ECOSYSTEM CONSIDERATIONS

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Compiled by

The Plan Teams for the Groundfish Fisheries of the Bering Sea, Aleutian Islands, and Gulf of Alaska

in Consultation with the Staff of the

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INTRODUCTION

In 1995, the NPFMC Groundfish Plan Teams prepared a much expanded Ecosystem Considerations (EC) section to the annual SAFE report. That report is considered to present a compendium of general information on the Bering Sea, Aleutian Island, and Gulf of Alaska ecosystems which will not be repeated on an annual basis. Instead each new annual EC report will present updates and new information that has recently come available as a supplement to the original report. This, the 1996 EC report, represents the first of these supplements.

ECOSYSTEM CONSIDERATIONS

Ecosystem Management - In 1994, the Plan Teams cited five goals of Grumbine (1994) to provide a framework for a discussion of ecosystem management in the groundfish fisheries off Alaska:

1. Maintain viable populations of all native species in situ.
2. Represent within protected areas, all native ecosystem types across their natural range of variation.
3. Maintain evolutionary and ecological processes (i.e. disturbance regimes, hydrological processes, nutrient cycles, etc.)
4. Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.
5. Accommodate human use and occupancy within these constraints.

Grumbine summarized from a review of the literature that "Ecosystem management integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long term." The five goals cited generated much debate among the Council participants which suggested that a more specific set of goals should be developed for the North Pacific ecosystem.

In a parallel effort, the Bering Sea/Aleutian Island Ecosystem Management Plan developed by the U.S. Fish and Wildlife Service identified four goals to part of its Alaska Maritime National Wildlife Refuge ecosystem plan:

1. Maintain species diversity and natural populations consistent with the natural ecological process.
2. Maintain and restore natural habitats across their full range of variations.
3. Manage the human use of species and habitats consistent with all ecosystem management goals.
4. Promote integrated management of ecosystems through partnerships and informed public.

What does this imply for groundfish management off Alaska? For one thing, it would imply that biodiversity in each involved ecosystem should be maintained at a level close to the historic average. This simple restatement, however, begs the question. What constitutes an "ecosystem" and what constitutes the period of time over which the "historic average" is computed? The Plan Teams proposed in 1994 that the large marine ecosystems off Alaska be classified as the Bering Sea proper, the Aleutian Island chain, and the Gulf of Alaska. These three large ecosystems have groundfish resources that are managed under FMPs. Along with the impacts of harvesting on target species are impacts on ecologically related species -- for both lower and higher trophic levels. Some are taken directly during fishing, but all are subject to impact through the food chain. While the conservation of all ecosystem components is important, it would be most prudent to concentrate on those that are most clearly impacted by a sustained pattern of fishing over some specified period of time.

Provisionally, it is suggested that the primary ecosystem management goal would be the maintenance of Alaskan marine biodiversity at the average level observed over a reasonably long period of time in modern history, say the past 100 years, roughly 1900-2000. This period encompasses nearly 50 years of history prior to the development of major groundfish fisheries in the late 1950s, as well as the present period of managed fishing and fisheries resource utilization. Furthermore, all of the important ecosystem components that exist at present have been prominently visible at one time or another during this period. Thus the maintenance of Alaskan marine biodiversity can be better addressed within a fixed time window by scientists and managers.

With regard to the selection of ecosystem components for special emphasis, the MFCMA, the MMPA, and ESA provide guidance to the type of ecological groups upon which attention should be focused. These include fisheries species as well as seabirds, marine mammals, and other taxa that are affected by fishing and ecological events. Ecosystem management would require maintenance of their abundances at levels concordant with those observed over the historic time frame, i.e. the past 100 years. In practical terms, the Council and NMFS wish to manage fishing activities so that they do not impact on the natural tendency of the resources to persist in their respective ecological niches. However, it should be recognized that the nature of the marine ecosystem is dynamic -- resource abundance and ecosystem composition undergo inherent changes.

Given this tendency of nature to change, it is reasonable to expect that all of the living marine resources off Alaska will fluctuate in abundance and that their encompassing ecosystems will fluctuate in composition. The main goal of ecosystem management is to ensure that human activities do not significantly alter the natural course of such dynamics. To achieve this goal, it must be recognized that not all ecosystem components can maximize their abundance simultaneously. Thus, the maintenance of all major ecosystem components at abundance levels concordant with those observed over the historic time frame (the past 100 years) would be a realistic target for management of the marine ecosystems off Alaska.

What does this mean with respect to the known cases of marine mammal and seabird declines off Alaska? Have fishing activities which are authorized and managed under the two groundfish FMPs been the driving force behind these fluctuations? Should fishing be cut back or closed areas modified to protect the declining species? Or are the dynamics of these populations driven almost entirely by natural forces? These questions cannot be easily answered. It is clear that the available data and the extent of scientific understanding are, more often than not, insufficient to provide adequate answers to these questions.

The Council and NMFS have enacted certain measures in the past decade which have subtly shifted management of the groundfish fisheries of the North Pacific towards an ecosystem management approach. A recent instance where mitigation of possible fishery-induced impacts was included was the setting of ABCs and TACs for pollock in the Gulf of Alaska for the 1993-95 fishing seasons. The stock assessement model used to determine pollock ABCs incorporates pollock as prey items for natural predators like marine mammals and seabirds. It incorporated estimates of the probability, or risk, of the future spawning pollock population biomass declining below a pre-determined level. This approach reflected the concern of the Council in preserving pollock biomass in the face of a declining stock size, and it also acknowledged that the pollock resource is important to other marine organisms including Steller sea lions, Pacific harbor seals, and seabirds. Similarly, attempts to minimize localized depletion of fish stocks through the spatial allocation of GOA pollock and AI Atka mackerel also represent concerns that sufficient prey remain available for upper level predators.

Perhaps the most difficult issue to address at present pertains to ecosystem management off Alaska is mitigation of Steller sea lion, harbor seals, and seabird declines. Ten to twenty-mile sanctuary areas have been created around certain key rookeries to protect sea lion populations from the effects of fishing. Conscious choices have been made to refrain from fully utilizing ABCs in order to provide a buffer for groundfish stocks and their ecologically related species. The Council and NMFS must continue to monitor the situation, to conduct research into mitigating actions, and to seek better methods of managing living marine resources off Alaska.

U.S. Fish and Wildlife Service Ecosystem Management Plan - The Alaska Maritime National Wildlife Refuge (AMNWR) includes most of the oceanic islands and some areas of coastal Alaska from Dixon Entrance in southeastern Alaska to the Beaufort Sea. As part of a national mandate the AMNWR has adopted an ecosystem approach to management of its lands and resources. Nine ecological monitoring sites have been identified in different geographic portions of the refuge to monitor trends in populations and productivity of indicator species of seabirds to better understand ecosystem processes. Five of the sites are within the Bering Sea/Aleutian Islands ecosystem which has been identified by USF&WS to be an ecosystem of national priority. An additional three sites are in the Gulf of Alaska.

During spring 1994, ecosystem teams were established to develop and implement plans for research and resource monitoring within the ecosystem. The ecosystem team for the U.S. Fish and Wildlife Service's Bering Sea/Aleutian Island Ecosystem Management Plan in addition to identifying the four goals discussed previously, also identified four major issues of concern within this ecosystem. One was the impact of commercial fisheries on sea bird abundance (others were lack of knowledge about the ecosystem, introduced species, and pollution). Amongst the highest priority tasks identified to address this concern was the to conduct surveys and then to develop a model of the role fish play as sea bird and marine mammal prey in the ecosystem. As the first field work under this task the USF&WS (AMNWR), NMFS, National Biological Service, and University of Alaska (Fairbanks) formed a partnership to study ecosystem processes through coordinated studies on status of seabirds, marine mammals, forage fish, and oceanographic conditions at selected sites in the Aleutian Islands and Gulf of Alaska. The first year of the coordinated project called SMMOCI (Seabird, Marine Mammal and Oceanography Coordinated Investigations) focused on Aiktak and Ugamak islands adjacent to Unimak Pass.

Specific Ecosystem Concerns - As in previous years, there are a number of specific ecosystem concerns that the Council and NMFS should consider in the process of setting the 1996 groundfish TACs.

<u>Disproportionate harvest rates on groundfish</u> -- Large differences exist in the harvest rates of groundfish species off Alaska--some are harvested at or close to their F_{abc} levels while others are harvested substantially below them. Walleye pollock, Pacific cod, sablefish, and most of the rockfish species have been harvested at or close to their estimated ABCs since their history of management under the MFCMA. Flatfishes, on the other hand, have been exploited substantially below ABCs in both the BSAI and GOA.

