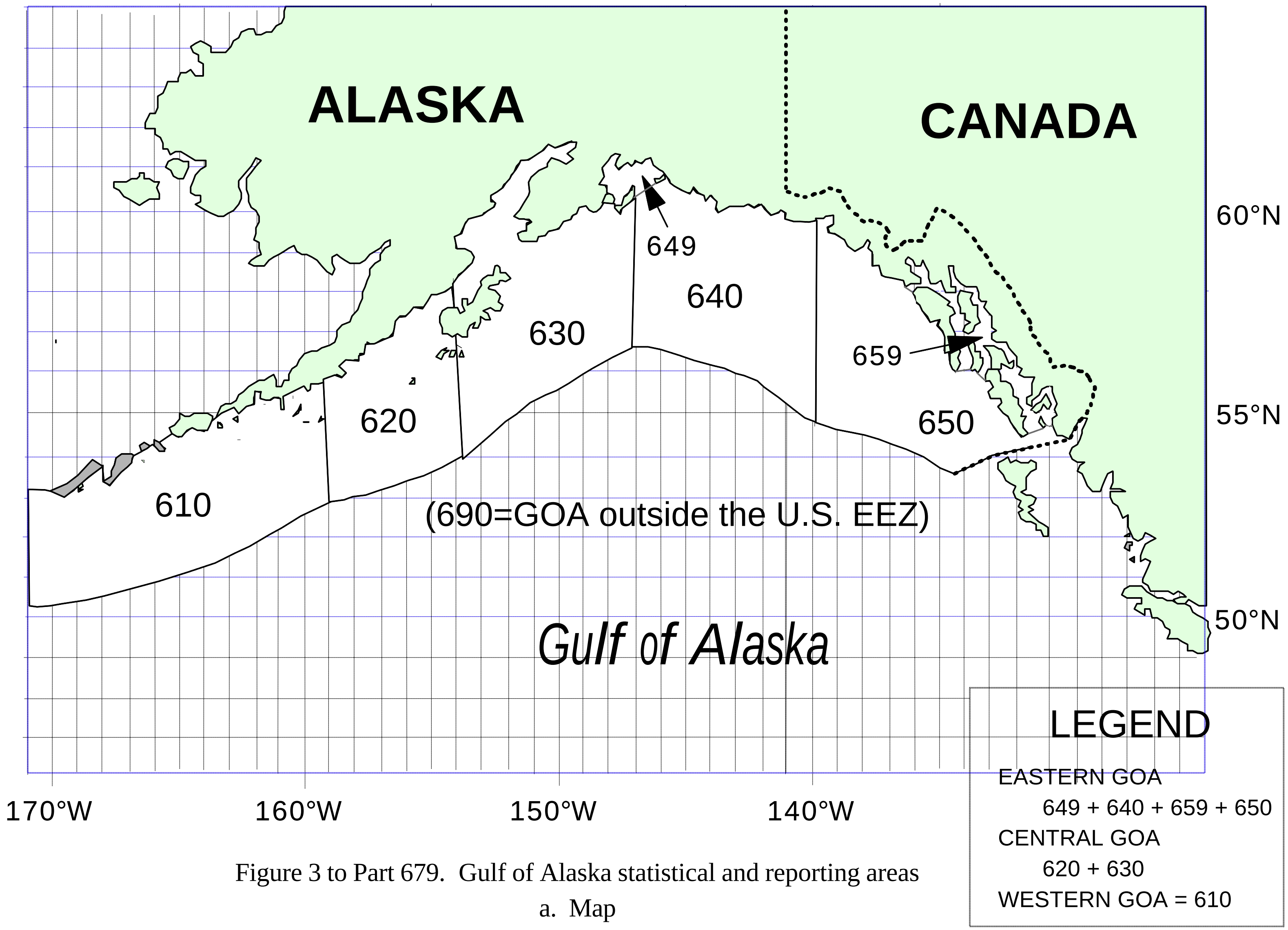
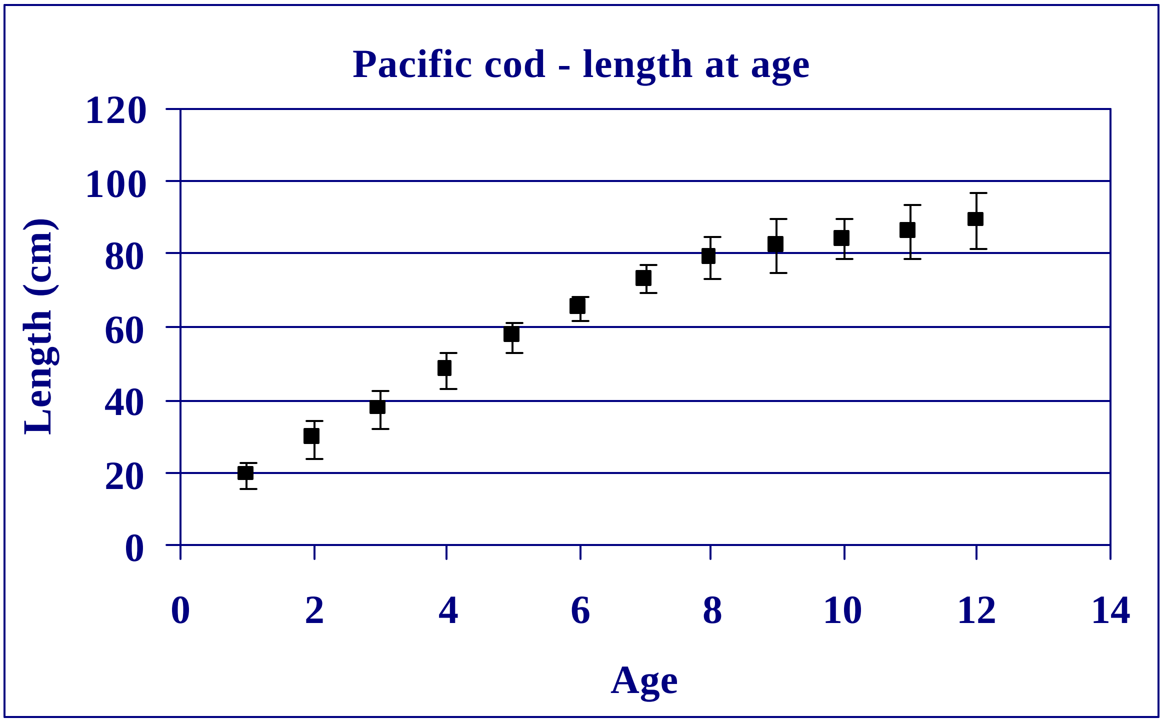


Figure 3 to Part 679. Gulf of Alaska statistical and reporting areas

a. Map



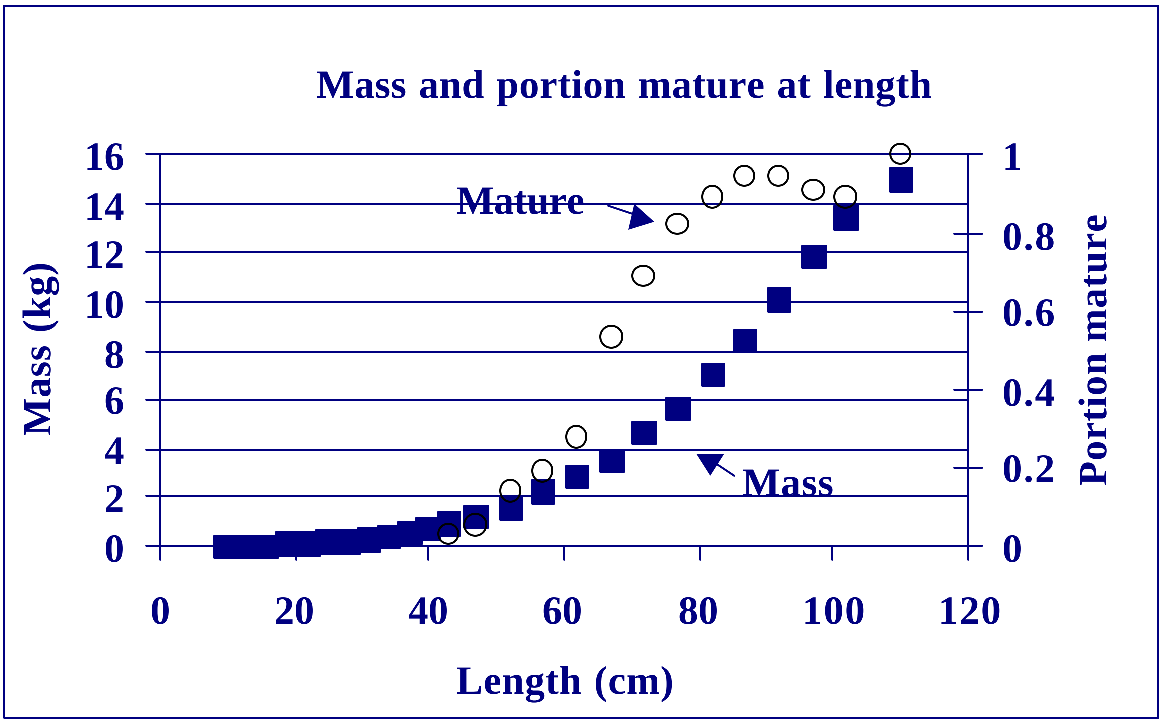


Figure 3. (Top) Growth of Pacific cod in mean length as a function of age. (Bottom) Mean mass of cod as a function of age, and portion mature as a function of age. Based on data from Thompson and Dorn (1999).

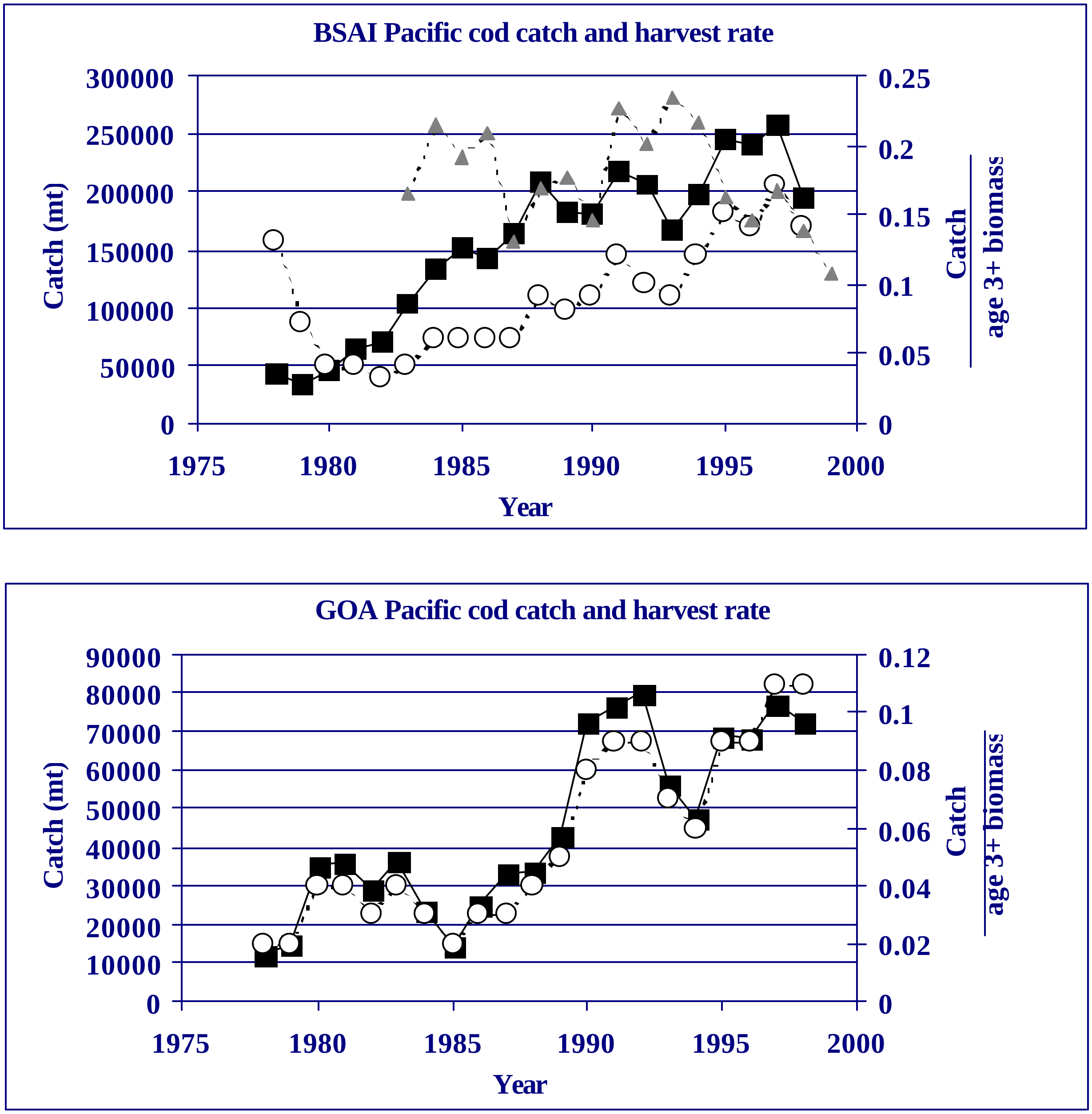


Figure 4. Pacific cod catch (filled squares) and harvest rates (hollow circles) in the BSAI (top) and GOA (bottom) from 1978 to 1998. In the top panel, the gray-shaded triangles (and dashed line) indicate the expected harvest rates at the time each annual TAC was set. The difference between the expected and observed harvest rates results from back correction of the estimated age 3+ biomass, based on more recent data and modeling.

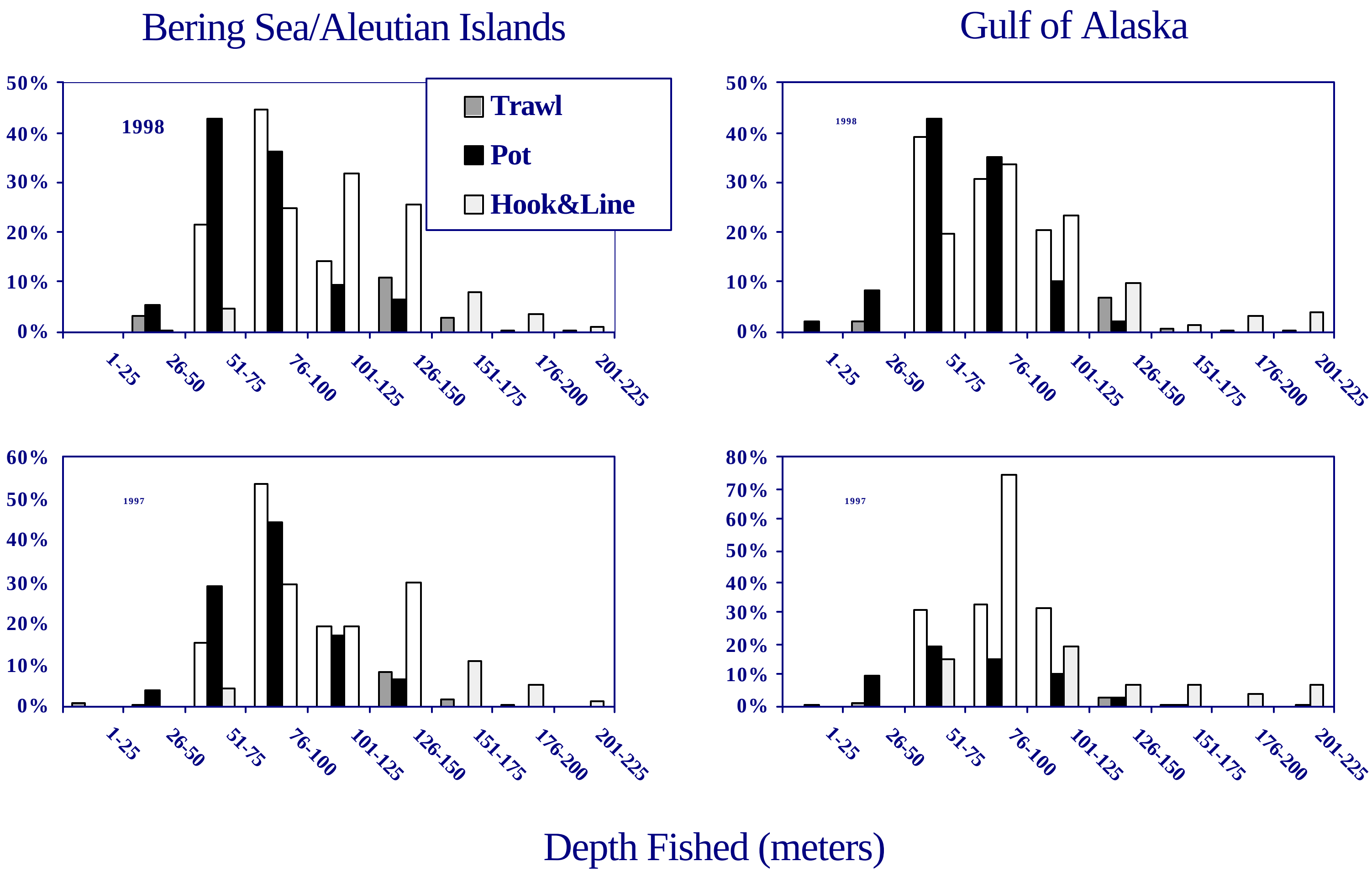


Figure 5. Depths of cod fishing by gear type in the BSAI and GOA.