The abundance of all flatfish species off Alaska (except for Greenland turbot in the Bering Sea) have been very high. In the Bering Sea, for example, the abundance of all flatfishes combined have increased from about 2.8 million t from 1979 to more than 6.7 million t in 1994. Their combined ABCs and TACS for 1994 was 868,400 t and 467,325 t, respectively. This represented a 46 percent under-utilization of the full ABC as set by the Council. In reality the catch of these flatfish species totaled less than 270,000 t in 1994; thus, flatfishes were 69 percent under-utilized. Because the utilization of the flatfish resources are constrained by bycatch limits for prohibited species (like crabs and Pacific halibut) and lack of commercial value, the resources have been severely under-exploited. Under-exploitation may have kept their biomass high; thus creating greater predation pressure on the prey community.

Disproportionately high biomasses of predator species would have great impacts on the trophodynamics of the marine ecosystem and shift the species composition. The flatfishes are major predators of forage fish (including juvenile pollock) and benthic organisms. Crabs that substantially overlap the fish feeding range would be subject to heavy predation. While more is known about crab-fish interactions, other crustacean resources, like shrimp, may also have been negatively impacted by high abundance of flatfishes.

Thus, as a step towards the ecosystem management, consideration should be given to balancing the exploitation rates of ground fishes. It is apparent that all the flatfishes resources off Alaska can be utilized at substantially much higher rates. The only exception would be the BSAI Greenland turbot resource.

The Plan Teams also identified the need to harvest species spatially in proportion to their biomass, if the stock or species was characterized by little movement between local stocks. This was the rationale used in the past to support spatial allocations for species such as walleye pollock in the GOA and Atka mackerel in the BSAI. The teams propose that this rationale be further extended to include Pacific Ocean perch in the AI.

Climatic changes -- This draft has included a section on "ecosystem change" and ongoing research on the subject. Shifts between warm and cool eras appear to occur on a decadel or greater (e.g., 18.6 years) frequency in the North Pacific Ocean. Such shifts in physical conditions may also be associated with changes in ocean productivity. A relationship between oceanic conditions and increased production of a variety of plankton, nektonic fish and cephalopods has been hypothesized. Year class strengths of commercially important species have also been related to oceanic temperature conditions. A review dating back to 1948 of 23 fish stocks indicates that 43% of them had more frequent strong year classes during a particular type of ocean temperature regime (e.g., warm or cold). A somewhat longer time scale relationship has also been hypothesized for salmon. Compelling links between ocean conditions and production can be seen in strong year classes of a number of Bering Sea fish stocks (pollock, Pacific cod, Pacific herring) spawned at the onset of warm current regimes (1976-77) that are accompanied by apparent simultaneous decline in stocks of some other finfish (e.g. capelin), shrimps, and king crabs).

Decreases in marine mammal and increases in the arrowtooth flounder population have been previously discussed. However, evidence is now accumulating of large decreases in the abundance of forage fish and fish eating seabirds in the GOA. Because of the apparent changes in the ecosystem components, the Plan Team encourages the Council to consider a broader look when setting TACs for individual species.

Forage fish species -- Based upon concerns expressed on this issue last year, a plan amendment has now been drafted to prohibit target fisheries on forage fish species in both the GOA and BSAI. As opportunities to harvest pollock decrease in the Gulf of Alaska, for example, the potential for displacement of fishing effort into new fisheries may increase. The development of new fisheries on underutilized species is not to be discouraged; however, significant changes in exploitation of forage fish, for example, may exacerbate efforts to manage declining populations of non-target species such as Steller sea lions and harbor seals. This draft amendment is now out for public review.

Predation on crabs by fishes in the Gulf of Alaska and Bering Sea -- The Plan Team notes that predation of crabs by groundfish may be a major factor that would impede recovery of crab stocks. In particular, crab larvae are subject to predation by pelagic fishes (e.g., pollock and salmon). Newly settled and juvenile crabs are consumed by Pacific cod and a variety of flatfish species. Older crab cohorts can be significant dietary items for halibut and Pacific cod, particularly when crabs have soft shells during the molt.

For snow crabs, estimates of annual consumption by groundfish from May through September for the Bering Sea ranged from 11 billion to 31 billion crabs. Snow crabs consumed by fish were primarily age 1, and to a lesser extent, age 2 and 3 crabs. Pacific cod is a primary predator of snow crabs. Other snow crab predators are yellowfin sole, flathead sole, and rock sole.

Annual consumption of Tanner crab by groundfish ranged from 10 to 153 billion crabs, consisting primarily of age-0 and age-1 crab. Their predators are Pacific cod, yellowfin sole and flathead sole. Little information is available concerning predation of red king crabs by groundfish; but the data indicates that predation may be low.

This low rate may be due to sampling during the summer months when king crabs have hard shells that may make them less vulnerable to predation.

Predation by groundfish are also likely to be a contributing factor in the continued low populations of GOA Tanner, Dungeness, and king crabs. Predation on larvae, juvenile, and adult crabs are thought to be similar to the Bering Sea.

Steller sea lions -- The Plan Teams identified several fishery concerns relevant to the continuing decline of Steller sea lions in the BSAI and GOA. One was diet diversity of sea lions. Discussion included within this report suggests that sea lions need a variety of prey available, perhaps as a buffer to significant changes in abundance of any single prey. The need to maintain a variety of prey for sea lions was the rationale for the BSAI Plan Team proposing that the AI pollock fishery be constrained as a bycatch only fishery.

Atka mackerel in the Aleutian Islands area is the primary summer prey for sea lions in the area. As the sea lion population is continuing to decline in the Aleutian Islands, the Council should also consider sea lion concerns when setting a TAC for Atka mackerel for the Aleutian area.

Finally, the Plan Teams wishes to note that a variety of near shore and pelagic areas have been identified as important foraging habitat for a variety of marine mammal and seabird species. Three of these are of particular concern--Steller sea lions (threatened under the ESA), red-legged kittiwakes (a candidate species for threatened status), and northern fur seals (depleted under the MMPA). As the Council considers the BSAI pollock allocation this year, concerns for the health of the populations of these and other species' foraging habitats should also be considered.

Species listed under the ESA -- There is a listing of the species that are designated as threatened or endangered under the ESA in a later section of this report. In addition to listing species under the ESA, the critical habitat of a species must be designated concurrent with its listing to the "maximum extent prudent and determinable". In compliance with this require of the ESA, NMFS has designated critical habitats for the Steller sea lion on August 27, 1993. These critical habitats include all rookeries, major haul-outs, and specific aquatic foraging habitats of the BSAI and GOA. The designation of these critical habitats continues for the 1996 fishing year.

Federal agencies are also required to initiate Section 7 (ESA) consultations with NMFS or USFWS for their actions (e.g., FMPs, regulatory measures, annual specifications of TACs) and make a determination as to whether the action may or may not affect endangered or threatened species. There were two such consultations made with the USFWS dated 3 July 1989 and 7 February 1995. The biological opinions of these consultations concluded that the groundfish fisheries of the BSAI and GOA would not jeopardize the existence of the endangered and threatened species of seabirds under the ESA.

PBR's under the MMPA -- The 1994 reauthorization of the MMPA provided for a long-term regime for managing marine mammal takes in commercial fisheries, replacing the Interim Exemption Program that had provided a general exemption on the MMPA take prohibition since 1988 for Alaska's groundfish fisheries. The cornerstone of the new regime is the calculation of Potential Biological Removals (PBRs) for each marine mammal stock. A list of the PBRs for all the marine mammal stocks off Alaska is contained in Table 4. The PBRs, the level of human caused mortality, and the overall status of the marine mammal stock are to be used to prioritize management of marine mammal/fisheries interactions.

This step identifies "strategic" and "non-strategic" stocks. The short term management goal is to reduce human caused mortality of strategic stocks below their PBRs, while the long term goal is for all fisheries to meet their "zero mortality goal" by April 2001. Under the currently proposed definition, the "zero mortality goal" would be met when total fishery mortality (all fisheries) is less than 10% of the stock's PBR, or in cases where total fishery mortality is above 10%, no individual fishery removal is more than 1% of the stock's PBR.

The MMPA goal of incidental takes would require a coordinated approach with fisheries management. Take Reduction Teams will be formed. One of the Teams to be formed will address Alaskan marine mammals, including Stellar sea lions.

Suggested recent reading -

Alpert, P. 1995. Incarnating ecosystem management. Cons. Biol. 9: 952-955.

Apollonio, S. 1994. The uses of ecosystem characteristics in fisheries management. Rev. Fish. Sci. 2:157-180.

Grumbine, R.E. 1994. What is ecosystem management? Cons. Biol. 8:27-38.

Stanley, T.R., Jr. 1995. Ecosystem management and the arrogance of humanism. Cons. Biol. 9:255-262. (a critique of Grumbine 1994)

BIOLOGICAL FEATURES

Demersal Resources

In January 1995, the North Pacific Fishery Management Council (Council) formed a committee to develop a rebuilding plan for Bering Sea crab stocks. The committee was composed of Bering Sea/Aleutian Islands (BSAI) Crab Plan Team and Groundfish Plan Team members, and was chaired by Council member Dave Fluharty. The committee synthesized available information on sources and magnitude of crab mortality and identified alternative management strategies the Council might use to enhance the survival of crab stocks and thus promote rebuilding (Witherell 1995).

Bering Sea crab stocks are at relatively low levels compared to historic National Marine Fisheries Service (NMFS) survey data collected since 1969. Data from the 1994 NMFS bottom trawl survey indicate that exploitable biomass of Bristol Bay red king crab (Paralithodes camtschaticus), and Bering Sea Tanner (Chionoecetes bairdi) and snow crab (Chionoecetes opilio) stocks are about one-fifth record levels (Stevens et al. 1994). The survey revealed that female red king crab stock in Bristol Bay was below a threshold of 8.4 million females > 90 mm (3.5", the size at 50% maturity). Very few pre-recruit red king crab were detected in the survey. The survey also indicated low abundance of pre-recruit Tanner crab, as a high proportion of sublegal males (<140 mm) had reached terminal molt, and consequently most could never be harvested. Although snow crab stocks were declining, a fair amount of pre-recruits was observed.

Directed crab fisheries are impacted by these low stock sizes. Red king crab stocks are at their lowest since the fishery was closed after the first stock collapse in 1983. In 1994 Bristol Bay was closed to red king crab fishing because the annual trawl survey indicated little prospect for increased recruitment of mature males or females, and female threshold was not reached. The Tanner crab fishery in the Bering Sea opened as scheduled, but with a much reduced guideline harvest level of 7.5 million pounds. Additionally, the area east of 163° W was closed to Tanner crab fishing to minimize handling of by caught red king crabs. The 1995 snow crab harvest was less than one-fourth of the record 1991 harvest (73.6 million pounds in 1995, 325 million pounds in 1991).

Developing a rebuilding plan for crab stocks will be complex due to the existing management regime, sources of mortality, and life history. Crab year class strength depends on the number of spawners and environmental condition such as temperature and currents (Tyler and Kruse 1995). Habitat availability for larval settlement and rearing is also likely to be important, particularly for red king crabs. Survival of juvenile crab after settlement until they reach maturity depends on a number of factors, which are listed in the accompanying table. Rebuilding crab stocks will hinge upon changing management strategies for crab and groundfish fisheries to maintain adequate crab spawning stock and provide suitable habitat. There is nothing that can be done about abiotic factors (temperature, currents, etc.) that likely play a larger role in determining crab year-class strength.

Sources of mortality for adult and juvenile crab in the BSAI.

Crab Fishery	Groundfish/Scallop Fishery	Natural Mortality
* fishery removals	* habitat impacts	* predation
* bycatch	* bycatch	* competition
* ghost fishing	* ghost fishing by pots	* parasites/disease
	* unobserved mortality	* other sources

The State has been conducting research on crab stock dynamics (Zheng et al. 1994, Zheng et al. 1995, Tyler and Kruse 1995), as well as evaluating changes to crab fishery management (Kruse 1993, Murphy et al. 1994, Kruse 1995, Zhou and Shirley 1995). A review of available information indicates that the impacts of bycatch mortality and ghost fishing remain unknown, but several studies are in progress. he State has instituted numerous regulatory changes in the past few years to reduce crab bycatch in the directed crab fishery. Crab bycatch in the directed fishery includes females of target species, sublegal males of target species, and non-target crab. Beginning in 1993, the Tanner crab season opened on November 1 to coincide with the red king crab fishery, This allowed retention of legal males of both species, thereby reducing bycatch (prior to 1993, the Tanner crab fishery opened 7 days after the Bristol Bay red king crab fishery closed). Additionally, some legal size male Tanner and snow crabs were retained when fishing seasons overlapped (prior to 1994/95). A regulation instituted in 1993 to restrict tunnel openings to a 3" maximum has reduced the bycatch of red king crab in both Tanner and snow crab fisheries, as indicated by the adjacent table (data from Tracy 1994). A regulation scheduled to be implemented in September 1995 will require all king crab pots in Bristol Bay to have at least one-third of one vertical surface of the pot composed of not less than 7.75" stretched mesh webbing.

Crab bycatch in the 1993 directed crab fisheries.

	Red king fishery	Tanner fishery	Snow fishery
legal males	2,022,165	7,209,948	228,487,123
non-legals	5,502,508	18,150,624	4,563,916
red king crab	-	233,272	24,465
Tanner crab	3,968,374	-	6,700,215
snow crab	20,012	1,485,835	-
hybrid C. spp.	nr	293,428	9,613,355

Fishery managers have been concerned with mortality of crab captured incidentally in scallop dredge and groundfish trawl fisheries and its impact on crab stocks. Together, these fisheries by caught about 248,000 red king crab, 3,700,000 Tanner crab, and 14,600,000 snow crab in 1993. Although these numbers may appear large, the total impact on crab populations may be relatively small because (1) bycatch accounts for less than one percent of the crab population annually, and (2) some bycatch survives. Total crab bycatch by groundfish fisheries has accounted for about 0.6% of the red king crab stock, 1.2% of the Tanner crab stock, and 0.1% of the snow crab stock in the Bering Sea as indexed by the 1992-94 NMFS surveys. When survival is factored into the equation, impacts of bycatch become smaller. Stevens (1990) found that 21% of the king crabs and 22% of the Tanner crabs captured incidentally in BSAI trawl fisheries survived at least 2 days following capture. Observations of the 1993 BSAI scallop fishery indicated immediate survival of by caught crabs was about 80-90% (Urban et al. 1994). On the other hand, potential impacts of dredging and trawling on crabs that are not captured by the trawl has proven difficult to quantify because they occur on the ocean floor and cannot be directly observed.

Crab bycatch in the 1993 groundfish and scallop fisheries, by gear type.

	Red king	Tanner	Snow
Trawl	248,121	3,412,342	14,631,617
Hook and Line	417	7,949	127,966
Groundfish pot	11	1,535	1,138
Scallop dredge	6	276,000	15,000

Trawling and dredging may also impact crab habitat, particularly living substrate on which young red king crab depend for food and protection from predators. Juvenile red king crab in the Bering Sea depend on both physical substrate and biogenic assemblages for settlement, food, and protection from predators. Both the physical substrate (cobble, shell) and biogenic assemblages (such as ascidians and tube-building polychaete worms) are vulnerable to trawling. Studies have shown that trawling and dredging impacts the seabed through scraping and ploughing, sediment re-suspension, and physical destruction, removal, or scattering of non-target benthos (Messieh et al. 1991, Jones 1992). In the Wadden Sea, scientists have observed destruction and elimination of erect epifaunal species (Reise 1982). If critical habitat is impacted by trawling and dredging, crab settlement and survival could be reduced, thereby lowering recruitment.

Areas have been closed to trawling to protect prohibited species and their habitats in the BSAI. Several of these areas were specifically closed to protect crab resources. Crab protection zones were first implemented in 1987 to prevent the incidental catch of adult male and female red king crabs in the domestic trawl fisheries. Zone 1 (Area 512) extends south of 58°N, between 160°W and 162°W, is closed to trawling year-round and covers a substantial portion of the red king crab mating area. An additional areas extends the Zone 1 closure west to 163°W from March 15 to June 15. The Pribilof Islands Habitat Conservation Area was implemented in 1995 to protect blue king crabs and their habitat. Due to the continued decline in the red king crab population, NMFS issued an emergency order in January 1995 to close to trawling the area from 57°N to 56°N, between 162°W and 164°W, the red king crab savings area. The Council made this a permanent time/area closure to reduce bycatch of adult red king crab. In January 1995, the Council initiated an analysis of a trawl area closure in northern Bristol Bay east of 162°W longitude and north of 58°N latitude. This area, as well as other nearshore areas in Bristol Bay, is known to contain juvenile red king crab habitat.

In the Bering Sea, juvenile red king crab live within <50m depth and have been found along the Alaska Peninsula, and around Kvichak and Togiak Bays (McMurray et al 1985). Within this area juveniles live among epifaunal communities, which are associated with gravel/cobble substrate. Suitable juvenile habitat is "extremely patchy" (McMurray 1985, Jewett & Onuf 1988) in Bristol Bay. Juvenile red king crab are solitary, cannibalistic, and require habitat that provides protection, such as tube building polychaete worms, sea onion, erect bryozoans, mussels, kelp, and ascidians (McMurry et al 1985, Stevens et al. 1992, Armstrong et al 1993).