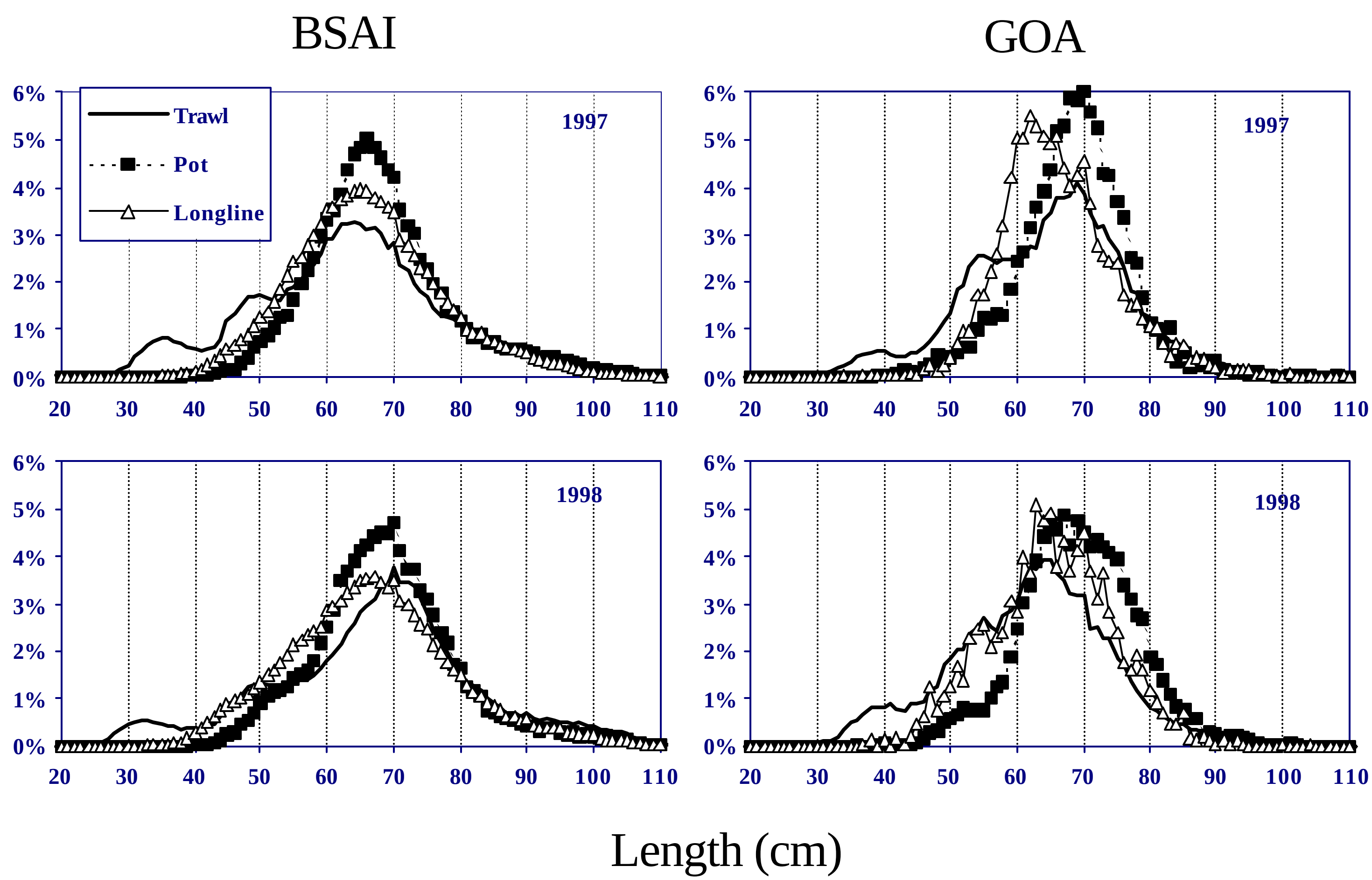


Figure 6. Size distributions of cod taken in the BSAI and GOA in 1997 (top) and 1998 (bottom) by gear type.

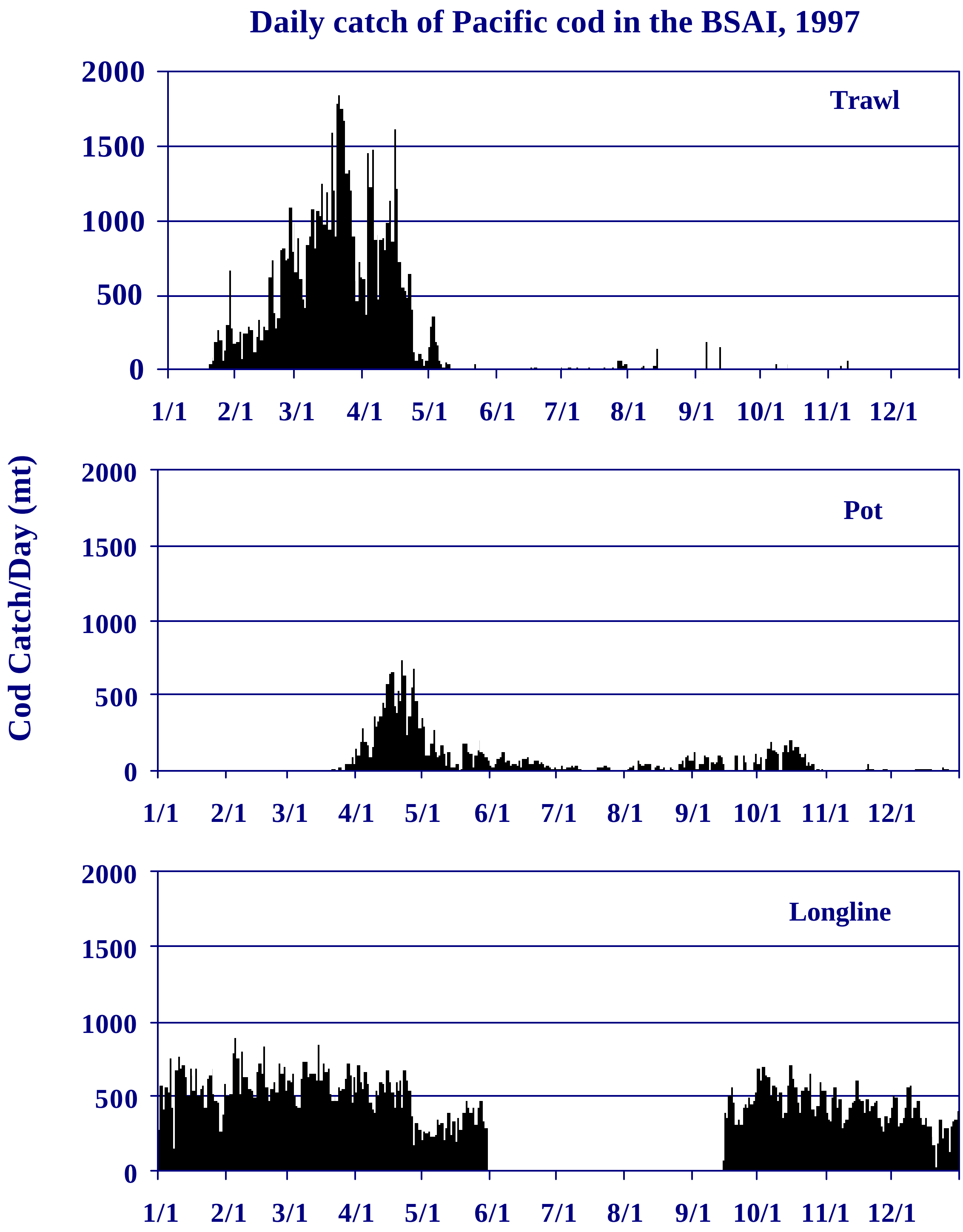


Figure 7a. Daily catch of Pacific cod in the BSAI in 1997.

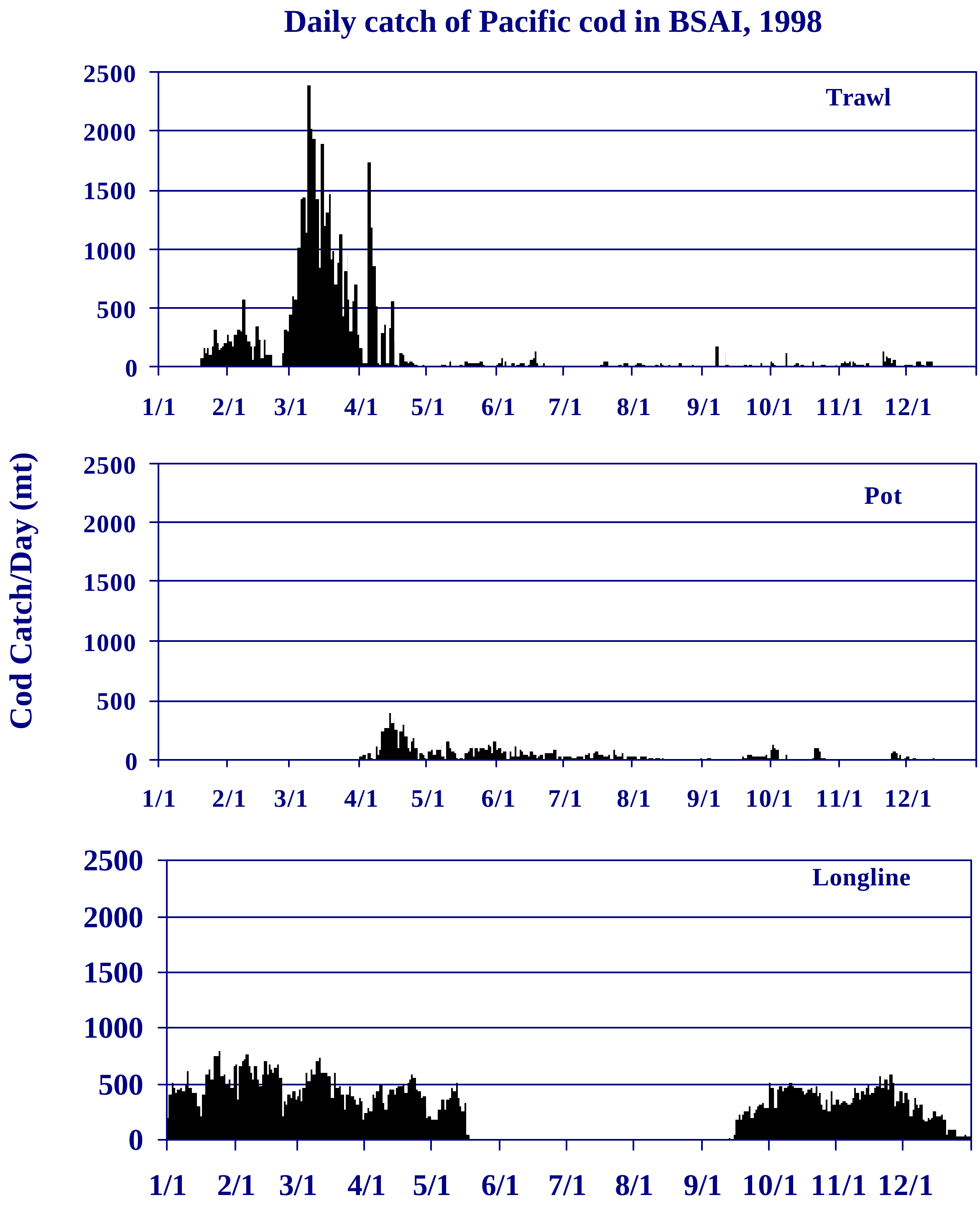


Figure 7b. Daily catch of Pacific cod in the BSAI in 1998.

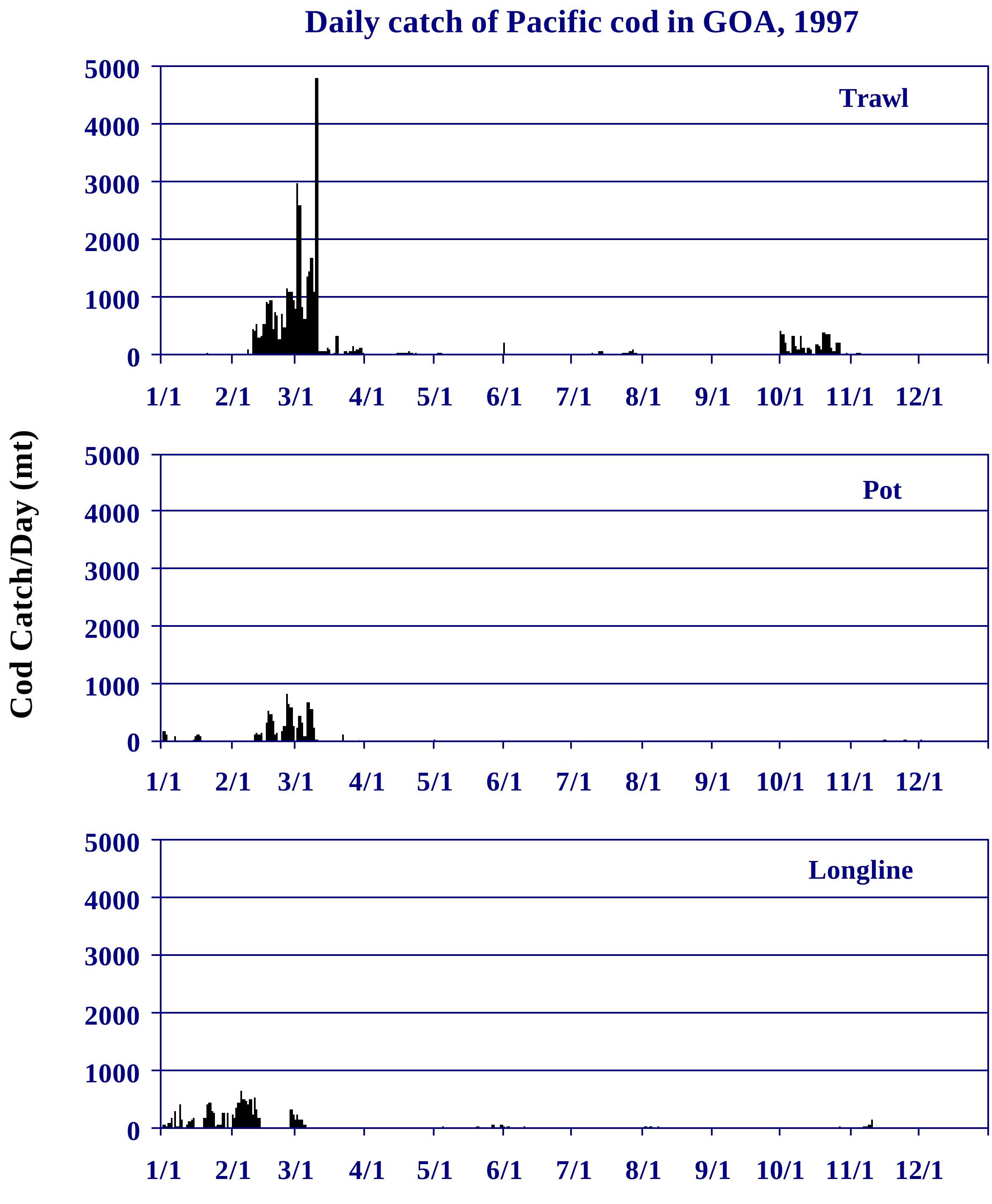


Figure 7c. Daily catch of Pacific cod in the GOA in 1997.

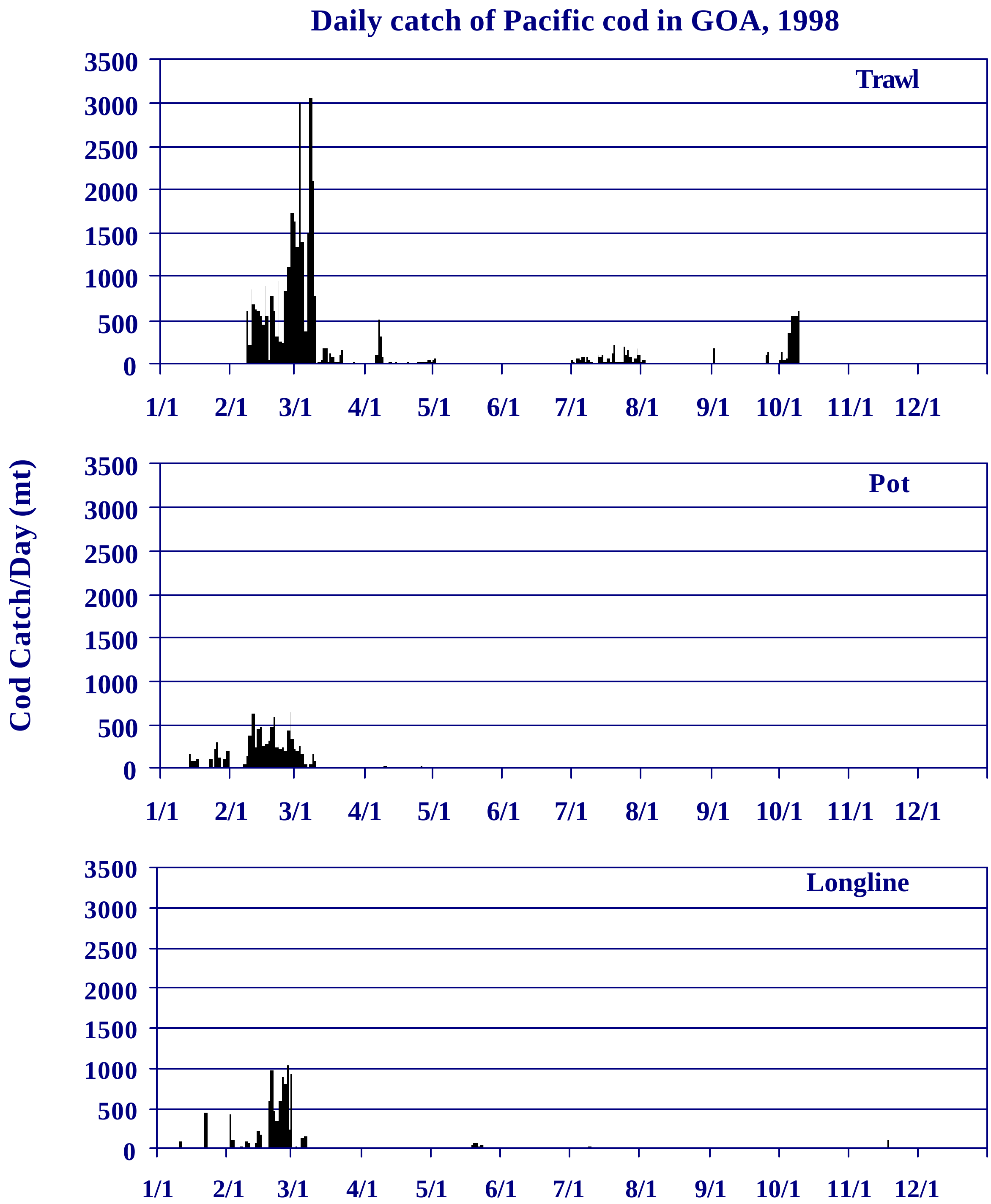


Figure 7d. Daily catch of Pacific cod in the GOA in 1998.

Figure 8a. Observed Pacific cod trawl fishing locations, BSAI and GOA in 1997.