Another factor that may impede stock recovery is the impact of competition with groundfish. Biomass of crab competitors (inshore benthic infauna consumers such as starfish and flatfish) has increased about 40% from 1979-1993. Most of this increase is attributable to a growing rock sole biomass, and to a lesser extent starfish and flathead sole biomass. Of the crab species, only snow crab comprises a substantial portion of the infauna consumer guild (species that eat clams, polychaetes, etc.). Yellowfin sole had dramatically increased in abundance in the early 1980's to become the largest component of this guild until the early 1990's when rock sole became co-dominant. Mean size at age has declined for yellowfin sole and rock sole, indicating stress caused by competition, and to a lesser extent a decrease in average bottom temperature.

Predation by groundfish may be a major factor affecting the recovery of crab stocks. For snow crabs, estimates of annual consumption by groundfish from May through September ranged from 11 billion to 31 billion crabs (Livingston et al. 1993). Snow crabs consumed were primarily age 1, and to a lesser extent age 2 and 3 crabs. Pacific cod is a primary predatory of snow crab, particularly soft shell female and juvenile crab (McLellan & Leong 1981, Livingston 1989, Livingston et al. 1991). Flathead sole, yellowfin sole, and rock sole have been found to be predators on younger snow crabs (Haflinger and Roy 1983, Livingston et al. 1993). Annual consumption of Tanner crabs by groundfish ranged from 10 billion to 153 billion crabs, consisting primarily of age-0 and age-1 crabs (Livingston et al. 1993). Yellowfin sole and flathead sole were found to be the primary consumers of Tanner crabs < 20 mm. Pacific cod also preyed on young crabs, and were responsible for all of the larger (20-35 mm) Tanner crabs consumed. The little information concerning predation on red king crab suggests that mortality caused by groundfish predators may be low, however, that sampling occurs in the summer, when king crabs have hard shells and less vulnerable to predation.

Pelagic Resources

Forage fish - A draft analysis of Amendment 36 to the Fishery Management Plan for the groundfish fishery Of the Bering Sea and Aleutian Islands Area and Amendment 39 to the Fishery Management Plan for groundfish of the Gulf of Alaska to prohibit a directed fishery on specified forage fish species will undergo initial review by the Council at its September 27 through October 2, 1995 meeting. This environmental assessment provides analysis on alternatives that prohibit a directed fishery on certain groundfish known as "forage fish". The purpose of this action is to prevent the development of a directed fishery on the forage fish species (FFS). For the purpose of this analysis forage fish are defined as capelin, eulachon, rainbow smelt, Pacific sand lance, Family Myctophidae, Family Bathylagidae and Pacific sandfish. The intent of this measure is to limit forage fish from being overexploited as they are essential components in the ecosystem.

Salmonids - The size of the state and the differences between the various species makes it difficult to estimate the size of Pacific salmon runs in Alaska. The reporting of catch, however, provides a proxy of the relative run strengths of each species. However, factors affecting the fish or fishers can have some influence on the catch statistics. Examples of such factors include fishery closures in the early 1990's to protect chinook salmon in Western Alaska, fishery strikes for better prices, and the closure of fisheries or impacts on fisheries due to the 1989 Exxon Valdez oil spill.

The catches of salmon in directed fisheries across all gear groups during the years 1990 - 1994 in the State of Alaska are provided in Tables 1-2. Although the statistics are collected by Alaska Department of Fish and Game (ADF&G) management area, the catch has been summarized into the following principal areas: (1) Southeast area (ADF&G Management areas A - Juneau, B - Ketchikan, C - Petersburg, D - Sitka); (2) Gulf area (ADF&G Management areas E - Prince William Sound, H - Cook Inlet, K - Kodiak, L - Chignik, M - Alaska Peninsula); and (3) Bering Sea area (ADF&G Management areas T - Bristol Bay, Q - Bering Sea, W - Kuskokwim, X - Kotzebue, Y - Yukon, Z - Norton Sound). The highest catch during the five year period 1990 - 1995 was in 1994 when approximately 196 million fish and 866 million pounds were taken. Pink salmon have consistently been taken in the highest numbers, and sockeye salmon have comprised the highest amount of weight in all but one year (Table 1).

The catch of chinook salmon is generally split between Southeast Alaska and the Bering Sea, and this species comprises between 0.3% and 0.4% of the total catch (numbers) of all species combined in any given year. The greatest catch of sockeye salmon occurs in the Bering Sea, and virtually all of this catch is taken in the Bristol Bay management area. Sockeye salmon catch in numbers has comprised between 24% and 43% of the catch across the years presented in Table 1. Pink salmon are primarily taken in the Gulf of Alaska and Southeast Alaska, comprising between 44% and 68% of the total number of salmon caught each year.

Chum salmon catch has risen consistently over the five year period, and the number taken in 1994 doubled the 1990 catch. Although not following the same increasing trend, coho salmon catch in 1994 also doubled the 1990 catch. Over the five year period, coho salmon have comprised between 3% and 5% of the total catch, and chum salmon have comprised between 5% and 8% of the total catch.

Seabirds

Declines in kittiwake and murre populations have been recorded in the eastern Bering Sea (i.e., Pribilof Island area) since at least the mid-1970s (Byrd et al. 1993; Hatch 1993; Hatch et al. 1993). Kittiwake nesting success has frequently been very low at many colonies in the Bering Sea over the past 15 years (Hatch et al. 1993), and breeding failures were recorded at most colonies in this region in (G. V. Byrd, AMNWR, USF&WS, pers. comm. 1995).

Piatt and Anderson (in press) have now documented similar declines for common murres (Uria aalge; Table 3) throughout most of the Gulf of Alaska (the Semidi Islands excepted). Declines were noted at levels equal to or exceeding those found in areas effected by the T/V Exxon Valdez oil spill. Declines at specific colonies ranged from -39% to -96% since 1989. They also note large (>50%) declines the Gulf of Alaska in either breeding success or adult population size for black-legged kittiwakes (Rissa tridactyla), marbled and Kittlitz's murrelets (Brachyramphus spp.), cormorants, and horned puffins (Fratercula corniculata).

Marine Mammals

Population assessments - As part of the Marine Mammal Assessment Program conducted by the NMFS and USF&WS estimates of recent population size have now been prepared for most Alaskan marine mammals (Table 4). No new population surveys effort were conducted in Alaskan waters during CY 1995.

Steller sea lion status - The U.S. population of Steller sea lions (Eumetopias jubatus), which numbered close to 192,000 adults and juveniles (nonpups) 30 years ago, declined by 64% to less than 69,100 nonpups by 1989. The only area unaffected by the decline was from Southeast Alaska to northern California. As a result of these declines, the National Marine Fisheries Service (NMFS) published a final rule in the Federal Register on November 26, 1990 (55 FR 49204) listing the Steller sea lion as a threatened species under provisions of the Endangered Species Act (ESA).

The Steller sea lion population in the U.S. has declined to 52,200 animals (-24%) since 1989 (Fig. 1). Most of this decline occurred in southwestern Alaska (the Gulf of Alaska, Aleutians Islands, and Bering Sea) where abundance of nonpups decreased 35% (-8% per year) during 1989-94. Numbers in southeast Alaska, Oregon, and northern California remained stable, although declines have continued in central California. Pup numbers in the Gulf of Alaska and Aleutian Islands declined at a rate of 8% per year during 1990-94, while Southeast Alaska and Oregon pup production also remained stable. In 1994, the U.S. eastern stock (east of Cape Suckling) included an estimated 18,600 nonpups and the western stock included 33,600 nonpups.

Population trends from 1990 through 1993 and a population viability analysis suggested that the NMFS should reevaluate the status of the species. Therefore, on November 1, 1993, NMFS published in the Federal Register (58 FR 51318) that it would review the status of the U.S. Steller sea lion population. As part of this process, a status review report was prepared which summarized all available information on the species and its status through the June-July 1994 population assessments. This report is available from NMFS, Office of Protected Resources offices in Juneau and Washington, D.C.

The Steller Sea Lion Recovery Team met in November 1995 to consider whether the status of the species should be changed. Based on population data through summer 1994 they recommended that the western stock be listed as endangered and the eastern stock remain listed as threatened. This nonbinding recommendation was forwarded to NMFS but as of August 1995 no decision had been made by the NMFS Directorate.

Steller sea lion GOA/AI food habits - Food limitation has been suggested as the most likely cause of the Steller sea lion population decline in Alaska. In this study, we examined the diet of Steller sea lion for June-August (summer) of 1990-93 using fecal materials collected at rookeries and haul-outs from the western Aleutian Islands to the central Gulf of Alaska. Diets in all areas were dominated by one or two taxa (walleye pollock, Theragra chalcogramma, or Atka mackerel, Pleurogrammus monopterygius) of the seven taxa analyzed and the dominant taxon changed from east (pollock) to west (Atka mackerel). Only the western Gulf of Alaska-eastern Aleutian

Islands area had all seven taxa in the diet. In that area, Atka mackerel and walleye pollock each made up around 25% of the diet with the remainder composed of forage fish, other demersal fish, and salmon. The diet in the central Gulf of Alaska generally included mostly walleye pollock as fish prey, while the central and western Aleutian Island's diet was composed mostly of Atka mackerel. These differences between areas produced distinctly different diet diversities and a strong negative correlation ($r = -0.959$) was found between diet diversity and the amount of decline in an area--as diet diversity increased, population declines decreased. This suggests that sea lions need a variety of prey available, perhaps as a buffer to significant changes in abundance of any single prey.

ECOSYSTEM CHANGE

A major shift in the physical oceanography of the North Pacific Ocean occurred around 1976-77 (Kerr 1992; Francis and Hare 1994; Trenberth and Harrell 1995). In the subarctic North Pacific Ocean (the Bering Sea, Aleutian Islands, and Gulf of Alaska) this was manifested in increased sea surface temperatures (SST) and winds, which changed the mixed layer depth and intensified ocean transport (Royer 1989; Tabata 1989; Polovina et al. in press). Shifts between warm and cool eras appear to occur on a decadal or greater (e.g., 18.6 yr) frequency in the North Pacific Ocean (Royer 1989; Hollowed and Wooster 1992; Royer 1993; Trenberth and Harrell 1995; Wooster and Hollowed 1995).

Such shifts in physical conditions may also be associated with changes in ocean productivity. First, Venrick et al. (1987) have shown that primary production began to increase in the area north of the Hawaiian Islands around 1976/77, due to an apparent deepening of the mixed layer depth (Venrick 1995). Modeling of the phytoplankton response to the shoaling of the Gulf of Alaska mixed layer suggested that primary production had probably increased there as well (Polovina et al. in press). Next, Brodeur and Ware (1992) found that zooplankton production had doubled in the Gulf of Alaska between 1956-62 and 1980-89. They hypothesized that this was either because 1) primary production increased during 1980-89 from the increased Ekman pumping of nutrients into the upper mixed layer brought on by increased surface winds, or 2) winds decreased the mixed layer depth, slowed phytoplankton production, and allowed zooplankton to more efficiently graze the phytoplankton.

A relationship between oceanic conditions and increased production of a variety of nektonic fish and cephalopods has also been hypothesized (Beamish and Boullion 1993; Beamish 1994; Francis and Hare 1994; Polovina et al. in press; Beamish and Boullion 1995; Brodeur and Ware 1995; Hare and Francis 1995; Hollowed and Wooster 1995). One mechanism for this increased production could be the coupling of increased zooplankton production with transport into areas favorable for consumption by the zooplanktivores (Brodeur and Ware 1992). A general relationship between oceanic SST (as a proxy for other physical factors) and year-class strength of fishes has been hypothesized by Hollowed and Wooster (1995). They found in a review dating back to 1948 of 23 fish stocks that 43% had more frequent strong year-classes during a particular type of ocean temperature regime (e.g., warm or cool). A similar relationship has been hypothesized for Alaska salmon stocks but on a somewhat longer time-scale (Francis and Hare 1994; Hare and Francis 1995). One of the most compelling pieces of evidence supporting a linkage between ocean conditions and production is the strong year-classes of a number of Bering Sea fish stocks (e.g., walleye pollock, Pacific cod, Pacific herring) spawned at the onset of the current warm regime in 1976-77 accompanied by the apparent simultaneous decline in stocks of some other finfish (e.g., capelin; Anderson et al. 1994) and shellfish (e.g., pandalid shrimps, Albers and Anderson 1989; king crab, Otto 1989 and Kruse 1993).

EFFECTS OF HUMAN ACTIVITIES ON THE BS/AI AND GOA ECOSYSTEMS-- BYCATCH AND DISCARDS

Absolute Estimates of Bycatch and Discard by Groundfish fisheries in the Bering Sea/Aleutian Islands and Gulf of Alaska, 1991-94 - There are many reasons why groundfish fisheries discard groundfish. Among these are: 1) the directed fishery for a given species, say species A, may be closed (due to quota or other restrictions) forcing all other fisheries which catch species A as bycatch to discard it; 2) individual fish in the catch are too small or large for mechanical processors, or are the wrong sex (e.g., males in the rock sole roe fishery); 3) to change the species composition of their total catch for the reporting week, preventing the vessel from being considered a "participant" in a particular fishery for that week, and as such, subject to different, possibly more stringent, prohibited species bycatch rate standards set by the North Pacific Fishery Management Council; 4) a lack of handling or processing capacity aboard the vessel; or 5) market limitations on the utilization or retention of certain species. Particularly for various roundfish fisheries (e.g. pollock, Pacific cod, Atka mackerel and rockfish), the size composition of the target species population can greatly affect the rate of discard by the fishery. If a pre-recruited year-class is very strong, large catches of fish too small for market may be unavoidable, increasing the rate of discard. Discards are subtracted from catch tonnage prior to calculation of product recovery rates, but discarded fish are included as part of the total harvest for in-season management. For a more thorough treatment of the biological, ecological and economic impacts of bycatch and discard in the groundfish fisheries of the North Pacific, the reader is referred to a recent summary by Queirolo et al. (1995).

Data sources - Estimates of the discard of groundfish and other species, and the bycatch and discard of prohibited species from 1991-1994 for domestic fisheries are presented in Tables 5-8. These are based on a blend model incorporating observer data and processor weekly production reports.

The "other" species category listed in Tables 7 and 8 consists of squids, octopus, smelts, sharks, skates, and sculpins, among others. These species have a collective allocation or catch quota in both the Bering Sea/Aleutian Islands and the Gulf of Alaska. Currently there is no significant directed fishing on these species in the BSAI and GOA. Records of catches of "other" species exist in observer sample data as well as in weekly processor reports and fish tickets. To investigate the species composition of the "other" species category and how this is affected by gear and target fishery, catch rates of each of the species groups listed above (and more, including grenadiers, eelpouts, snipe eels, greenlings, lumpsuckers, hagfish, ratfish, and poachers) by each target fishery and gear were obtained from the observer data base (NORPAC). These rates were then applied to the target species/gear catches in the "blend" file to obtain estimates of the catch weights of each "other" species group in the BSAI and GOA in 1991-93 (Tables 7.A. and 8.A.). In theory, the total obtained using this method should be similar to the total listed in the Other species category in Tables 5 and 6.

Groundfish and other allocated species - The average total discard rate of groundfish and other allocated species (sum of total discards/sum of total catch) by the domestic groundfish fisheries in the BSAI from 1991-94 was 15% (Table 5). Flatfish have been discarded at higher average rates than round fish. For flatfish species that are commonly retained (not including arrowtooth flounder and other flatfish), discard rates have ranged from a low of 27% for yellowfin sole to a high of 61% for rock sole. By contrast, roundfish average discard rates have ranged from a low of 3% for sablefish to a high of 30% for all rockfish combined. However, the tonnage of pollock discarded has been much greater than any other species in the BSAI (despite the average discard rate of 9%) because the pollock fishery is the largest groundfish fishery by far in the BSAI. Pollock discards, on average, have accounted for over 40% (127,600 t) of the 304,900 t of groundfish and other species discarded in the BSAI in 1991-94. Reaccumulating total discards by fishery rather than by species yields similar results, with higher average total discard rates for flatfish fisheries (ranging from 20% for Greenland turbot to 66% for rock sole) than for roundfish fisheries (ranging from 6% for pollock to 42% for sablefish). Pollock fisheries have accounted for an annual average of about 30% (91,800 t) of the 304,900 t of groundfish discarded by BSAI groundfish fisheries in 1991-94.

In the GOA, the average groundfish discard rates by the groundfish fisheries in 1991-94 was 20%, slightly higher than in the BSAI (Table 6). This may, in part, be due to the classification as discards of some pollock from shore side plants that was converted to fish meal. However, the total tonnage discarded has been much smaller than in the BSAI, averaging 52,400 t in 1991-94. In the GOA, discards of arrowtooth flounder (19,900 t) comprised more than a third of the average total annual discards from 1991 to 1994, while average annual pollock discards were the second largest (11,700 t). By fishery, flatfish fisheries in the GOA have also had higher total average discard rates (ranging from 43% for shallow flatfish to 63% for deepwater flatfish fisheries) than roundfish fisheries (ranging from 7% for pollock to 31% for rockfish).