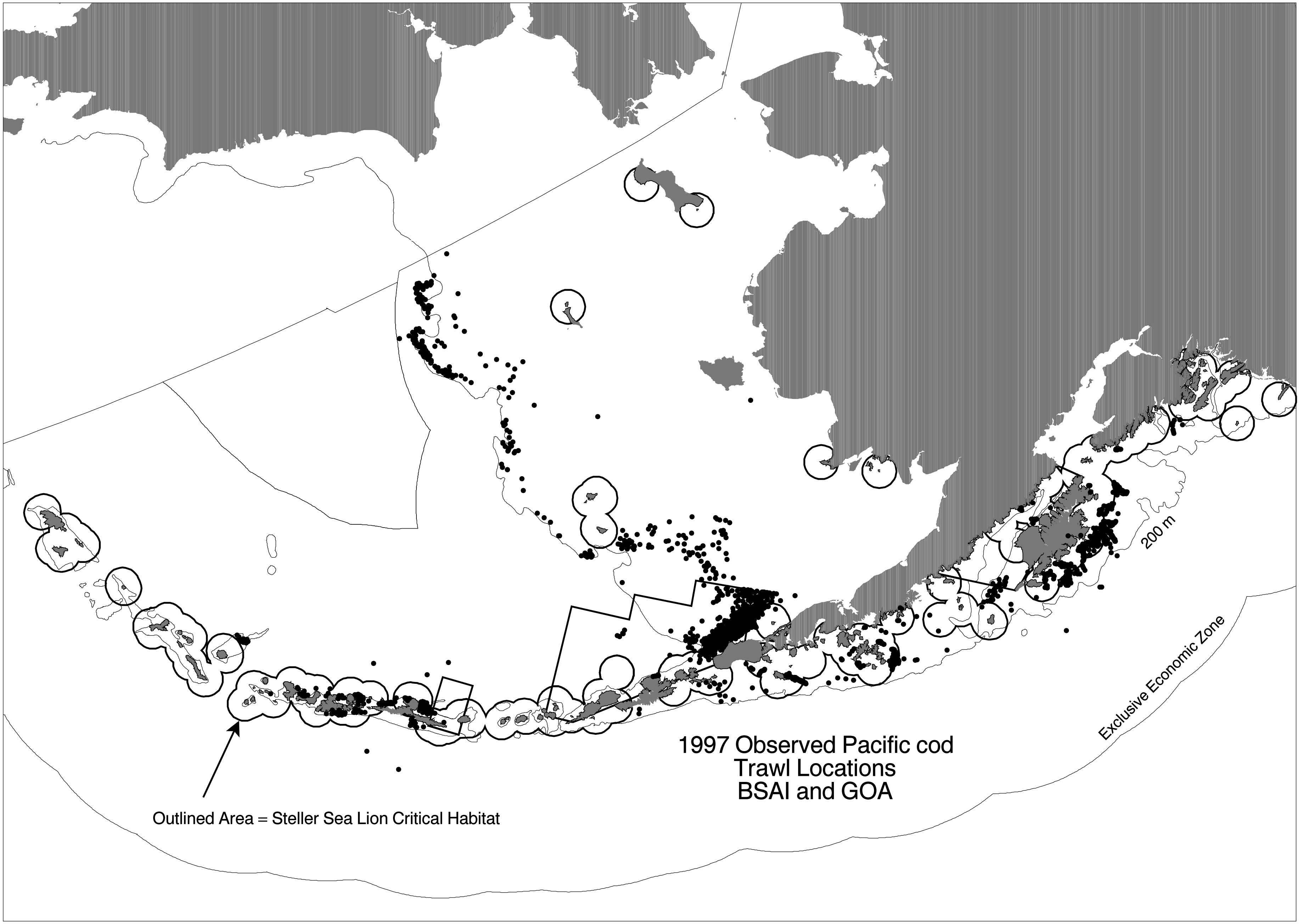
Figure 8b. Observed Pacific cod pot fishing locations, BSAI and GOA in 1997.

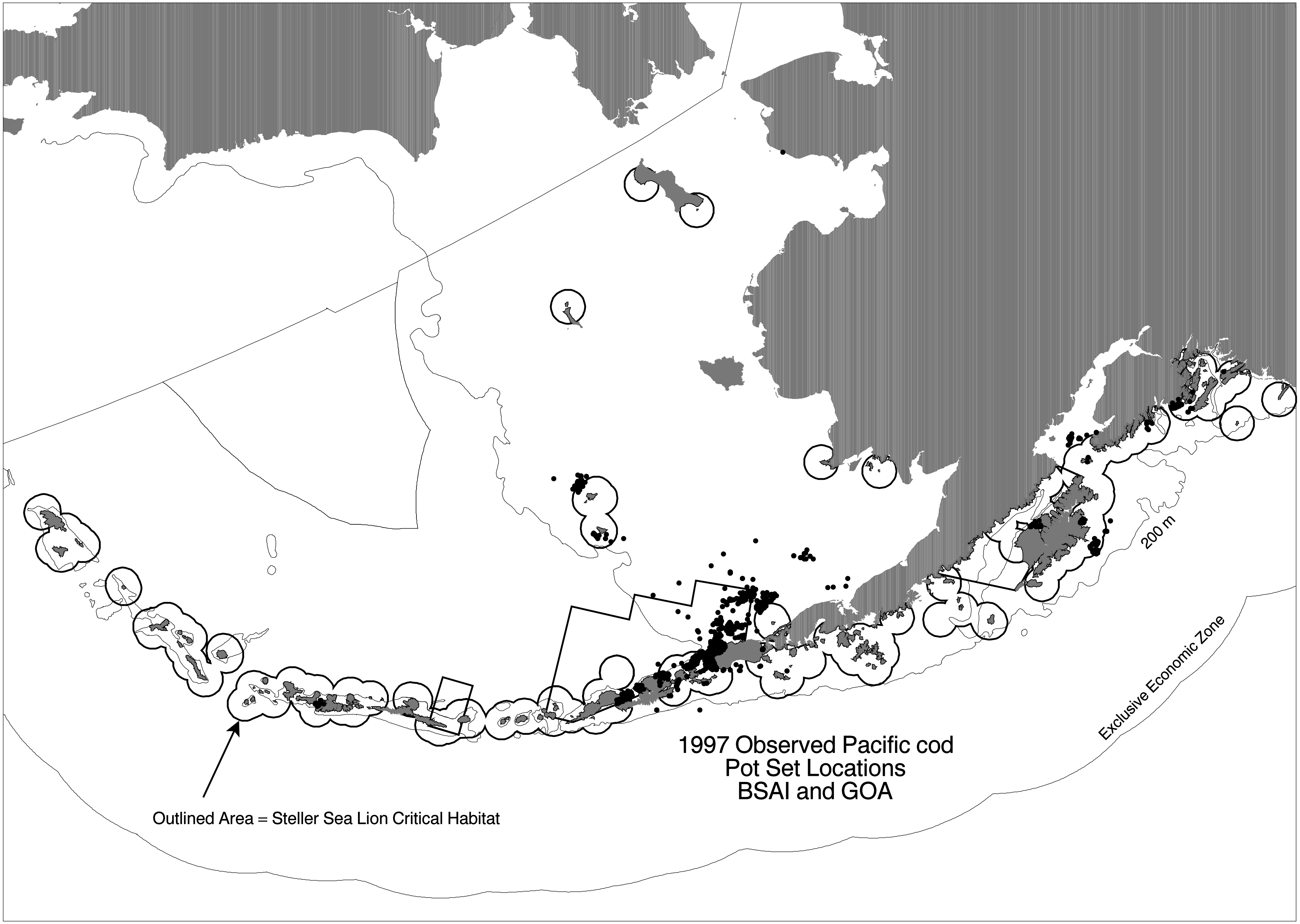
Figure 8c. Observed Pacific cod longline fishing locations, BSAI and GOA in 1997.

Figure 8d. Observed Pacific cod trawl fishing locations, BSAI and GOA in 1998.

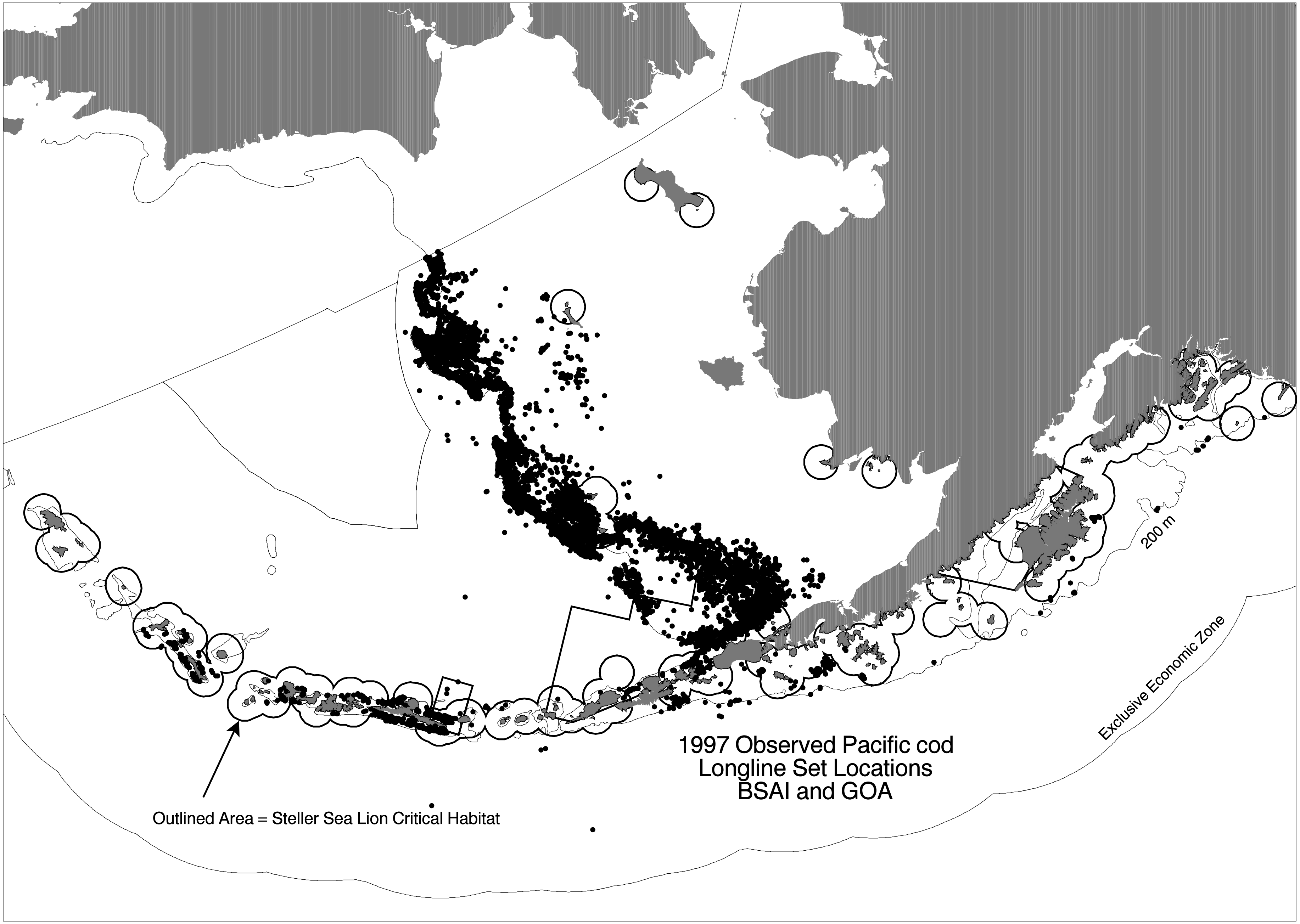
Figure 8e. Observed Pacific cod pot fishing locations, BSAI and GOA in 1998.

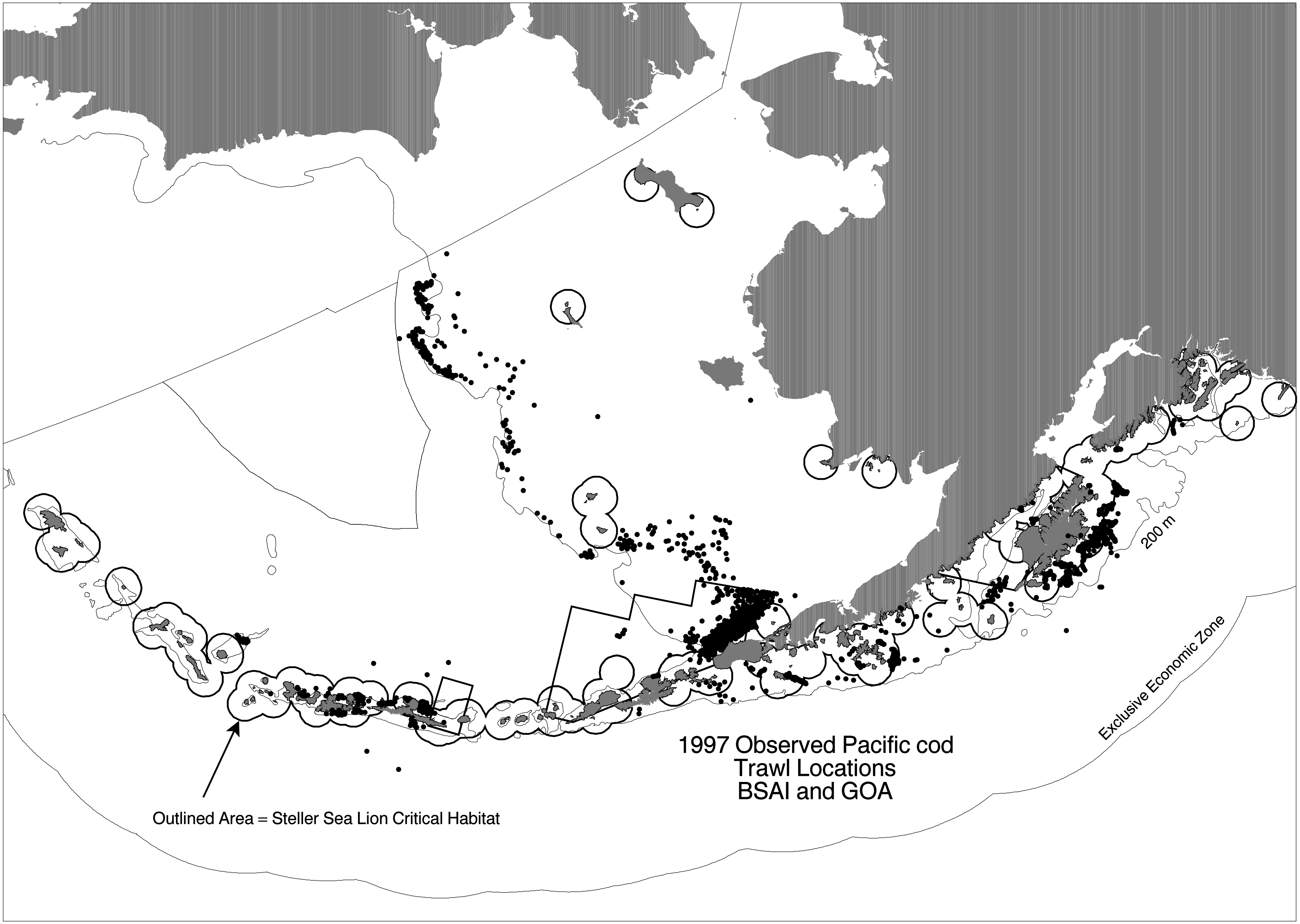
Figure 8f. Observed Pacific cod longline fishing locations, BSAI and GOA in 1998.


200 m
Exclusive Economic Zone
1997 Observed Pacific cod
Trawl Locations
BSAI and GOA
Outlined Area = Steller Sea Lion Critical Habitat

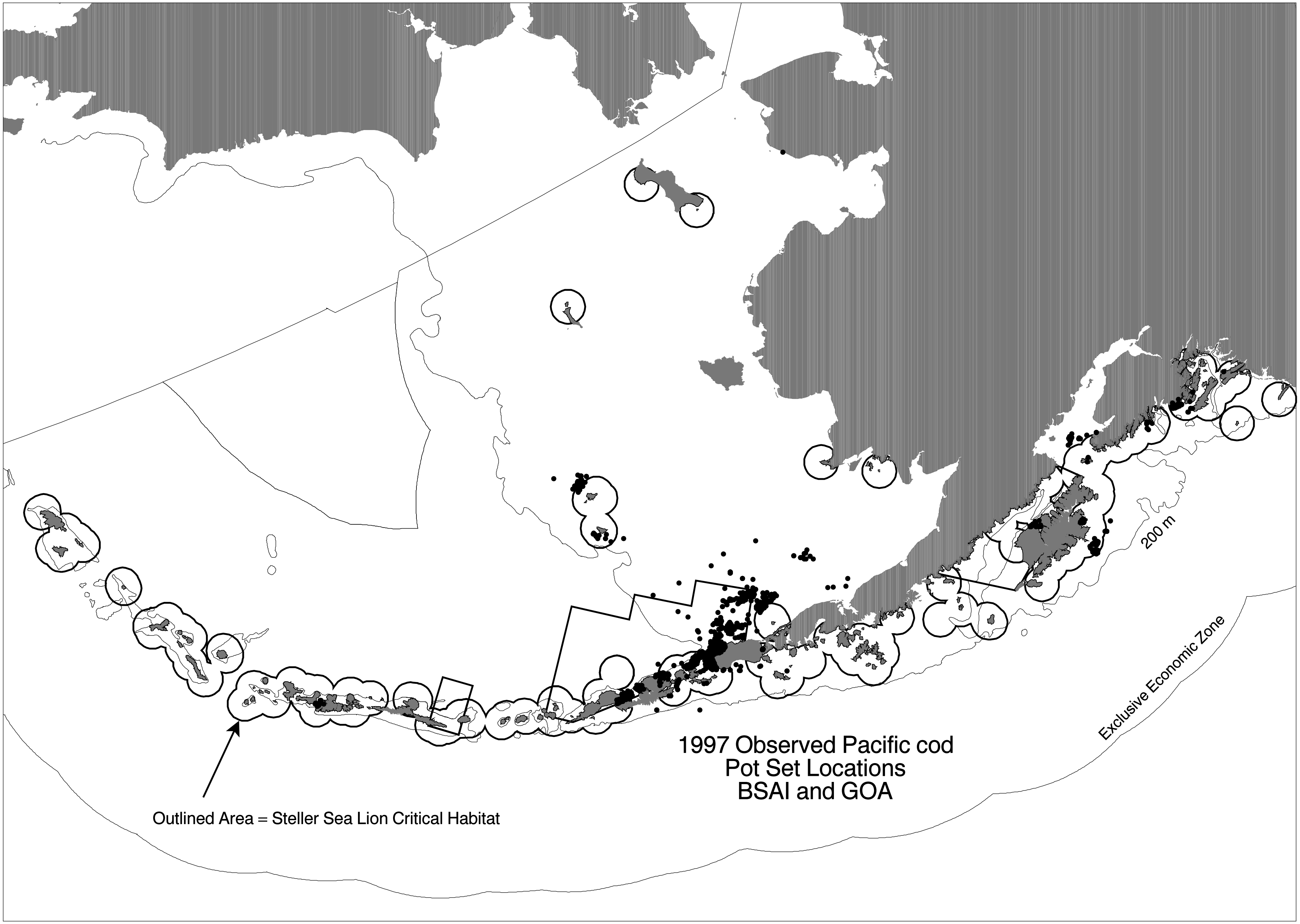


1997 Observed Pacific cod
Pot Set Locations
BSAI and GOA

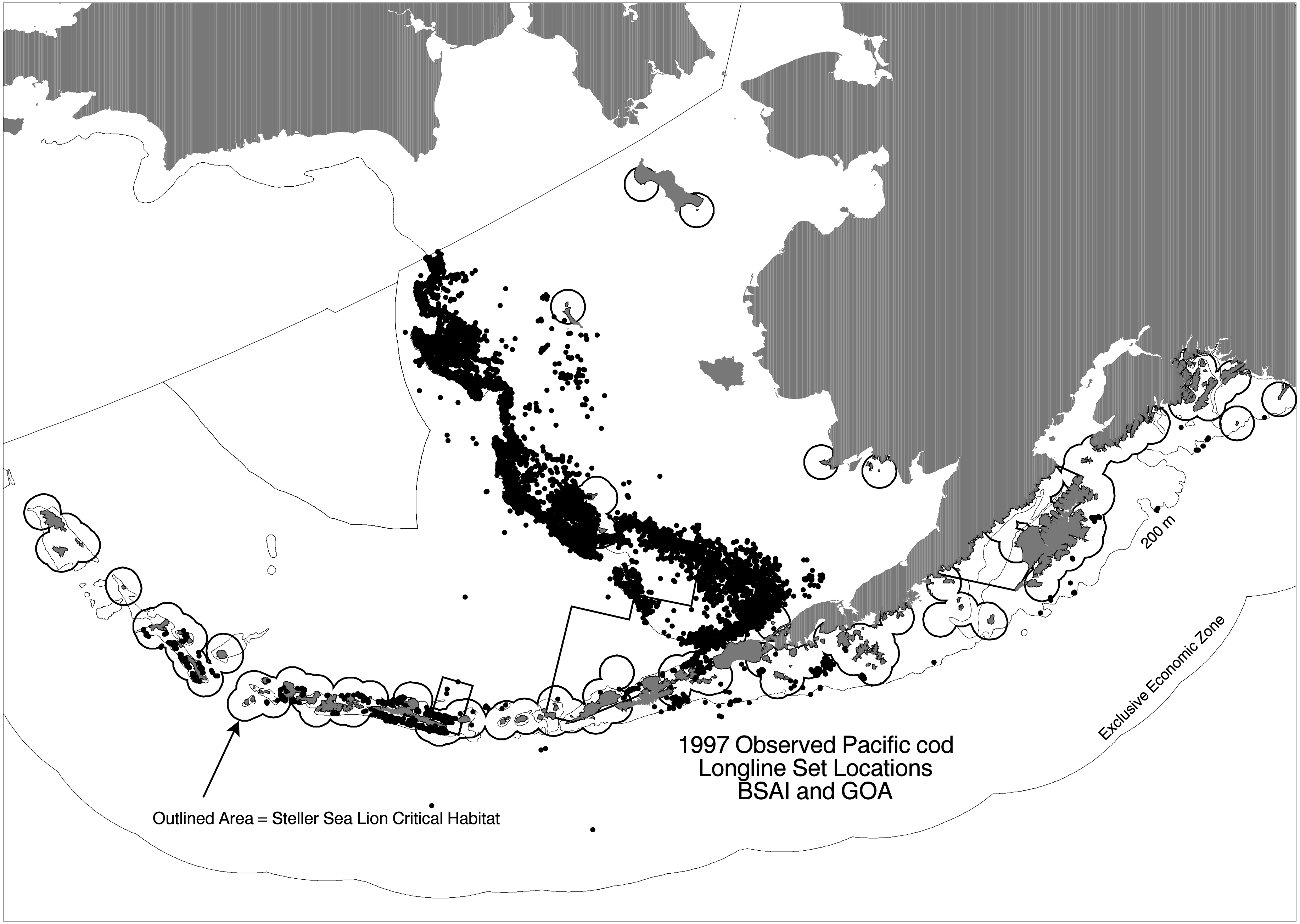

200 m
Exclusive Economic Zone
1997 Observed Pacific cod
Longline Set Locations
BSAI and GOA
Outlined Area = Steller Sea Lion Critical Habitat



1997 Observed Pacific cod
Trawl Locations
BSAI and GOA



1997 Observed Pacific cod
Pot Set Locations
BSAI and GOA


200 m
Exclusive Economic Zone
1997 Observed Pacific cod
Longline Set Locations
BSAI and GOA
Outlined Area = Steller Sea Lion Critical Habitat

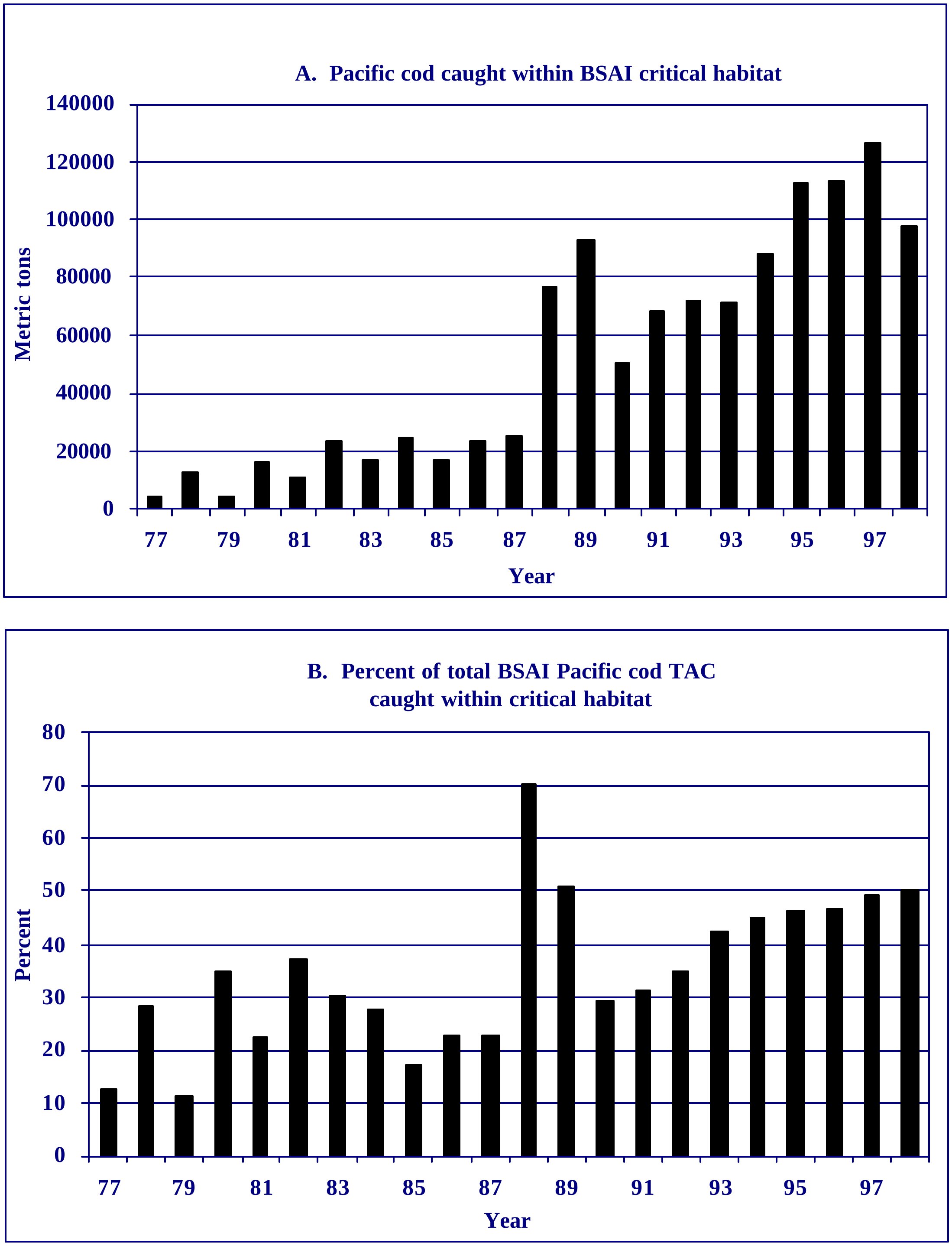
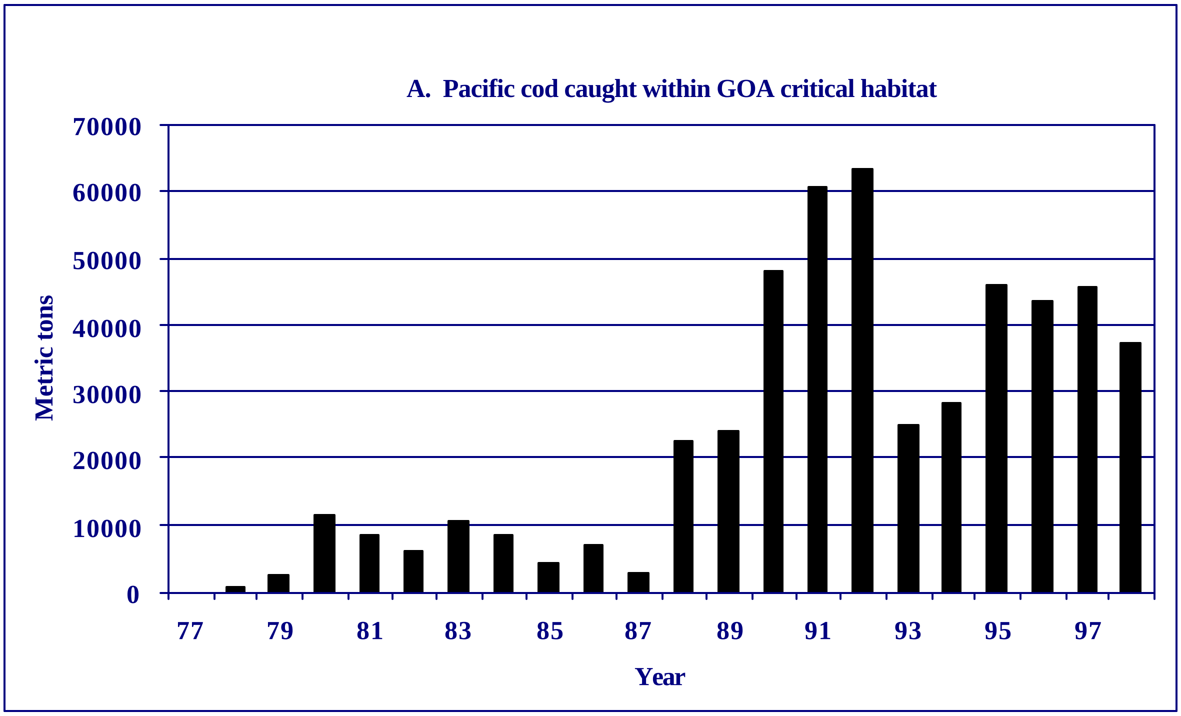


Figure 9. Metric tons of Pacific cod caught within BSAI Steller sea lion critical 1977-98 (top), and percent of annual catch taken within critical habitat (bottom).



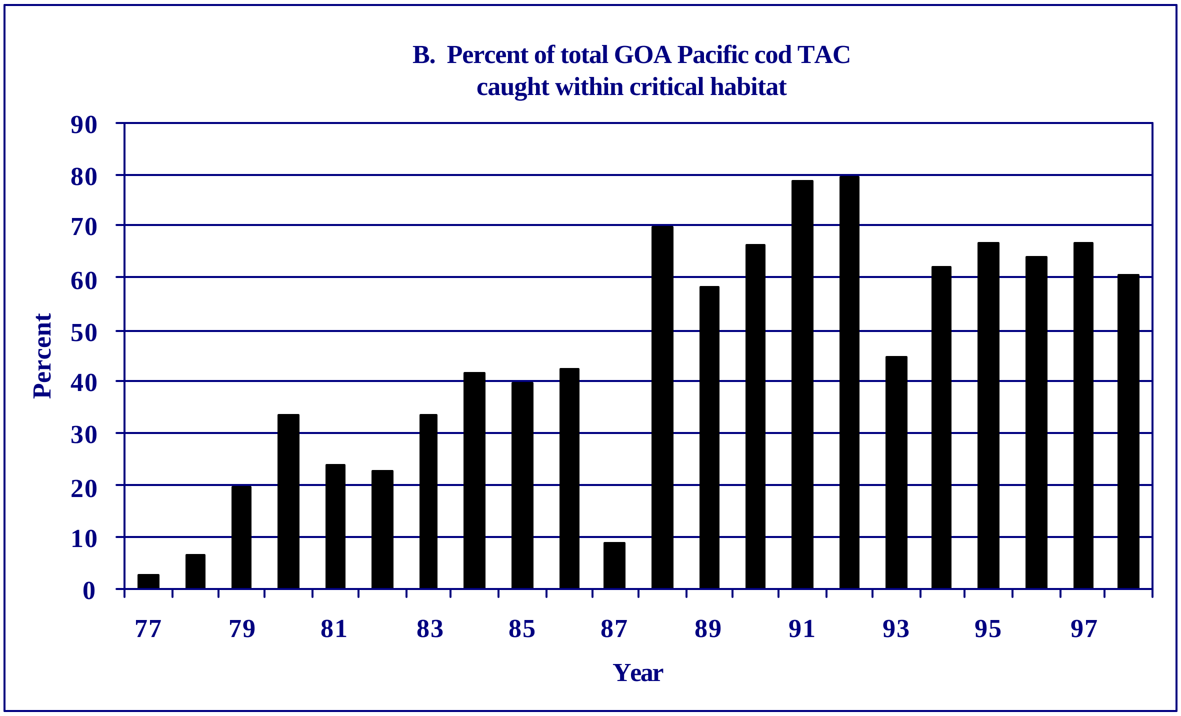


Figure 10. Metric tons of Pacific cod caught within GOA Steller sea lion critical 1977-98 (top), and percent of annual catch taken within critical habitat (bottom).

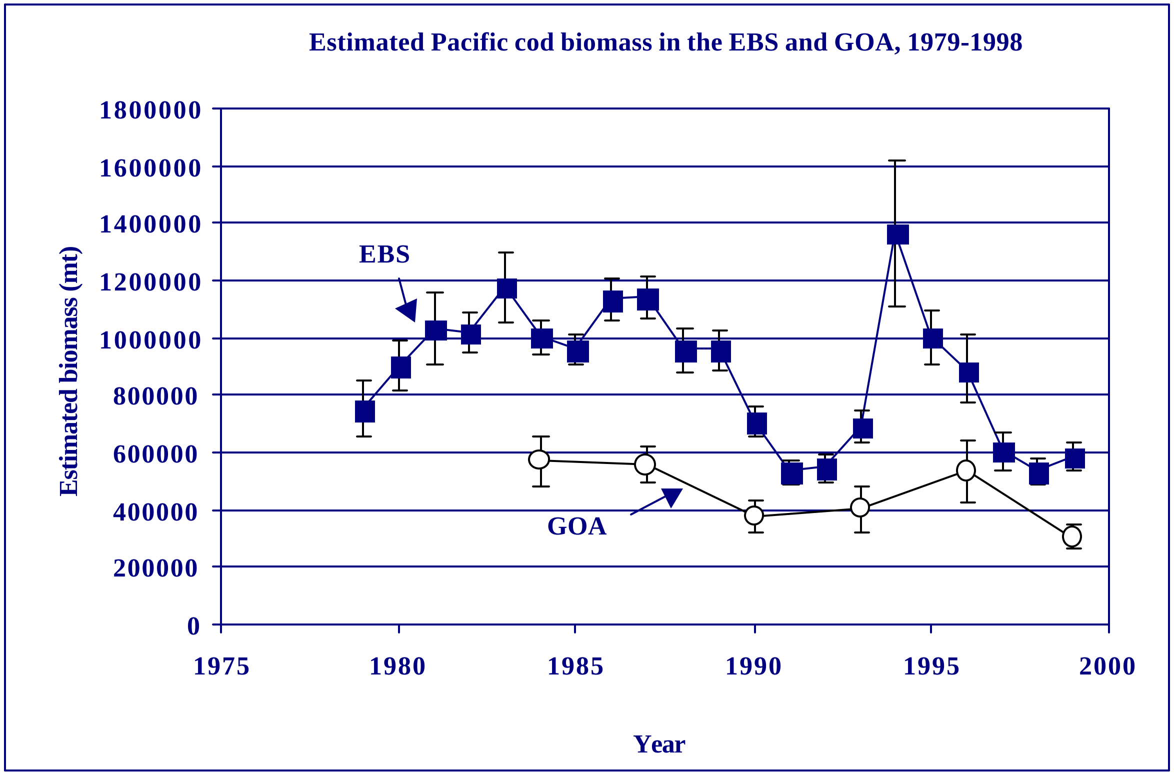


Figure 11. Estimated biomass of Pacific cod (±1 SE) in the EBS and GOA, 1979-1999.