Prohibited species: catch trends - Total catch and discard amounts and rates in Tables 5 and 6 do not include the mandatory discards of Pacific halibut, Pacific herring, salmon, and all king and Tanner crabs by groundfish fisheries. Groundfish fisheries are prohibited from retaining these species[1] to eliminate any incentive to target on them. Blend estimates of catches and discards of prohibited species in 1991-94 are listed in Tables 7.B. and 8.C. for the BSAI and GOA groundfish fisheries, respectively. These data are catches and discard estimates, not estimates of mortality which are used for in-season management of halibut bycatch (Williams, 1994). In 1994, inclusion of the discards of prohibited species with the discards of groundfish and other species by all BSAI groundfish fisheries increases the estimates of total discards and total catch by 18,811 t (to 313,551 and 2,013,080 t, respectively), and the total discard rate by only 0.8% (to 15.6%; Tables 5 and 7.C.II). However, in the GOA, the estimates of total discards and total catch increase by 10,889 t (to 54,316 and 250,904 t, respectively) and the total discard rate by 3.5% (to 21.6%; Tables 6 and 8.C.II).

Bycatch of salmon - A historic high of approximately 113,000 chinook salmon were taken by foreign groundfish trawl fisheries in 1980 in the Bering Sea (Table 9). The highest bycatch in the domestic trawl fisheries was approximately 46,000 chinook salmon in 1993, and approximately 44,000 chinook were by caught in 1994. The highest number of chinook salmon by caught in the Gulf of Alaska was approximately 74,000 fish in 1984, and more recently, a high of approximately 38,000 chinook were by caught in 1991.

Prior to 1993, "Other salmon" bycatch (predominantly chum salmon) saw an historic high of approximately 72,000 fish the 1984 joint venture and foreign fisheries. A record high of 243,000 other salmon were by caught by the Bering Sea domestic trawl fleet in 1993, and approximately 96,000 fish were taken in 1994 as well. The highest bycatch of other salmon in the Gulf of Alaska was approximately 56,000 fish by caught in 1993.

Other species - In both the BSAI and GOA, almost all of the "other" species caught are discarded. As shown in Tables 7 and 8, the "other" species category consists primarily of skates and sculpins in the BSAI, and grenadiers in the GOA. The data in Tables 5 and 6 represent the blend estimates of total "other" species discards, which are not broken out by species or species groups. Observer data-based discards of other species in Tables 7 and 8 were calculated by multiplying the catch rates of individual other species or species groups in each fishery, gear and in each area by the target species catches, and applying the annual other species discard rate (Tables 5 and 6).

[1] Pacific salmon by catches have been retained in the BSAI groundfish trawl fisheries under an experimental program whereby it is processed and delivered to agencies which distribute food to the needy through food bank programs.

In the BSAI, annual blend estimates of discard were slightly lower than the expanded observer estimates for 1991-93. Annual blend estimates ranged between 22,900 t and 29,800 t, while expanded observer estimates ranged from 28,600 t to 30,300 t for the same period. However, these differences made little difference in the overall average discard rate (including prohibited species) of BSAI groundfish fisheries (compare discard rates I and II in Table 7.C.).

In the GOA, blend estimates of other species discards were always less than the expanded observer estimates of "other" species catches: in 1992 and 1993 the blend estimate was considerably less than half the expanded observer estimate. Almost all of this difference between the two totals was due to by catches of grenadiers by the sablefish hook and line fishery (Fritz 1994). Apparently, there could be under-reporting of the catch of other species in the GOA by unobserved vessels. The GOA sablefish fishery has been one of the least-observed fisheries (about 10% or less of the target species catch) in the North Pacific because of the large number of small vessels in the fishery. Use of the observer-based estimates of other species discard increases the total discard rate (including prohibited species) by GOA groundfish fisheries by 2-3% in 1992 and 1993 (compare discard rates I and II in Table 8.C.).

Potential Ecosystem Impacts of Bycatch and Discards - Several aspects of the current discarding and processing practices of North Pacific groundfish fisheries have the potential to alter the regular paths of energy flow and balance in the Bering Sea and Gulf of Alaska. Although estimated mortality due to discards of utilized groundfish species is accounted for in the stock assessment process, little is known about its ecosystem-level effects. Fishing removes biomass from the system but discarding and fish processing return some biomass back to the system. The recipients, locations, and forms of this returned biomass may differ from those in an unfished system. The fishing process itself may cause unobserved mortalities in animals escaping through the trawl mesh or caught by abandoned pots or long lines. Finally, mortality of bottom-dwelling animals can also be caused by the mechanical action or weight of fishing gear on the bottom.

Discarded catch weights of species targeted in groundfish fisheries can be compared to population biomass and to total catches (discards + retained) in the BSAI and GOA. As noted before, these discards are accounted for in stock assessments of the main groundfish species targets. Discard amounts relative to population biomass are low, ranging from 5% of biomass for arrowtooth flounder to less than 1% of population biomass for Atka mackerel and sablefish in the BSAI and less than 2% of any of the allocated species biomasses in the Gulf of Alaska. Highest discard amounts relative to total catch occur for arrowtooth flounder and the miscellaneous species category "other." Rock sole and other flatfish in the Bering Sea also have high discard percentages of around 60-75% of total catch. Intermediate discard rates (25-40% of total catch) are seen in the rockfish, yellowfin sole, Greenland turbot, deepwater flatfish, and shallow flatfish groups. Lowest discard rates (2%-17%) are seen for sablefish, Atka mackerel, pollock and cod.

Groundfish fishery discard mortalities for prohibited species can be compared to the amounts landed of each prohibited species in their respective target fisheries and to population size. The weight of dead halibut discarded in groundfish fisheries in the Bering Sea is approximately equal to landed weight in the Bering Sea halibut fishery but is only about 3.5% of the estimated population biomass in that area. Many of the halibut caught in groundfish fisheries in the BSAI are juveniles, which might have recruited to other areas such as the Gulf of Alaska or even off the coast of British Columbia. The amount of dead halibut discarded in groundfish fisheries in the Gulf of Alaska is only about 11% of halibut landings in that area. Herring bycatch in groundfish fisheries in the eastern Bering Sea during 1993 was only 3% of herring landings in the eastern Bering Sea. The amount of chinook and other (primarily chum) salmon caught in groundfish fisheries could be around 20% of the landed catch number in the Bering Sea and less than 4% in the Gulf of Alaska. However, because chum salmon are widely ranging, the rivers of origin for chum intercepted by groundfish fisheries could be rivers that empty into the Gulf of Alaska, Bering Sea, and also the western side of the North Pacific. Mortality of crab induced by groundfish fisheries in the eastern Bering Sea is around 18% of the landed number of bairdi Tanner crab and 9%

of the red king crab landings in that area. Because some of the bairdi Tanner crab caught by groundfish fisheries are pre-recruit crab, the actual number of those pre-recruits that would have survived to enter the directed crab fishery is less than the number caught by groundfish fisheries.

Estimates of mortality due to discards in the target fisheries or in other non-groundfish fisheries are not available for all prohibited species. However, these discard mortalities can be larger than those induced by groundfish fisheries. For example, the bycatch of bairdi Tanner crab in crab pots during the 1993 bairdi crab season was estimated to be 68,910,000 crabs. If a mortality factor of 8% is applied to these, then discard mortality of bairdi crab in crab pot fisheries was about 36% of the landed number of bairdi crab, which was 15,317,000 crabs. Similarly, for red king crab in 1992 the crab pot fishery discarded around 7,320,000 crabs. If mortality is again assumed to be around 8%, then crab pot fishery discard mortality of red king crab was around 40% of the red king crab landings, which were 1,415,000 crabs, or about four times larger than the mortality induced by groundfish fishery discards..

The mortality of groups such as skates, sculpins and grenadiers, which form the largest amount of the bycatch of "other" species in groundfish fisheries, has not been explicitly considered in the past. The amount of these "other" species groups discarded in groundfish fisheries can be compared to biomass estimates of these species to get an idea of the impact of fisheries on these groups. Exploitation rates (catch biomass/population biomass) are low for skates and sculpins in the BSAI and GOA areas, ranging from 1-4%. The exploitation rate for grenadiers in the Gulf of Alaska appears high (32%) but biomass estimates of grenadiers are severely underestimated by bottom trawl surveys in the GOA that cover bottom depths up to 500m since the majority of grenadier biomass is found in waters deeper than 500m.

Consumers of discards and fish processing offal - Several years of groundfish food habits data collected by the Trophic Interactions Program at the Alaska Fisheries Science Center confirm the consumption of fish processing offal by fish in the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska. Estimates of groundfish consumption of offal in the Bering Sea during the main feeding season show a level of offal consumption by several species of groundfish approaching 200,000 mt/yr (Table 10). Although the estimated total amount of offal consumed by pollock is fairly high at around 45,000 mt/yr, the percentage of offal in the diet is less than 1% by weight. It is the large biomass of pollock relative to other predators that brings its estimated consumption up to this level. Pacific cod consumed the most offal compared to other groundfish in 1990 and 1991. The percentage by weight of offal in the diets of Pacific cod and skates is higher than the other groundfish species sampled in the eastern Bering Sea.