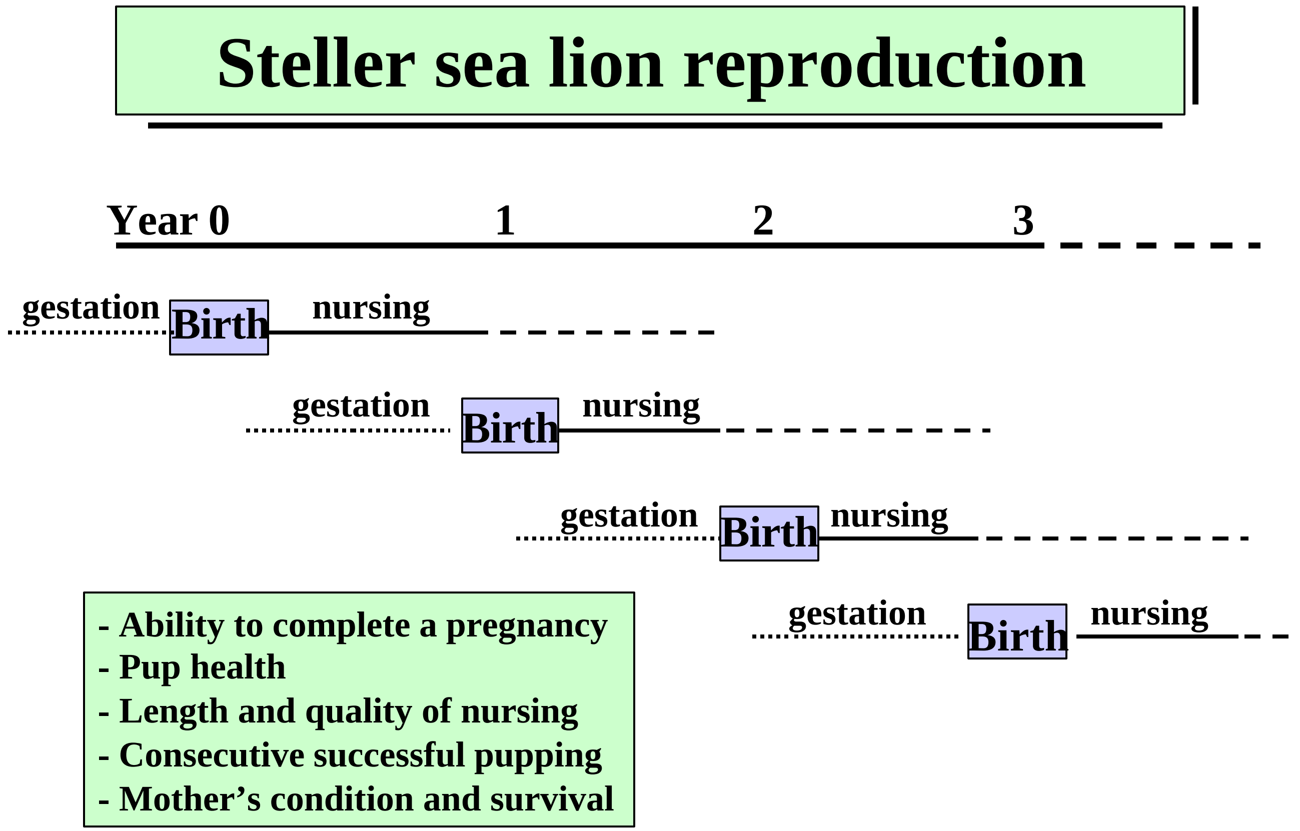
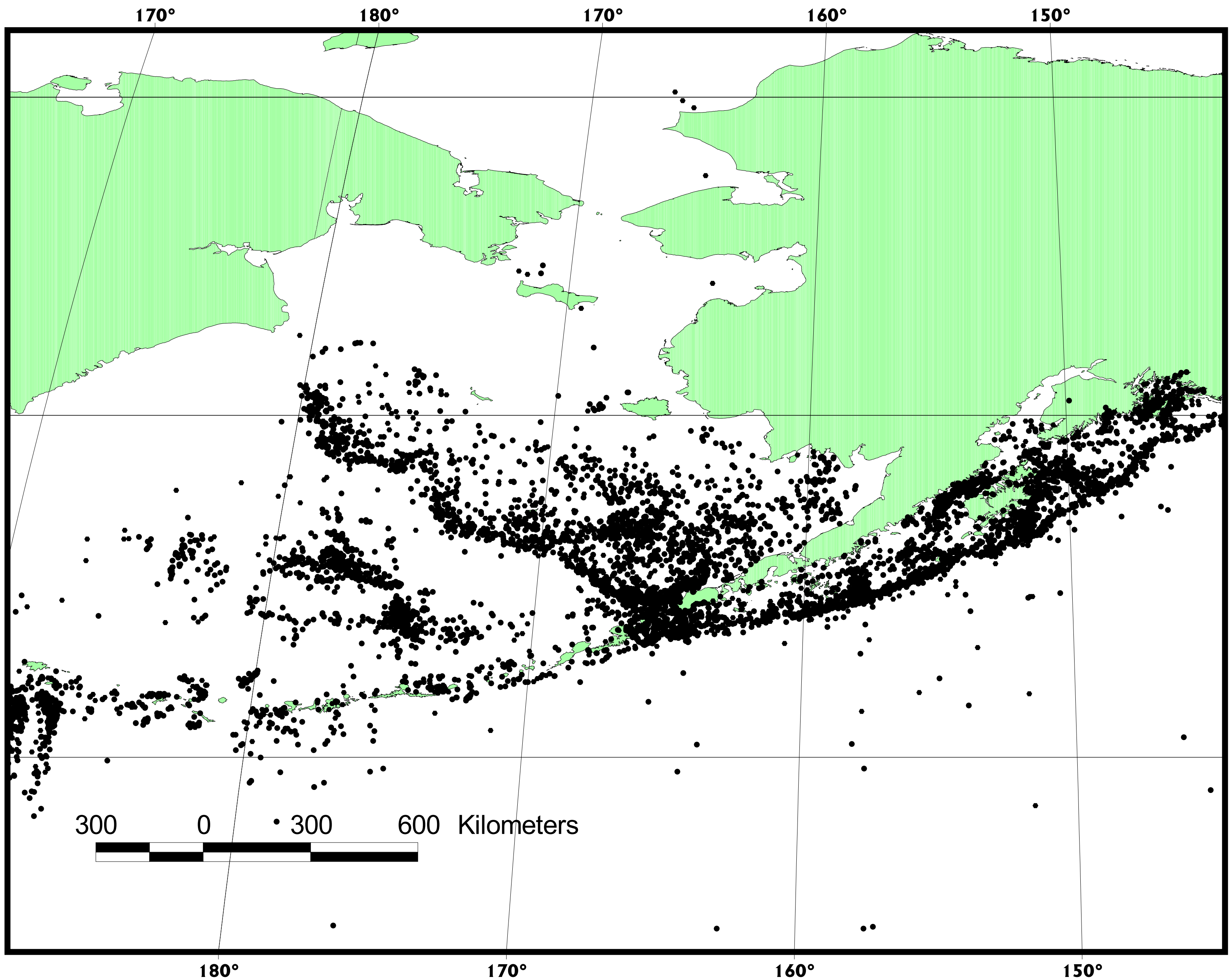


Figure 12. Schematic representation of the reproductive cycle of an adult female Steller sea lion over a period of year, indicating element s of the cycle that contribute to overall reproductive success and may be affected by nutritional stress.

Figure 13. Sighting locations for Steller sea lions in the BSAI and GOA based on data from the Platforms-of-Opportunity Program, 1958-1995.

Steller Sea Lion Sightings
Platforms of Opportunity Program Data 1958-1995



Source: POP data, 1958-1995; Mizroch, 4 Oct 99

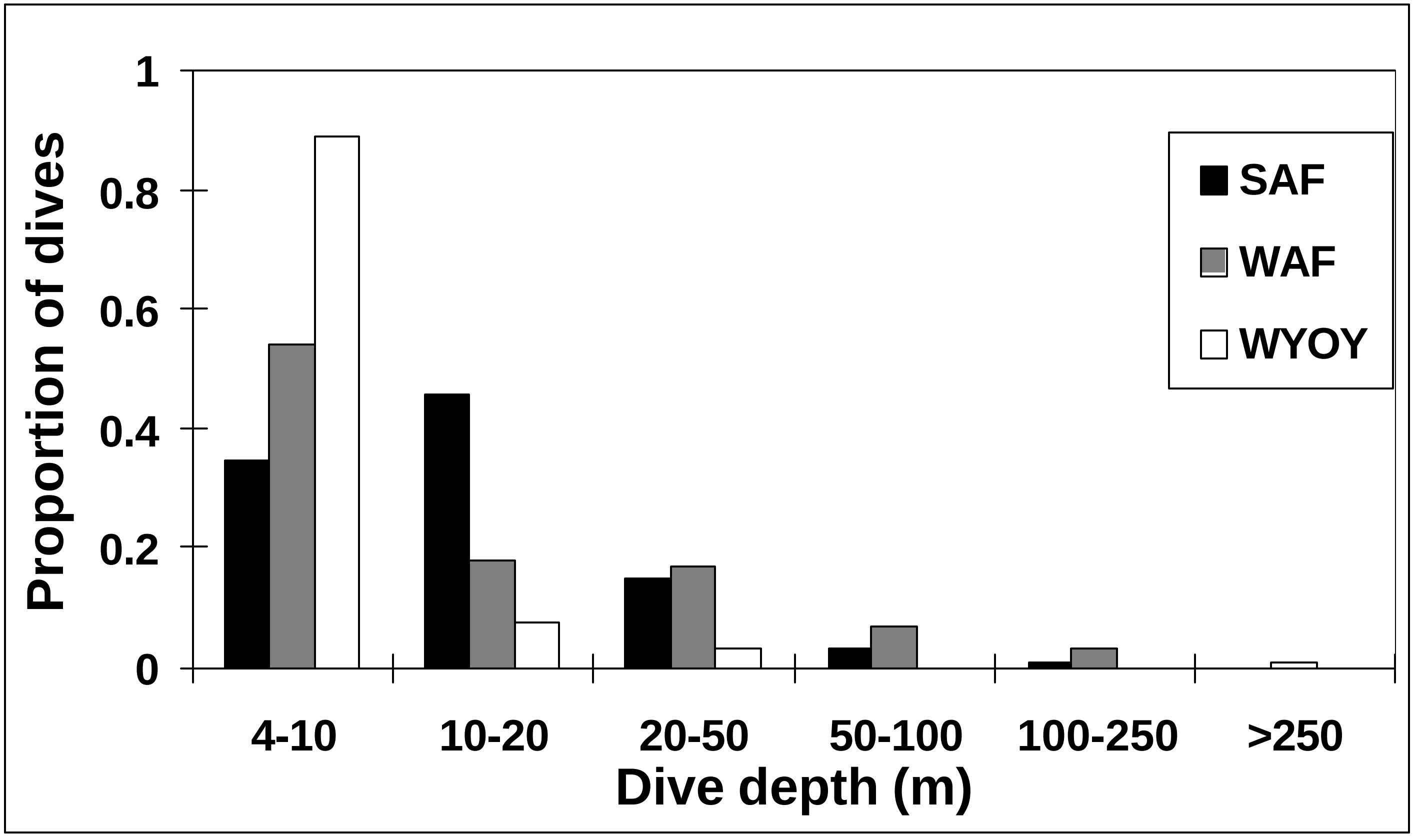


Figure 14. Portion of dives by depth range for young-of-the-year (WYOY) and adult female Steller sea lions in summer (SAF) and winter (WAF) tracked during 1990-1993 (from Merrick and Loughlin 1997).

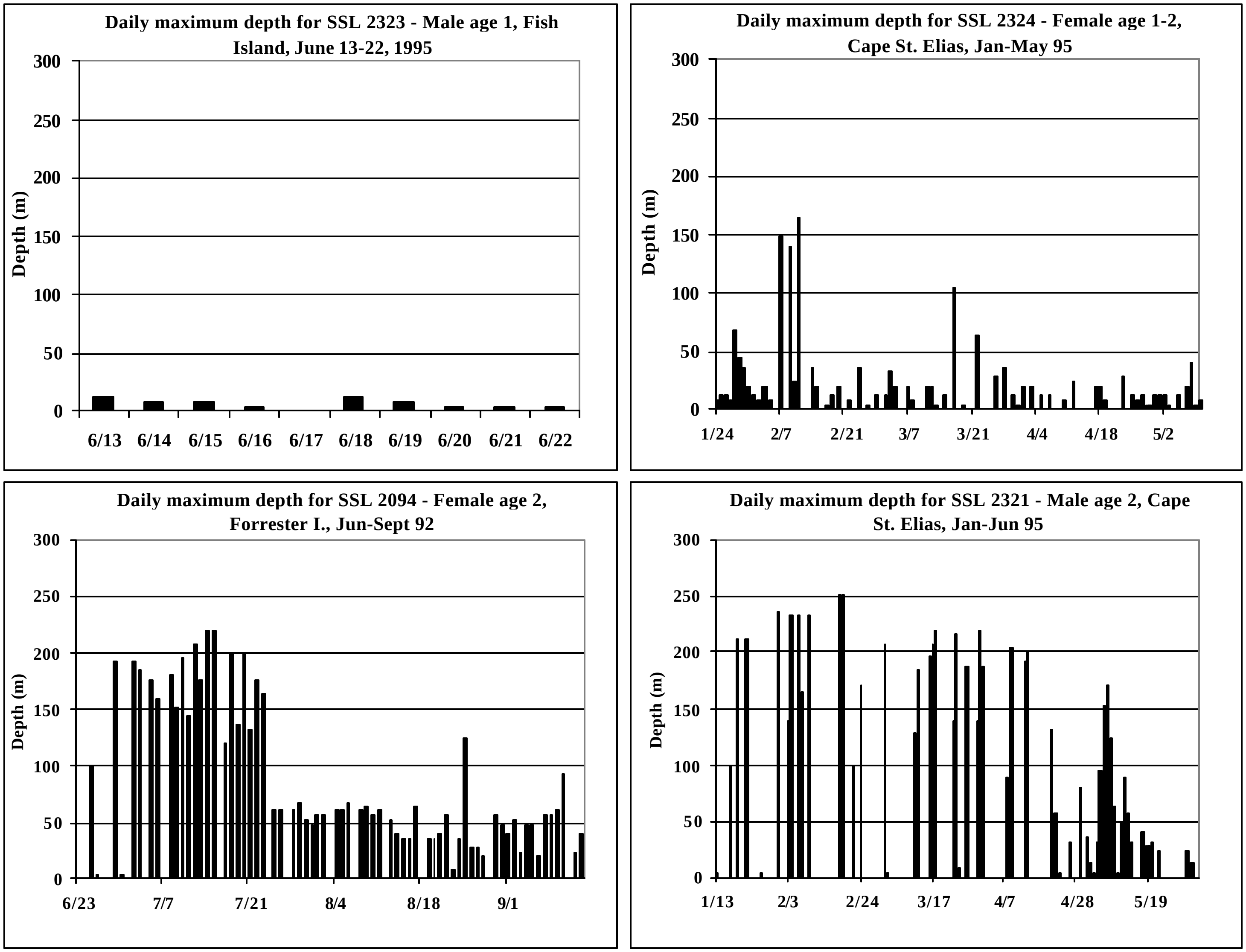


Figure 15. Maximum daily dive depths for four juvenile Steller sea lions (based on data from U. Swain, Alaska Department of Fish and Game).

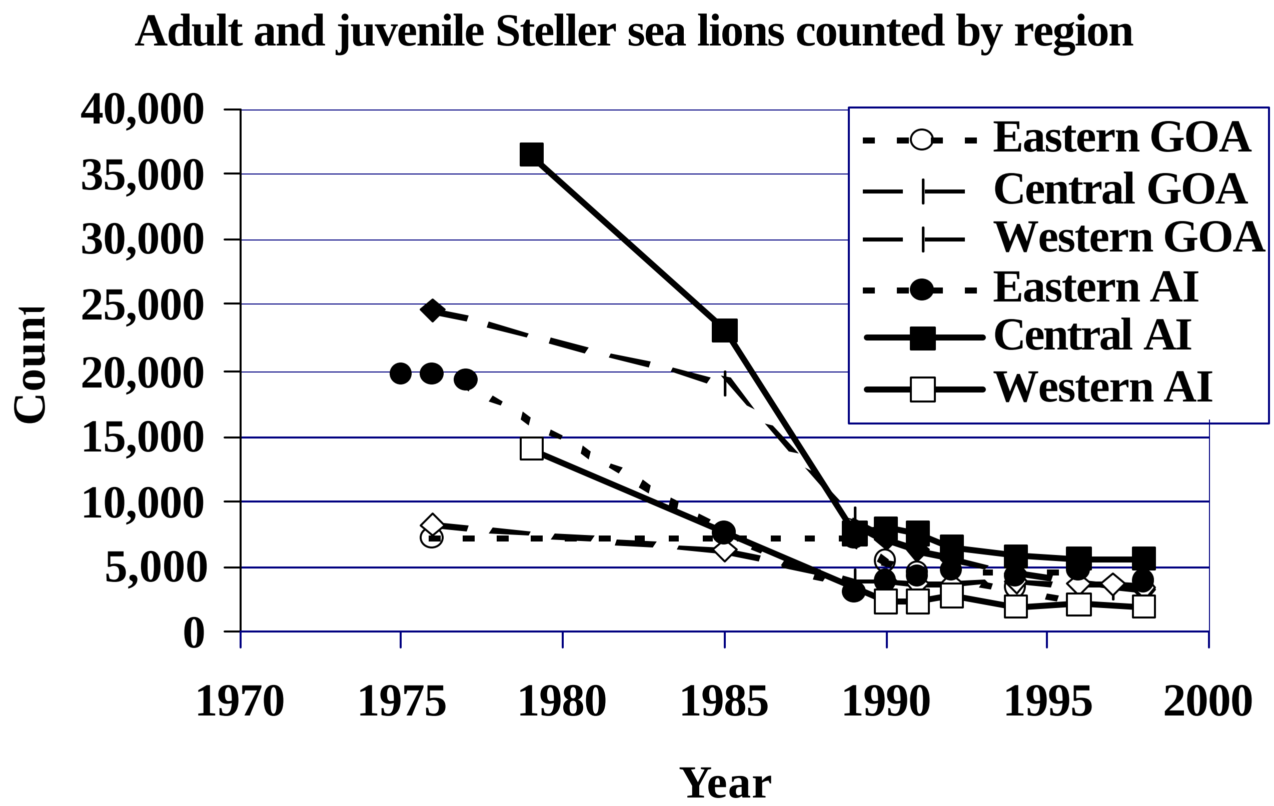
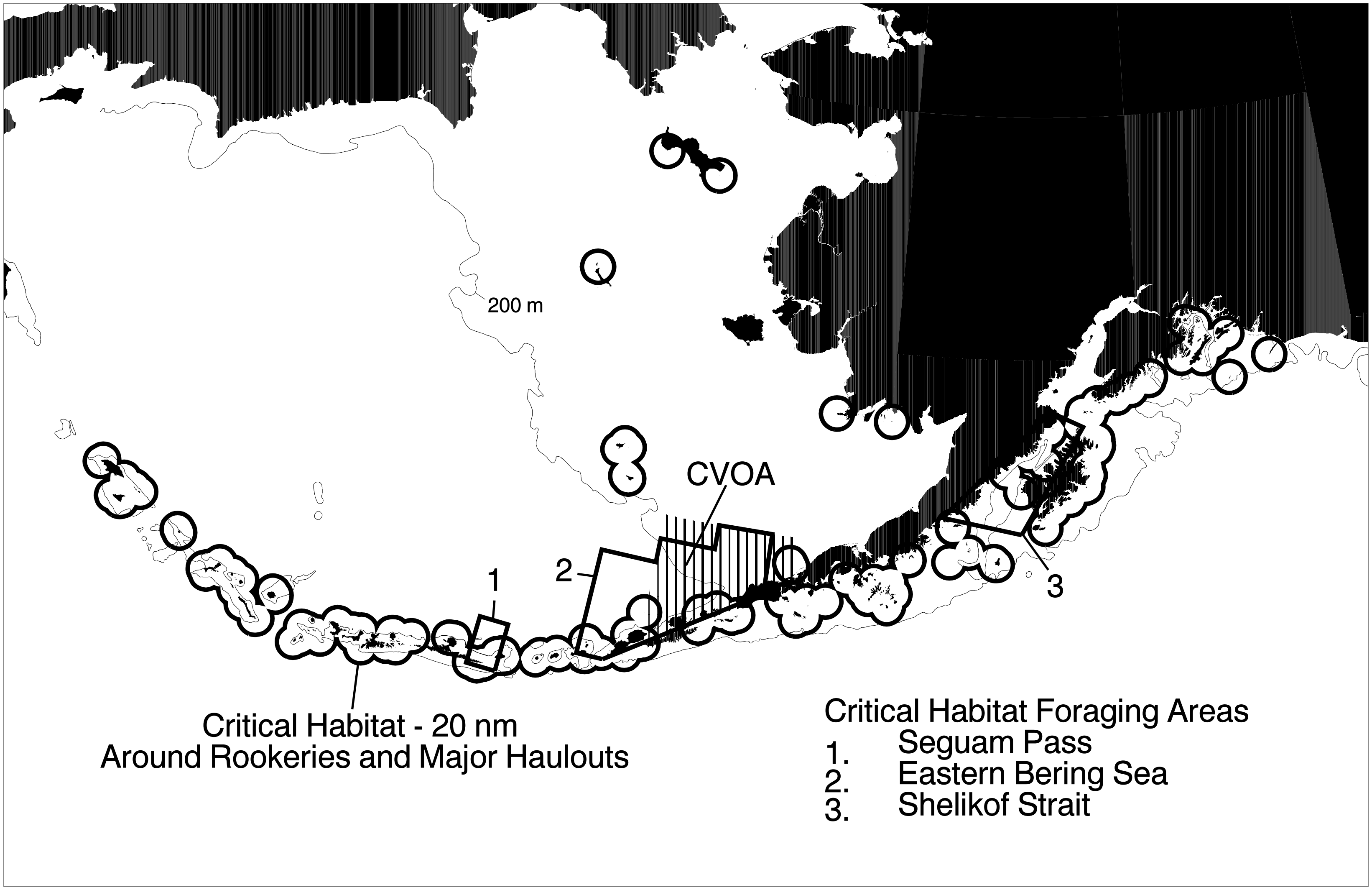


Figure 16. Counts of adult and juvenile Steller sea lions in the western population (by region) from the late 1970s to 1998.

Figure 17. Critical habitat of the Steller sea lion in the BSAI and GOA.



200 m
CVOA
1
2
3
Critical Habitat - 20 nm
Around Rookeries and Major Haulouts
Critical Habitat Foraging Areas
1. Seguam Pass
2. Eastern Bering Sea
3. Shelikof Strait

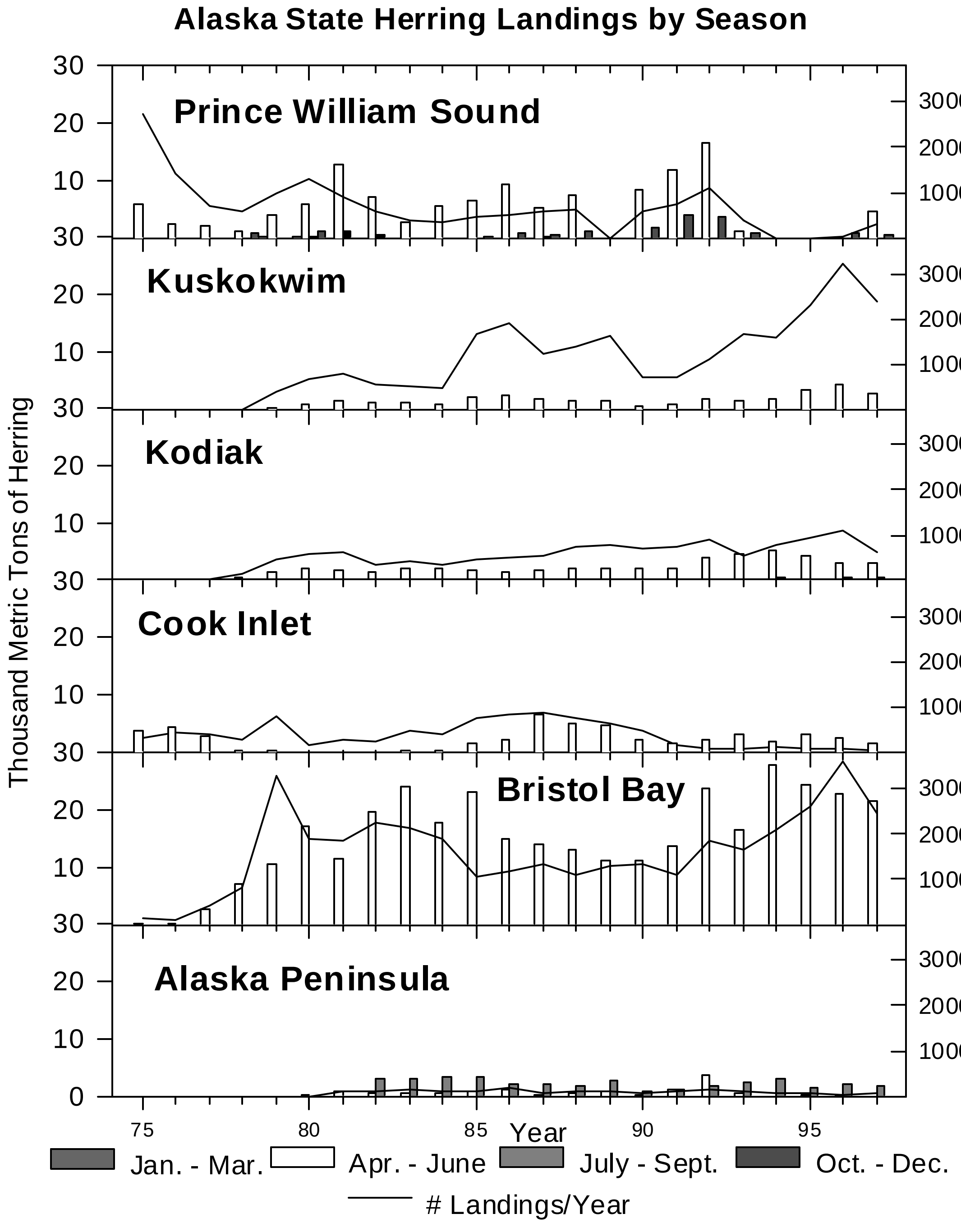


Figure 18a. Seasonal commercial catch of herring and annual number of landings in Alaska State waters. Bars indicate harvest amounts by 3-month seasons. The line indicates the number of landings/year (right axis), based on fish ticket data from the Alaska Department of Fish and Game.

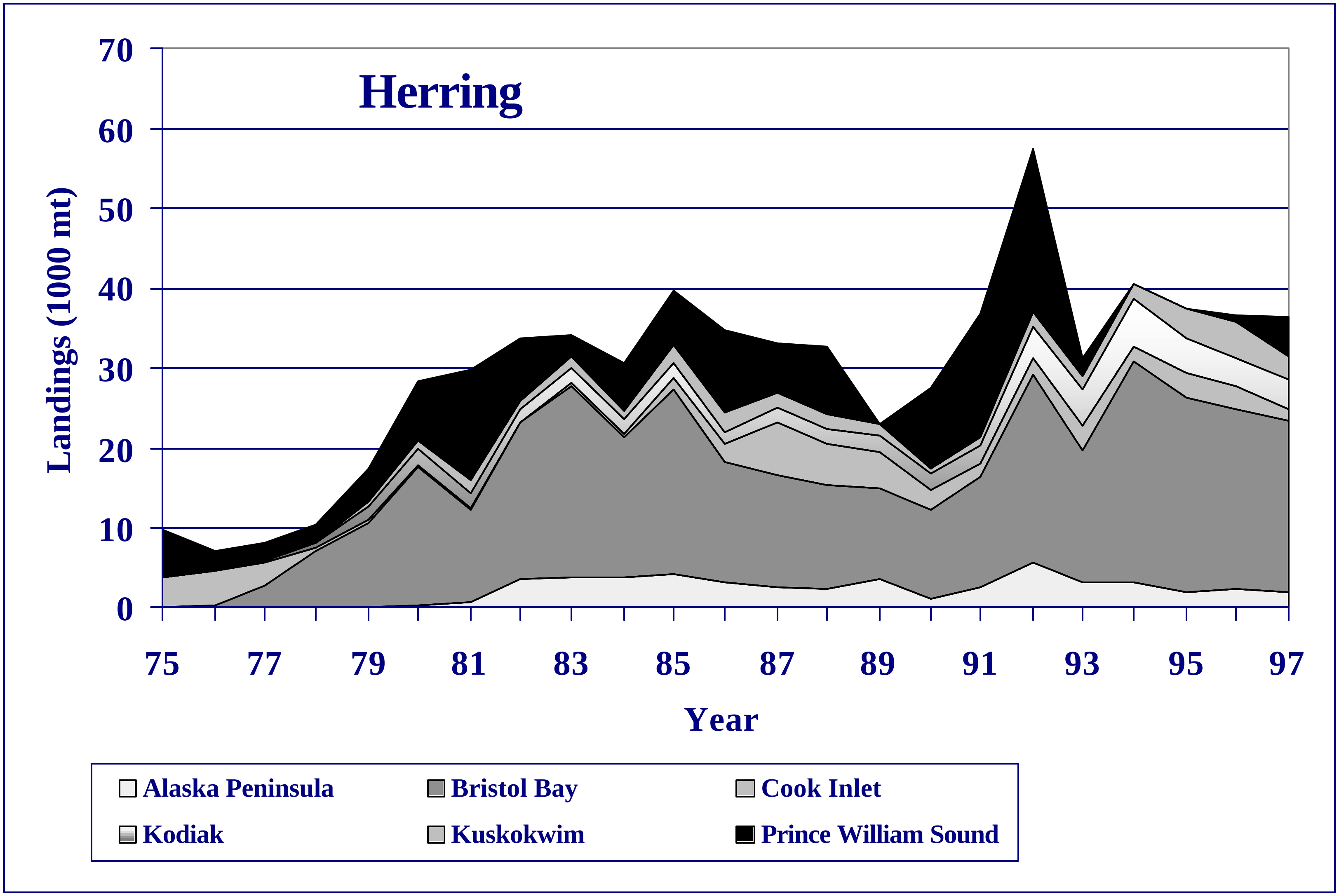


Figure 18b. Trends in Alaska State herring landings based on fish ticket data from the Alaska Department of Fish and Game.

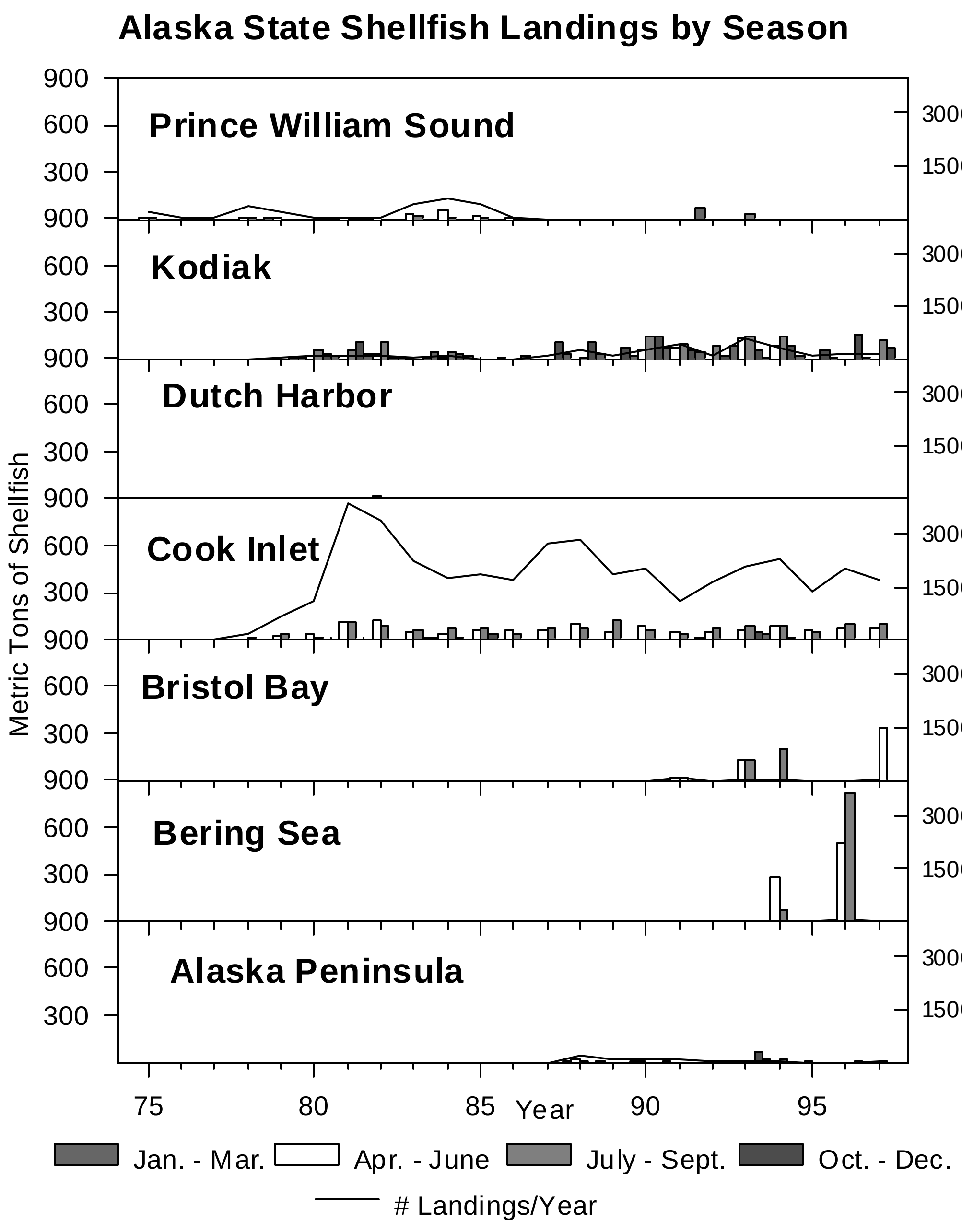


Figure 19a. Seasonal commercial catch of miscellaneous shellfish (excluding crab) and annual number of landings in Alaska State waters. Bars indicate harvest amounts by 3-month seasons. The line indicates the number of landings/year (right axis), based on fish ticket data from the Alaska Department of Fish and Game.

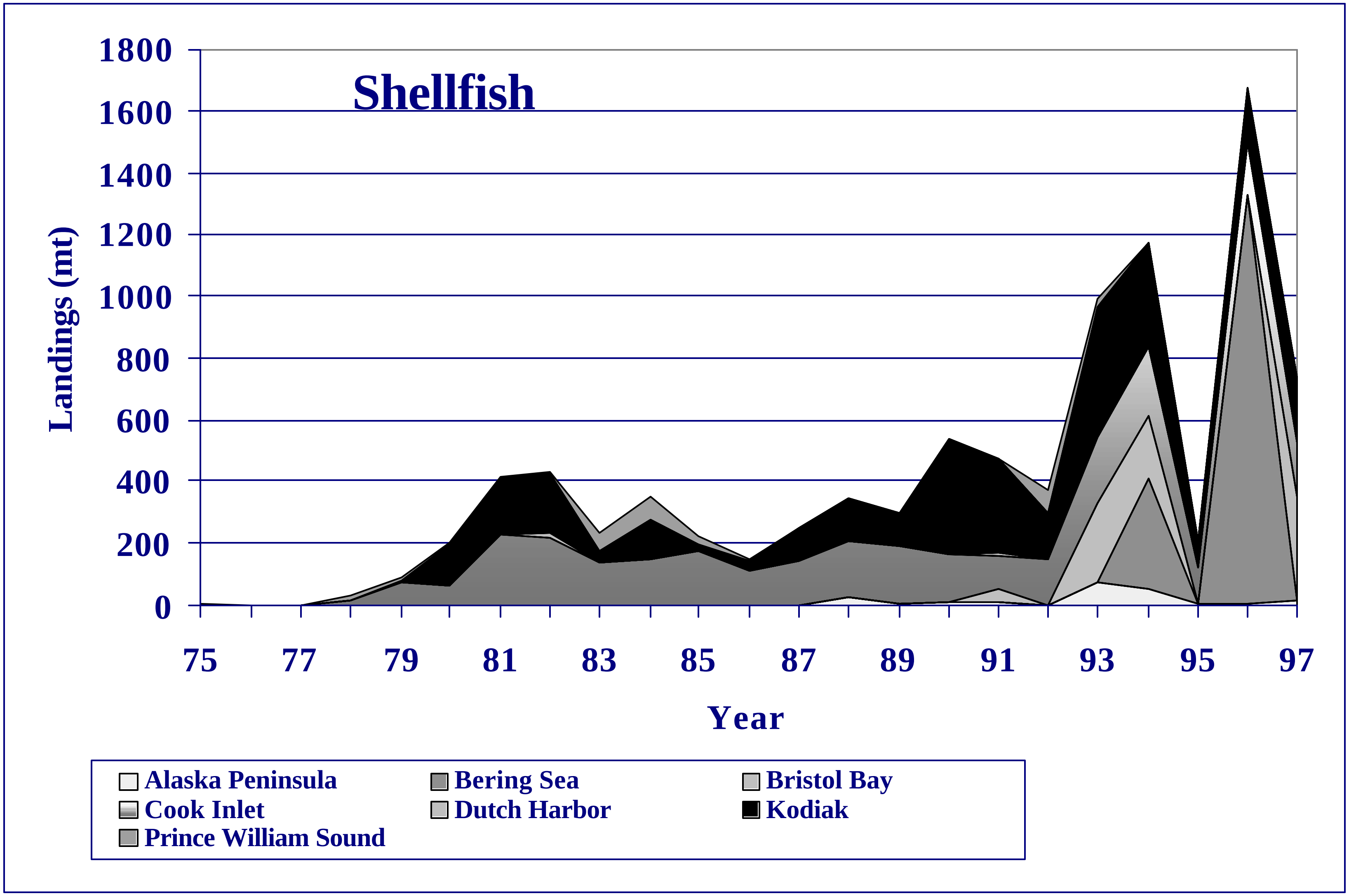


Figure 19b. Trends in Alaska State shellfish (excluding crab) landings based on fish ticket data from the Alaska Department of Fish and Game.