Diet information on groundfish from the Gulf of Alaska and Aleutian Islands (Yang, 1993 &1995) also show several species consuming unground offal (Table 11). In the Gulf of Alaska, sablefish had the largest percentage by weight of offal in the diet (29%), followed by Pacific cod (13%) and Pacific halibut (7%). The amount of offal in the diet of groundfish from the Aleutian Islands is low, except for northern rockfish (9% of the diet by weight). It should be noted that the diet percentages for the Gulf of Alaska and Aleutian Islands region were derived from grouping all food habits data for a species over the whole region. Lower percentages would likely result from predator-size and area stratification of the diet information.

An estimate of the amount of offal returned to the sea by at-sea and onshore processors can be obtained from subtracting the total round weight of the groundfish catch retained and processed from the product weight, which is available for 1994 (Table 12). Estimated at-sea offal production in the GOA and BSAI is 862,483 mt (= round wt of the catch(1,240,858) - product wt (378,375)) and shore side offal production is 477,312 mt. Presumably, the majority of the at-sea offal is produced in the Bering Sea and consists of pollock parts. Based on the estimates in Table 10, it appears that groundfish in the eastern Bering Sea consume at least 20% of the at-sea offal produced. This compares to an estimate of about 11% of total discards consumed by fish and crab in a study area off Australia (Wassenburg and Hill, 1990).

Other upper-trophic level scavenger species likely to benefit from offal production include sculpins, crabs, other predatory invertebrates, and marine birds such as gulls and fulmars. Studies performed in the North Sea and Australia indicate that birds are a likely recipient of discards and offal thrown overboard during daytime and which do not immediately sink (Anon., 1994; Evans et al., 1994; Wassenburg and Hill, 1990), while crabs may be the first to arrive in areas when discards reach the bottom (Wassenburg and Hill, 1987). Offal not consumed by these predators would presumably be decomposed by bacteria and also become available as detritus for benthic filter-feeding invertebrates.

Estimates are not available for groundfish consumption of whole animal discards in the BSAI and GOA areas. When analyzing stomach contents of groundfish, it is impossible to discern whether a whole animal in the stomach contents was consumed when alive or dead. Presumably, whole discards are consumed by the same scavengers that consume unground offal.

Table 12 provides a summary of the magnitude of offal and discard amounts relative to catch in the BSAI and GOA groundfish fisheries. The weight of offal returned to the sea is almost four times as large as the weight of discards. About 70% of the target catch is returned as offal. Almost 60% of the total catch becomes offal while only 15% of the total catch is discarded whole. Obviously, when considering energy transfer in the ecosystem, offal production overshadows discard amounts. The large proportion of the total catch returned to the sea as offal and discards could reduce any potential impacts of fishing to energy loss in these areas. However, availability of the returned energy (as offal and discards) to various ecosystem components may differ from that of the undisturbed energy form (live fish).

Ecosystem level concerns about discards and offal production primarily center on the possibility that these practices might alter the regular paths of energy flow and balance and enhance the growth of scavenger populations. In the eastern Bering Sea, at least half of the discards and most of the offal produced are from pollock. Most of the remaining discards tends to be flatfish such as yellowfin sole and rock sole. All of the groundfish species found to be consumers of offal are also predators of pollock, and some of them (Pacific cod and halibut) also consume flatfish (Livingston et al., 1993). The scavenging birds (gulls, fulmars) are also documented predators of pollock (Hunt et al., 1981). The annual consumptive capacity of these scavenging birds, groundfish, and crab in the eastern Bering Sea alone is over an order of magnitude larger than the total amount of offal and discards in the BSAI and GOA (Livingston, unpublished data). Although fishing removes some biomass from the system, the actual amount removed in the BSAI and GOA is much less than the total catch would indicate. A large proportion of the total catch is returned and apparently consumed by predators.

Even if offal and discards are not used by the upper trophic level scavengers that are a regular part of the energy pathway for pollock and flatfish, the total amount of dead organic material (detritus) that would reach the bottom is small relative to other natural sources of detritus. Walsh and McRoy (1986) estimate detrital flow to the middle and outer shelf of the eastern Bering Sea to be 188 $gCm^2 yr^{-1}$ and 119 $gCm^2 yr^{-1}$, respectively. When converted to biomass over the whole area[2], an estimated 337.7 million mt of naturally-occurring detritus goes to the bottom each year. Approximately 40% (142.9 million mt), is unused (Walsh and McRoy, op. cit.). The total offal and discard production in the BSAI and GOA as estimated for 1994 (1.7 million mt; Table 12) is only 1% of the estimate of unused detritus already going to the bottom. Simulation model results of discard effects on energy cycling in the Gulf of Mexico (Browder, 1983) confirmed that discards tend to be a small portion of the dead organic material on the bottom. However, depending on model assumptions, changing the amount of discards through full utilization or through selective fishing methods had the potential to change populations of shrimp and its fish competitors. Uncertainty about the predation rates and assumptions about alternate prey

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[2]Assuming 0.4 g C/1g dry weight and 0.5 g dry weight/1g wet weight, and total middle shelf area = 4 x 10^5 km^2 and outer shelf area = 2.2 x 10^5 km^2.

utilization indicated a need for further research to fully understand and predict responses of populations to changes in food availability.

Local enrichment and change in species composition in some areas might occur if discards or offal returns are concentrated there. There is evidence that such effects have been seen in Orca Inlet in Prince William Sound and in Dutch Harbor, Alaska. Poor water quality and undesirable species composition have been cited (Thomas, 1994) as the result of the current policy for grinding fish offal released in inshore areas and the inadequate tidal flushing in that region. However, deepwater waste disposal of offal in Chiniak Bay of Kodiak Island has not shown such problems (Stevens and Haaga, 1994). No apparent species composition changes, anaerobic conditions, or large accumulations of offal occurred in Chiniak Bay where such wastes have been dumped for over a decade. Local ocean properties (water depth and flow) and amount of waste discharged per year could be important factors determining the effect of nearshore disposal on local marine habitat and communities.

So far, most of the scavenger populations are not showing obvious signs of increase related to offal production. The only member of that group that might be exhibiting a constant increasing trend in biomass is the skates, whose biomass has doubled between 1982 and 1993. Little is known about the skate population, such as size or age-frequency over time, that might provide clues to why this change in biomass has occurred.

Unobserved mortalities - There is an unknown amount of unreported discard of Pacific cod, rockfishes, and other ground fishes in the unobserved portion of the fleet. These discards re largely management driven as it is illegal to land bycatch in excess of directed fishing standards. Unreported mortality is currently estimated for demersal rockfish in the GOA but unreported discard of other species is largely unaccounted for.

The fishing process itself may cause unobserved mortalities in animals that escape through the mesh of trawls or that are damaged by the action of the trawl passing over them. In addition, longline and pot gear may continue to fish after being lost or abandoned. A recent review of studies on the condition of fish escaping from fishing gear (Chopin and Arimoto, 1995) found a wide range of estimated mortalities. Percent mortality of fish escaping from trawl gear ranged from 9% to 90% depending on the fish species, size of fish, and conditions of the experiment. Fish with an opercular circumference of the same or larger size as the mesh may sustain more physical damage than smaller fish but stress inflicted due to the capture process (long sustained periods of swimming, etc.) can also be an important source of mortality for all fish. The authors suggest that standard protocol for conducting survival experiments, including longer term studies to estimate survival due to stress are required before knowledgeable decisions regarding the effect of mesh size restrictions can be evaluated. They advise that management measures undertaken to increase escapement of immature fish by increasing minimum mesh size could also increase mortality and conclude that such measures may not be the best method for protecting immature fish.

The evidence regarding the mortalities of animals in or on the bottom and possible long term changes in the bottom due to fishing gear shows mixed conclusions. Comparison of gear-induced mortality rates with natural mortality rates of the benthos in the heavily fished North Sea indicated that natural mortality rates were much larger than those from fishing (Daan, 1991), suggesting that fisheries exert a relatively small influence on the biomass of benthos. Most studies agree, however, that the larger, longer-lived animals in the sediments such as some clams are likely to be the most affected (Daan, 1991; Anon., 1994). Long-term changes in the benthos and persistence of trawl tracks have been found particularly in very deep water (Jones, 1992). Even though direct contact with gear may not inflict direct mortality, the gear action can expose burrowing animals and make them more vulnerable to predation (Kaiser and Spencer, 1994). It has been hypothesized that intensive fishing in an area could promote long-term changes in benthic communities by promoting populations of opportunistic fish species that migrate into fished areas to feed on animals disturbed by the fishing process.