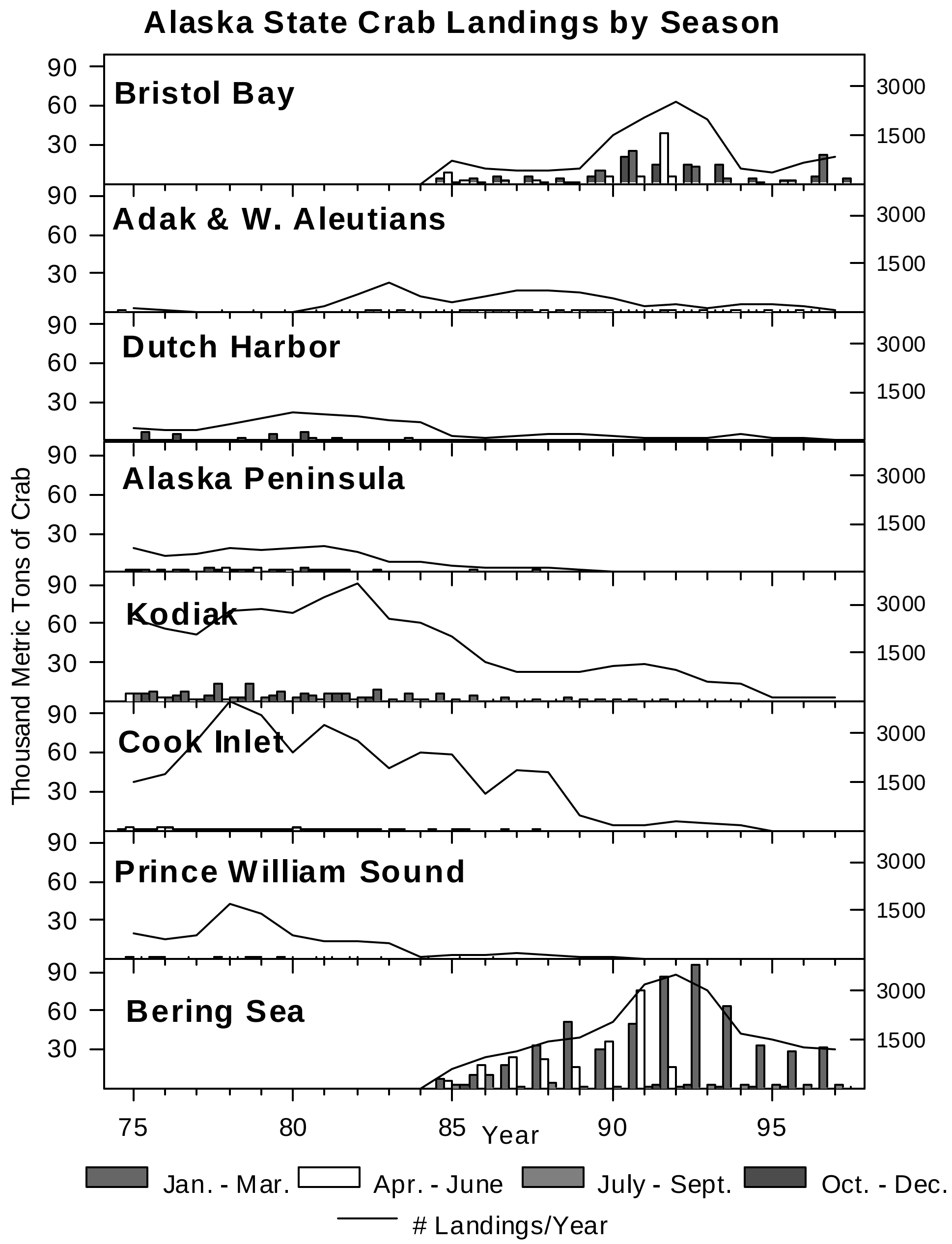


Figure 20a. Seasonal commercial catch of crab and annual number of landings in Alaska State waters. Bars indicate harvest amounts by 3-month seasons. The line indicates the number of landings/year (right axis), based on fish ticket data from the Alaska Department of Fish and Game.

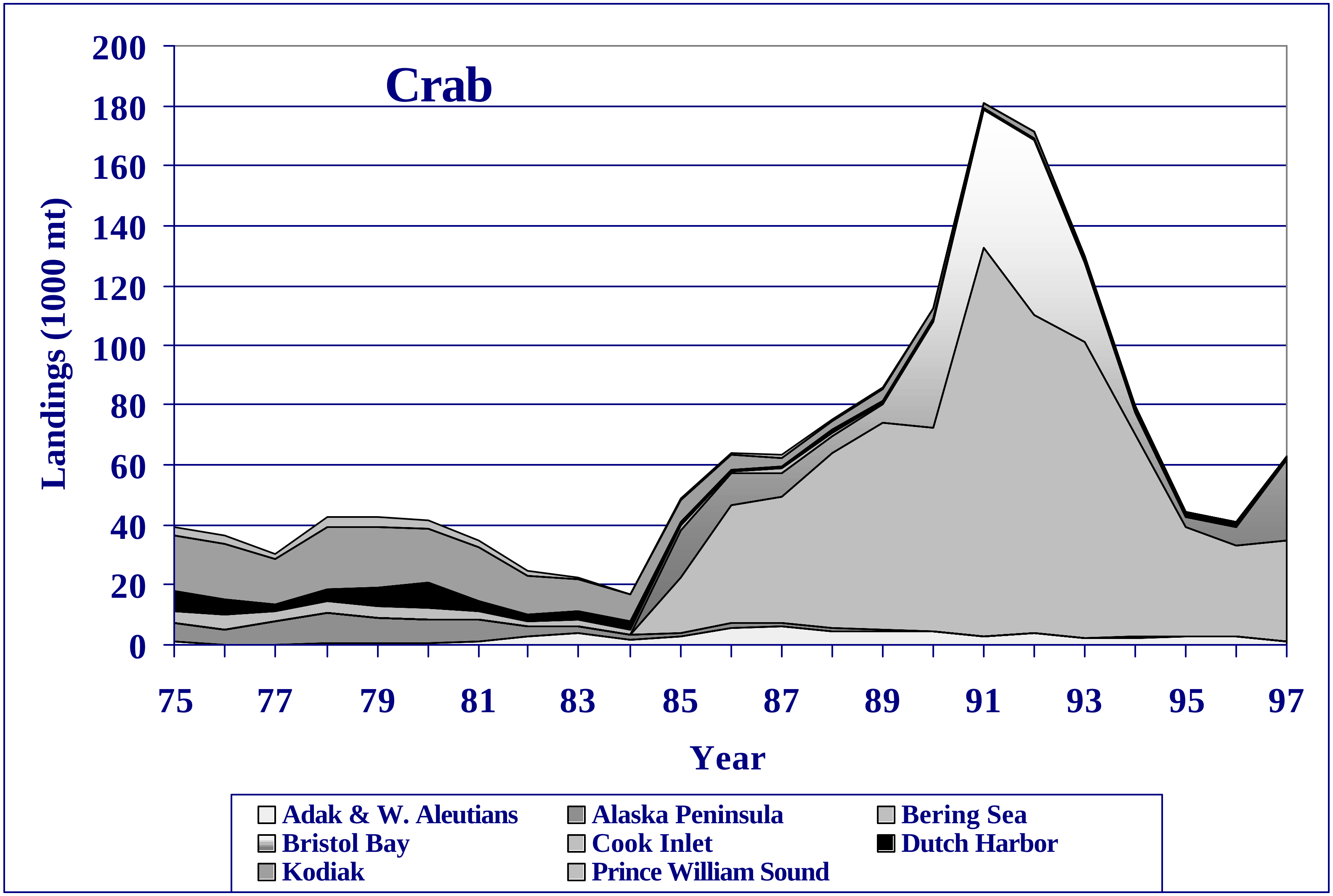


Figure 20b. Trends in Alaska State crab landings based on fish ticket data from the Alaska Department of Fish and Game.

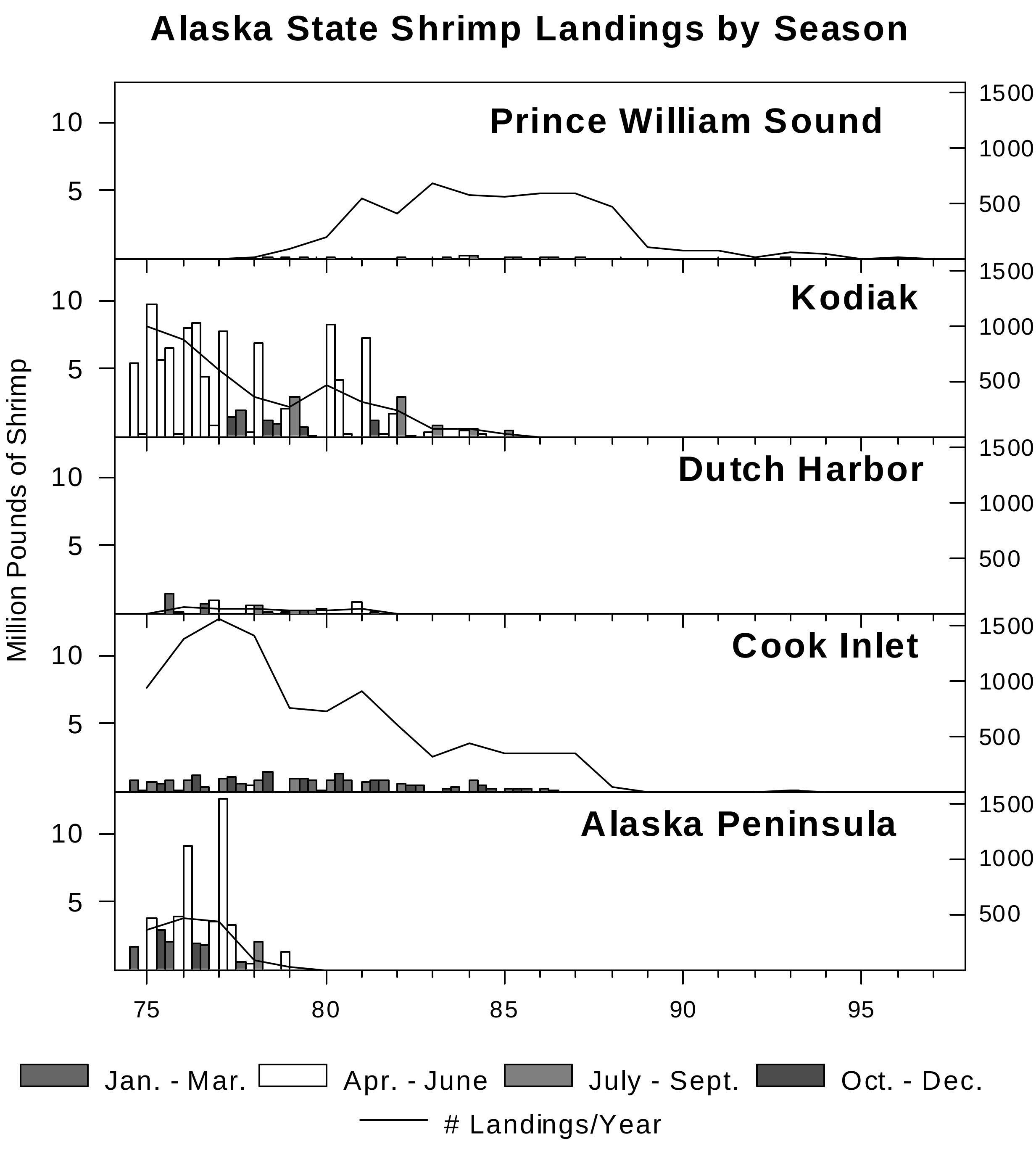


Figure 21a. Seasonal commercial catch of shrimp and annual number of landings in Alaskan waters other than in southeast Alaska or near Yakutat. Bars indicate harvest amounts by 3-month seasons. The line indicates the number of landings/year (right axis), based on fish ticket data from the Alaska Department of Fish and Game.

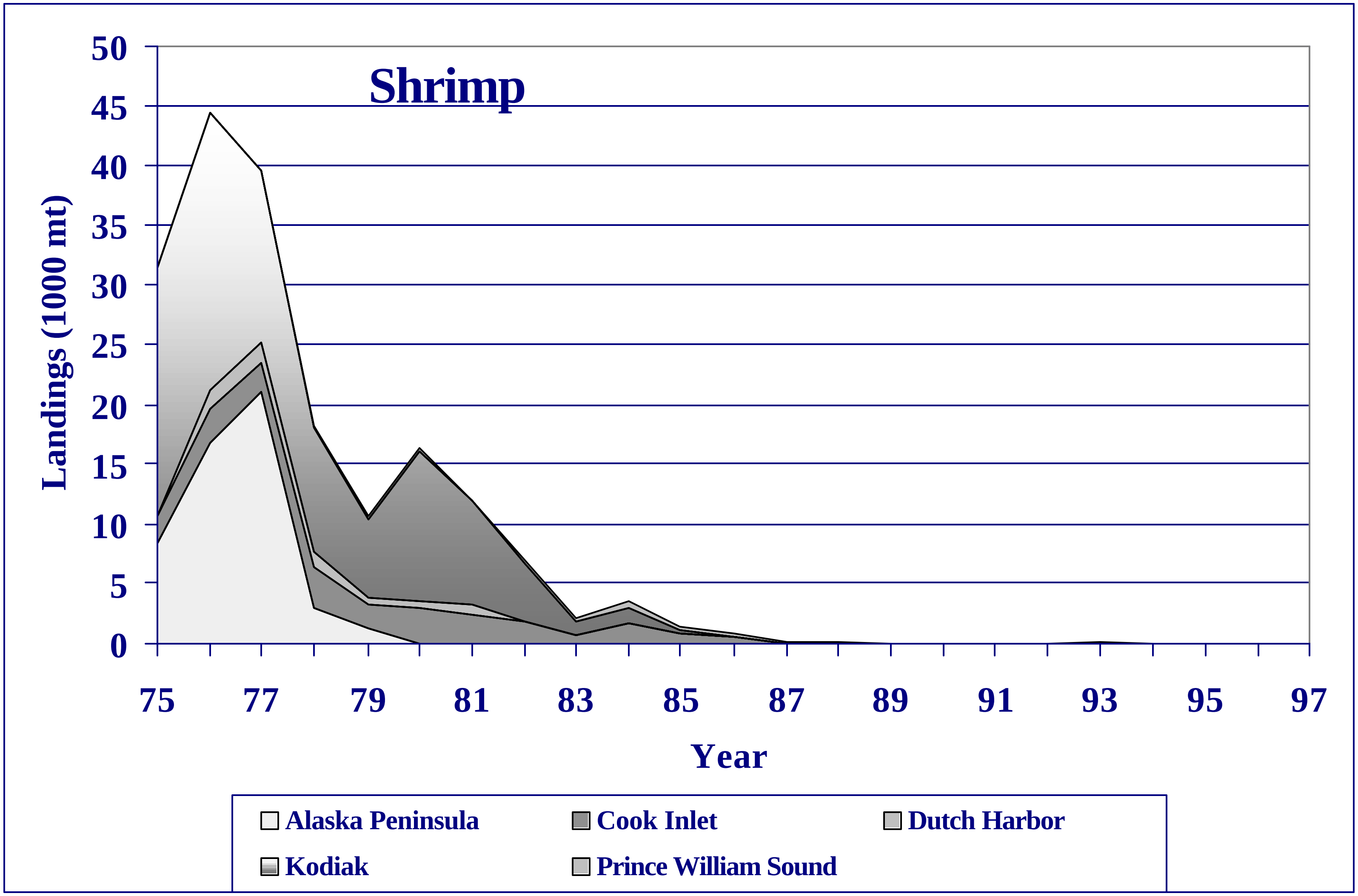


Figure 21b. Trends in Alaska State shrimp landings (excluding southeast Alaska and Yakutat area) based on fish ticket data from the Alaska Department of Fish and Game.

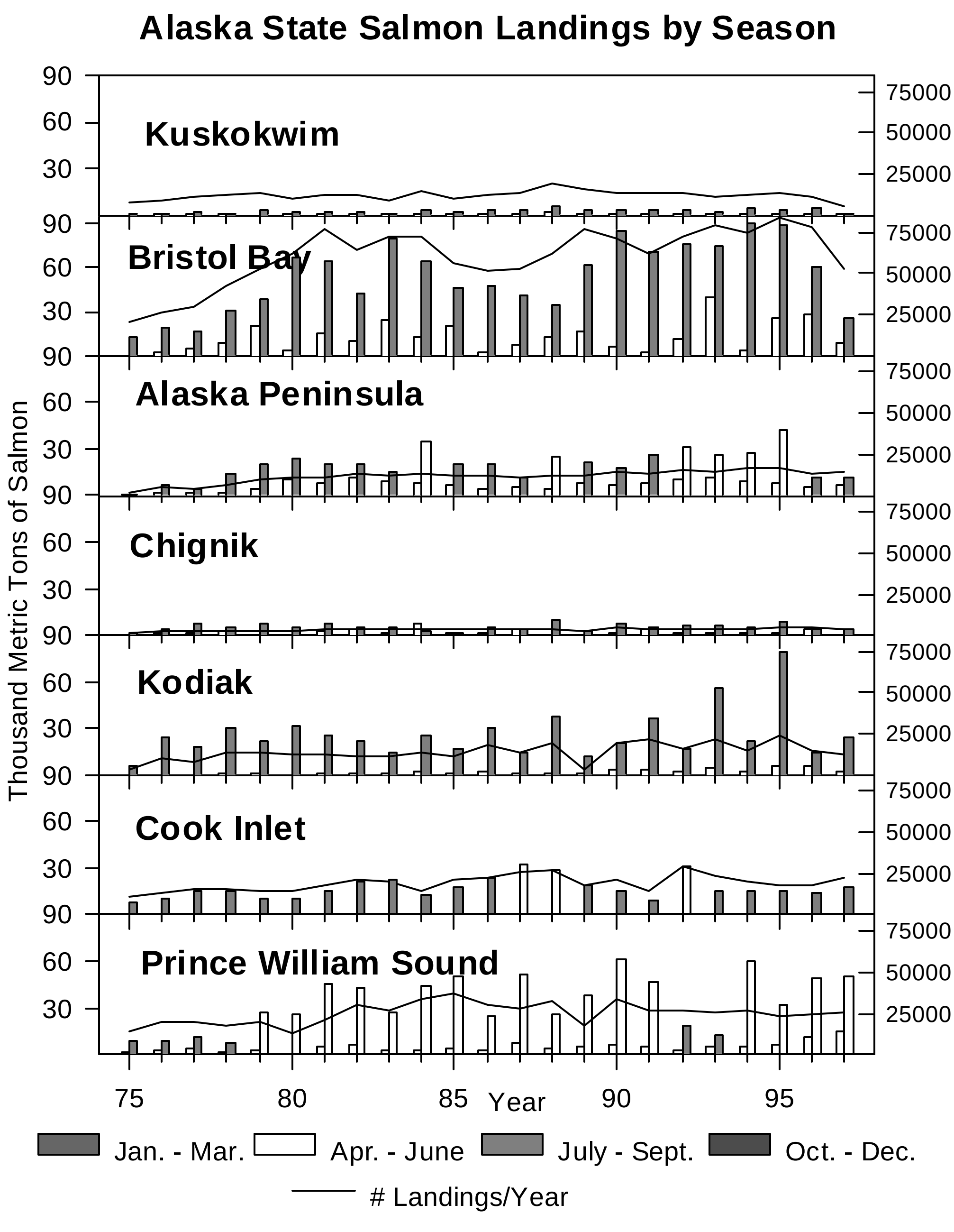


Figure 22a. Seasonal commercial catch of salmon and annual number of landings in Alaska State waters. Bars indicate harvest amounts by 3-month seasons. The line indicates the number of landings/year (right axis), based on fish ticket data from the Alaska Department of Fish and Game.

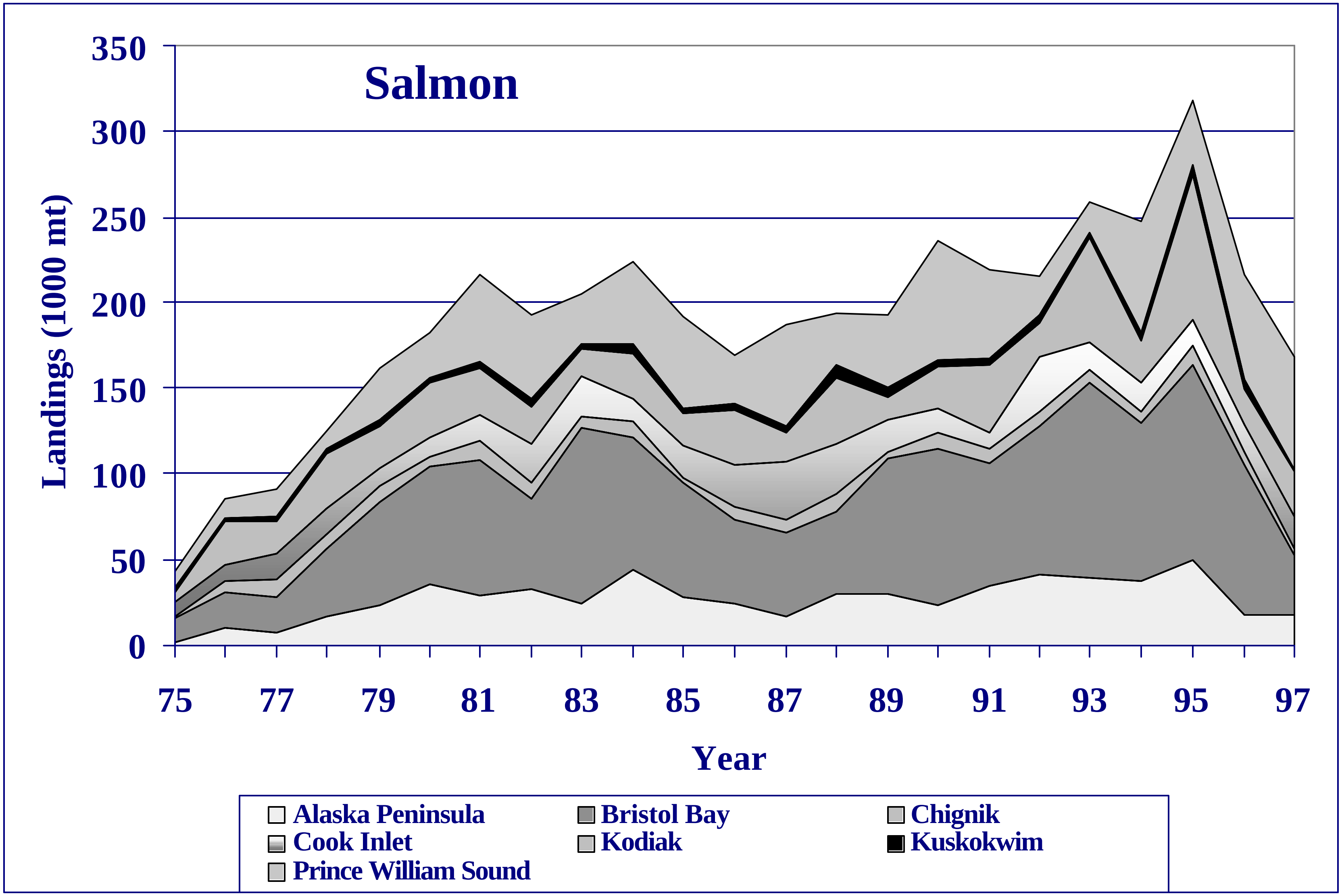


Figure 22b. Trends in Alaska State salmon landings based on fish ticket data from the Alaska Department of Fish and Game.

13.0 APPENDIX

Revised Final Reasonable and Prudent Alternatives to the pollock fisheries of the BSAI and GOA regions.

A. Bering Sea

1. Pollock no-trawl zones

a. Waters around Steller sea lion rookeries and major haulouts will be closed to pollock trawling out to 20 nm. This measure does not affect existing no-trawl and no-entry zones that apply to all groundfish fisheries. Specific sites, location, the size of closure around each site, and the period of closure are listed in the following table.

Bering Sea management area/island/site	Boundaries* to				Directed fishing for pollock prohibited within . . . (nm)	
	Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)	Nov 1 - Jun 1	Jun 1 - Nov 1
Walrus	57°11.00'	169°56.00'	-----	-----	20	20
Uliaga	53°04.00'	169°47.00'	53°05.00'	169°46.00'	-----	20
Chuginadak	52°46.50'	169°42.00'	52°46.50'	169°44.50'	-----	20
Kagamil	53°02.50'	169°41.00'	-----	-----	-----	20
Samalga	52°46.00'	169°15.00'	-----	-----	-----	20
Adugak	52°55.00'	169°10.50'	-----	-----	20	20
Umnak/Cape Aslik	53°25.00'	168°24.50'	-----	-----	20	20
Ogchul	53°00.00'	168°24.00'	-----	-----	20	20
Bogoslof/Fire Island	53°56.00'	168°02.00'	-----	-----	20	20
Emerald	53°17.50'	167°51.50'	-----	-----	-----	20
Unalaska/Cape Izigan	53°13.50'	167°39.00'	-----	-----	20	20
Unalaska/Bishop Point	53°58.50'	166°57.50'	-----	-----	20	20
Akutan/Reef-lava	54°07.50'	166°06.50'	54°10.50'	166°04.50'	20	20
Old Man Rocks	53°52.00'	166°05.00'	-----	-----	20	20
Akutan/Cape Morgan	54°03.50'	166°00.00'	54°05.50'	166°05.00'	20	20
Rootok	54°02.50'	165°34.50'	-----	-----	-----	20
Akun/Billings Head	54°18.00'	165°32.50'	54°18.00'	165°31.50'	20	20
Tanginak	54°12.00'	165°20.00'	-----	-----	20	-----
Tigalda/Rocks NE	54°09.00'	164°57.00'	54°10.00'	164°59.00'	20	20
Unimak/Cape Sarichef	54°34.50'	164°56.50'	-----	-----	20	20
Aiktak	54°11.00'	164°51.00'	-----	-----	20	-----
Ugamak	54°14.00'	164°48.00'	54°13.00'	164°48.00'	20	20
Round	54°12.00'	164°46.50'	-----	-----	-----	20
Sea Lion Rock (Amak)	55°28.00'	163°12.00'	-----	-----	20	20
Amak+rocks	55°24.00'	163°07.00'	55°26.00'	163°10.00'	20	20

* Where two sets of geographic coordinates are given, the baseline extends in a clock-wise direction from the first set of 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. Temporal dispersion

a. The period from November 1 to January 20 will be closed to all pollock trawling.

b. Inside the CHCVOA, the period from January 20 to November 1 will be divided into four seasons with starting dates of January 20, April 1, June 10, and August 20. Stand-down periods will not be required.

c. Outside the CHCVOA, the period from January 20 to November 1 will be divided into two seasons beginning January 20 and June 10. Stand-down periods will not be required.

d. The apportionment of catch to the A and B seasons combined can not exceed 40% of annual TAC allocated to directed fishing. Unused reserves set aside for bycatch during these two seasons may be reallocated to the C and D seasons.

e. Inside the CHCVOA, no more than 20% of the annual TAC can be taken in the combined A+B seasons, and no more than 15% of the annual TAC can be taken during either the A or B season. In the C and D seasons, a maximum of 4.5% and 7.5% of the annual TAC, respectively, can be taken from inside the CHCVOA.[3] Remaining portions of the TAC must be taken outside the CHCVOA.

These allocations are illustrated graphically as:

[3] These allocations are based on the limit of 30% TAC per season multiplied times the portion of the stock expected to be inside the CHCVOA during a particular season. For the A season, for example, 50% of the stock is expected to be in the CHCVOA. The product of 50% times 30% is 15%. Analyses reported in the environmental assessment for the extension of the emergency rule indicate that in the C and D season, approximately 15% and 25% of the pollock stock is in the CHCVOA. Therefore, for the C season, 30% times 15% is 4.5% of the annual TAC and, for the D season, 30% times 25% is 7.5% of the annual TAC. As these limits for the CHCVOA are based on the portion of the stock either known or expected to be within the CHCVOA, these allocations will be modified as better information becomes available on stock distribution.

		maximum 40%		60%*		
Outside CHCVOA	**Closed**	maximum of 40% of annual TAC minus catch taken inside the CHCVOA		60% of annual TAC minus catch taken inside the CHCVOA		**Closed**
Inside CHCVOA		maximums of 20% annual TAC for A+B combined, and 15% for A and B singly		maximum of 4.5% of annual TAC	maximum of 7.5% of annual TAC	
		A	B	C	D	
Starting date	Jan 20	Apr 1	Jun 10	Aug 20	Nov 1	

* Slight modification of the 60% to this period will be allowed to accommodate for management imprecision and bycatch adjustments.

f. NMFS will announce the closure of the CHCVOA conservation zone to catcher vessels over 99 ft (30.2 m) length overall before the inshore sector limit is reached with the intent of leaving remaining quota within the CHCVOA sufficient to support directed fishing for pollock by vessels less than or equal to 99 ft (30.2 m) length overall for the duration of any seasonal opening.

3. Spatial dispersion

a. A Steller sea lion conservation area will be established consisting of the southeastern Bering Sea special foraging area (also known as the Bogoslof foraging area) and the catcher-vessel-operation-area of the eastern Bering Sea. This Steller sea lion conservation area will be used to disperse catch in the Bering Sea. The CHCVOA will include the portion of the CVOA that extends eastward from the special foraging area. Specifically, it will consist of the area of the Bering Sea between 170°00'W long. and 163°00'W. long, south of straight lines connecting the following points in the order listed:

55°00'N lat., 170°00'W long.
55°00'N lat., 168°00'W long.
55°30'N lat., 168°00'W long.
55°30'N lat., 166°00'W long.
56°00'N lat., 166°00'W long.
56°00'N lat., 163°00'W long.

b. TAC allocations to this area will be as described under temporal dispersion for the Bering Sea (above).

B. Gulf of Alaska

1. Pollock no-trawl zones

a. Waters around Steller sea lion rookeries and major haulouts will be closed to pollock trawling out to 10 nm. This measure does not affect existing no-trawl and no-entry zones that apply to all groundfish fisheries. Specific sites, location, the size of closure around each site, and the period of closure are listed in the table on the following page.

b. Three exceptions to these closures are:

1) *Pt. Elrington and The Needles* --- NMFS will work with the State of Alaska to consider alternative measures for these sites. If equivalent alternatives can not be identified and implemented by 2001, these sites will be closed.

2) *Cape Barnabas and Gull Point* --- These sites may be opened for the purpose of conducting experiments to determine the effects of the pollock fisheries on prey resources in this area.

3) *Sea Lion Rocks* --- This site will be open out to 10nm for vessels less than or equal to 60 ft (18.3 m) length overall.

Gulf of Alaska management area/island/site	Boundaries* to				Directed fishing for pollock prohibited within . . . (nm)	
	Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)	Nov 1 - Jun 1	Jun 1 - Nov 1
Bird	54°40.50'	163°18.00'	-----	-----	10	10
South Rocks	54°18.00'	162°41.50'	-----	-----	10	10
Clubbing Rocks	54°42.00'	162°26.50'	54°43.00'	162°26.50'	10	10
Pinnacle Rock	54°46.00'	161°46.00'	-----	-----	-----	10
Sushilnoi Rock	54°50.00'	161°44.50'	-----	-----	-----	10
Olga Rocks	55°00.50'	161°29.50'	54°59.00'	161°31.00'	10	10
Jude	55°16.00'	161°06.00'	-----	-----	10	10
Sea Lion Rocks**	55°05.00'	160°31.00'	-----	-----	10	10
The Whaleback	55°16.50'	160°06.00'	-----	-----	10	10
Chernabura	54°47.50'	159°31.00'	54°45.50'	159°33.50'	10	10
Castle Rock	55°17.00'	159°30.00'	-----	-----	-----	10
Atkins	55°03.50'	159°19.00'	-----	-----	10	10
Spitz	55°47.00'	158°54.00'	-----	-----	-----	10
Mitrofania	55°50.00'	158°42.00'	-----	-----	10	10
Kak	56°17.00'	157°51.00'	-----	-----	-----	10
Lighthouse Rocks	55°47.50'	157°24.00'	-----	-----	10	10
Sutwik	56°31.00'	157°20.00'	56°32.00'	157°21.00'	-----	10
Chowiet	56°00.50'	156°41.50'	56°00.50'	156°42.00'	10	10
Nagai Rocks	55°50.00'	155°46.00'	-----	-----	10	10
Chirikof	55°46.50'	155°39.50'	55°46.50'	155°43.00'	10	10
Puale Bay	57°41.00'	155°23.00'	-----	-----	10	10
Point Ikolik	57°17.00'	154°48.00'	-----	-----	10	-----
Takli	58°03.00'	154°27.50'	58°02.00'	154°31.00'	-----	10
Cape Gull	58°13.50'	154°09.50'	58°12.50'	154°10.50'	-----	10
Sitkinak/Cape Sitkinak	56°34.50'	153°51.50'	-----	-----	10	10
Kodiak/Cape Ugat	57°52.00'	153°51.00'	-----	-----	10	10
Kodiak/Cape Barnabas**	57°10.00'	152°53.00'	-----	-----	10	10
Kodiak/Gull Point**	57°21.00'	152.36.00'	-----	-----	10	10
Shakun Rock	58°32.50'	153°41.50'	-----	-----	10	10
Twoheaded Island	56°54.50'	153°33.00'	56°53.50'	153°35.50'	10	10
Cape Douglas	58°51.50'	153°14.00'	-----	-----	-----	10
Latax Rocks	58°42.00'	152°28.50'	58°40.50'	152°30.00'	10	10
Ushagat/SW	58°55.00'	152°22.00'	-----	-----	-----	10
Ugak	57°23.00'	152°15.50'	57°22.00'	152°19.00'	-----	10
Sea Otter Island	58°31.50'	152°13.00'	-----	-----	10	10
Long	57°47.00'	152°13.00'	-----	-----	10	-----
Kodiak/Cape Chiniak	57°37.50'	152°09.00'	-----	-----	10	10
Sugarloaf	58°53.00'	152°02.00'	-----	-----	10	10
Sea Lion Rocks (Marmot)	58°21.00'	151°48.50'	-----	-----	10	10
Marmot	58°14.00'	151°47.50'	58°10.00'	151°51.00'	10	10
Perl	59°06.00'	151°39.50'	-----	-----	10	10
Outer (Pye) Island	59°20.50'	150°23.00'	59°21.00'	150°24.50'	10	10
Steep Point	59°29.00'	150°15.00'	-----	-----	-----	10
Chiswell Islands	59°36.00'	149°34.00'	-----	-----	10	10
Rugged Island	59°50.00'	149°23.00'	59°51.00'	149°25.00'	10	-----
Point Elrington**	60°07.00'	148°15.00'	-----	-----	-----	-----
Wooded Island (Fish)	59°53.00'	147°20.50'	-----	-----	10	10
The Needles**	60°07.00'	147°36.00'	-----	-----	-----	-----

Glacier Island	60°51.00'	147°09.00'	-----	-----	10	10
Seal Rocks	60°10.00'	146°50.00'	-----	-----	10	10
Cape Hinchinbrook	60°14.00'	146°38.50'	-----	-----	-----	10
Hook Point	60°20.00'	146°15.50'	-----	-----	-----	10
Cape St. Elias	59°48.00'	144°36.00'	-----	-----	10	10

** See exceptions below.

2. Temporal dispersion

a. The period from November 1 to January 20 will be closed to all pollock trawling.

b. The pollock fishery of the Gulf of Alaska will be divided into four seasons with the following TAC apportionment, and start and end dates.

Season	TAC apportionment	Start date	End date
A	30%	Jan 20	Mar 1
B	15%	Mar 15	May 31
C	30%	Aug 20	Sep 15
D	25%	Oct 1	Nov 1

c. Catch during any one season will be limited to 30% of the annual TAC.

d. Catch during the combined A+B seasons will be limited to 45% of the annual TAC.

e. Individual catcher vessel trips in the western, central, and eastern Gulf of Alaska will be limited to 136 mt (300,000 lbs).

f. Tendering will be prohibited in areas 620 (east of 157°W long.), 621, 630, 631, and 640. In area 610 and 620 (west of 157°W long.), tendering vessels will be limited to 272 mt (600,000 lbs) per trip.

g. Catcher vessels will be subject to a seasonal exclusive-area requirement. Vessels will be prohibited from directed fishing for pollock in both the Bering Sea and the Gulf of Alaska during the same season (A, B, C, or D). Vessels less than 125 ft (38.1 m) will be exempted from this seasonal exclusive-area requirement in area 630 and east of 157°W long. in area 620.

3. Spatial dispersion

a. A Shelikof Strait conservation area is established comprised of areas 621 and 631. Specifically, this conservation area is defined as the area bound by straight lines and shoreline connecting the following coordinates in the following order:

58°51'N lat., 153°15'W long.;
58°51'N lat., 152°00'W long.; and the intersection of 152°00'W long., with Afognak Island; aligned counterclockwise around the shoreline of Afognak, Kodiak, and Raspberry Islands to
57°00'N lat., 154°00'W long.;
56°30'N lat., 154°00'W long.;
56°30'N lat., 155°00'W long.;
56°00'N lat., 155°00'W long.;
56°00'N lat., 157°00'W long.; and the intersection of 157°00'W long. with the Alaska Peninsula.

b. TAC apportionments will be made to areas 610, 620 (outside the Shelikof Strait conservation zone), 630 (outside the Shelikof Strait conservation zone), and the Shelikof Strait conservation zone during the A and B seasons. TAC apportionments will be made to areas 610, 620, and 630 during the C and D seasons.

c. TAC apportionments will be made on the basis of the most recent stock surveys and model estimates. The TAC apportioned to the Shelikof Strait conservation area during the A and B seasons will be determined as the seasonal TAC apportionment multiplied by the quotient of the most recent estimate of biomass in the conservation area divided by the most recent estimate of the total biomass in the Gulf of Alaska.

C. Aleutian Islands

The Aleutian Islands region will be closed to all directed fishing for pollock.