Diet of a benthic-feeder, yellowfin sole, was examined during the period from 1984 to 1991 to determine if any changes have been apparent and could be linked to fishing activities in the eastern Bering Sea (Fig. 2). Prey composition was analyzed in two adjacent areas, a no-trawl zone (area 512 where trawling has been excluded since 1986) and a trawl zone (a similar size area just west of 512 where trawling still occurs in the eastern Bering Sea). No definitive trends in diet composition could be seen between the two areas that might be linked to trawling. Polychaete worm consumption was similar between the two areas. Echiuran worms predation increased in the trawled area compared to the no-trawl area. These are relatively short-lived worms that burrow in the sediment. Trawling could expose these animals and make them more vulnerable to predation immediately after a trawl passed through. If trawling were responsible for the increase in predation on echiurans, it would have been expected that the fraction of echiurans in the diet would have been consistently high in the trawl zone over the whole time series and would have declined in the no-trawl zone during the years when no-trawling was in effect (1986-91). Other studies have found an increase in amphipod predation due to the effects of trawling (Kaiser and Spencer, 1994) but our data indicate slightly higher predation on amphipods in the no-trawl zone than in the trawl zone. It is difficult to know whether changes have occurred in the eastern Bering Sea benthos without detailed study of the benthos and its biomass and composition before and after trawling. Yellowfin sole do not consume large, longer-lived clams or colonial ascidians that could be more sensitive indicators of the effects of fishing. However, there does not appear to be any major changes in certain species based on their amounts in the yellowfin sole diet.

ENDANGERED SPECIES ACT AND MARINE MAMMAL PROTECTION ACT CONSIDERATIONS

Endangered Species Act - The Endangered Species Act (ESA) provides for the conservation of endangered and threatened species of fish, wildlife and plants. The program is administered jointly by the Department of Commerce (NMFS) for most marine species, and the Department of Interior (USF&WS) for terrestrial and freshwater species.

The ESA's procedure for identifying or listing imperiled species is facilitated through a two-tiered process, classifying species as either threatened or endangered, based on the biological health of a species. Threatened species are those likely to become endangered in the foreseeable future [(16 U.S.C. §1532(20)]. Endangered species are those in danger of becoming extinct throughout all or a significant portion of their range [16 U.S.C. §1532(20)]. The Secretary of Commerce, acting through the NMFS, is authorized to list marine mammal and fish species. The Secretary of Interior, acting through the USFWS, is authorized to list all other organisms.

The following species are currently listed as endangered under the ESA and are present in the BSAI and GOA management areas:

Northern right whale	Balaena glacialis
Sei whale	Balaenoptera borealis
Blue whale	Balaenoptera musculus
Fin whale	Balaenoptera physalus
Humpback whale	Megaptera novaeangliae
Sperm whale	Physeter macrocephalus
Snake River sockeye salmon	Oncorhynchus nerka
Short-tailed albatross	Diomedea albatrus

Threatened species found in the BS/AI or GOA include:

Steller sea lion	Eumetopias jubatus
Snake River spring/summer chinook salmon	Oncorhynchus tshawytscha
Snake River fall chinook salmon	Oncorhynchus tshawytscha
Spectacled eider	Somateria fischeri

The Secretary must also establish a system that monitors the listing status of proposed species. Proposed species means any species of fish, wildlife, or plant that is proposed in the Federal Register to be listed under Section 4 of the ESA. Proposed species are species that are being considered by the Secretary for listing as endangered or threatened, but are not yet subject to final rule. Proposed species need not be included in Section 7 consultations (50 CFR §402) under the ESA. These species include:

Steller's eider	Polysticta stelleri (proposed Threatened)

Species for which there is evidence in the scientific literature that populations or habitat may be decreasing significantly are species of concern. Species of concern are subject to further evaluation, but are not included in Section 7 consultations. These species include:

Marbled murrelet	Brachyramphus marmoratus
Red-legged kittiwake	Rissa brevirostris
Kittlitz's murrelet	Brachyramphus brevirostris

In addition to listing species under the ESA, the critical habitat of a species must be designated concurrent with its listing to the "maximum extent prudent and determinable" [16 U.S.C. §1533(b)(1)(A)]. The ESA defines critical habitat as those specific areas that are essential to the conservation of a listed species and that may be in need of special consideration. Where appropriate, critical habitat can also be designated for threatened and endangered species. In compliance with the requirements of the ESA, NMFS designated critical habitat for the Steller sea lion on August 27, 1993. The Steller sea lion critical habitat designation does not place any additional restrictions on human activities within designated areas. For Steller sea lions, NMFS has designated critical habitats that are essential for reproduction, rest, refuge, and feeding. These critical habitats in Alaska include all rookeries, major haul-outs, and specific aquatic foraging habitats of the BSAI and GOA (58 FR 45278, August 27, 1993). The primary benefit of critical habitat designation is that it informs Federal agencies that Steller sea lions are dependent upon these areas for their continued existence, and that consultation with NMFS on any Federal action that may affect these areas is required.

Consultations on the Impacts of Fisheries on Listed or Proposed Listed Species

Federal agencies are required to initiate Section 7 (ESA) consultations with NMFS or USFWS for their actions (e.g., Fishery Management Plans, regulatory measures, annual specifications for total allowable catches) and make a determination as to whether the action may or may not affect endangered or threatened species. Typically, the consultation begins with an informal consultation. If the informal consultation concludes that the action "is not likely to adversely affect" endangered or threatened species or critical habitat, and the appropriate agency (NMFS or USFWS) concurs with that determination, the consultation requirements are satisfied and formal consultation is not required. The appropriate Regional Director is authorized to sign informal consultations.

If the action is determined as "likely to adversely affect" endangered or threatened species or critical habitat, then formal consultation is required. Formal consultations are necessary on actions that may affect endangered or threatened species and critical habitat if a "taking"[3] may occur. In the case of federally authorized fisheries actions, formal consultation is initiated and conducted by NMFS, and the resulting biological opinion is issued to NMFS.

Fishery Management Councils may be invited to participate in the compilation, review, and analysis of data used in the consultation. The ESA also allows private individuals to petition to list or change the status of a species [16 U.S.C. § 1533(b)3)A)]. Also considered, are the economic impacts in critical habitat designation decisions. However, the determination of whether the action "is likely to jeopardize the continued existence of" endangered or threatened species or to result in the destruction or modification of critical habitat is the responsibility of the appropriate agency (NMFS or USFWS). If the action is determined to result in jeopardy, the opinion will include reasonable and prudent measures that are necessary to alter the action so that jeopardy is avoided. If an incidental take of a listed species will occur, an incidental take statement will be appended to the biological opinion. Only the Assistant Administrator for Fisheries, NOAA, is authorized to sign NMFS biological opinions. Once the Opinion is issued, the appropriate Regional Director will advise the Fisheries Management Council of actions that should or must be taken relative to the fishery management program to be in compliance with the biological opinion.

A formal consultation on seabirds was previously concluded with the USFWS under section 7 of the ESA. Based on a biological opinion dated July 3, 1989, the USFWS determined that groundfish fisheries in Alaska may adversely affect the short-tailed albatross. The biological opinion concluded that the fishery would not jeopardize the existence of that endangered species.

Based on current species status information and 1995 TAC specifications, a recent informal consultation with the USFWS concluded (February 7, 1995) that the allowable incidental take of two birds during harvest of the 1995 groundfish TACs would not jeopardize the short-tailed albatross. Furthermore, the consultation concluded that the fishery is not likely to adversely affect the spectacled eider, Steller's eider, or marbled murrelet because of limited overlap in range between those species and the groundfish fishery. Consultation concluded on February 7, 1995 accommodates amendments affecting the allocation of the TAC specifications. Further consultation pursuant to Section 7 of the ESA is not necessary for the 1995 groundfish fishery in the BSAI or GOA unless any proposed species or species of concern within the range of the fishery is subsequently proposed for listing under the ESA.

Marine Mammal Protection Act - Since the reauthorization of the Marine Mammal Protection Act (MMPA) on April 30, 1994 several key provisions effecting commercial fisherman have been implemented or proposed. The 1994 amendments to the MMPA provide for a new long-term regime for managing marine mammal takes in commercial fisheries, replacing the Interim Exemption Program that had provided a general exemption on the MMPA take prohibition since 1988. Full implementation was expected to take more than a year, and indeed is ongoing. The various steps in the process are presented in the accompanying flow diagram (Fig. 3) while a summary of current highlights is provided below.

The cornerstone of the new regime is the development of Stock Assessment Reports for every marine mammal stock found in U.S. waters. These reports are now available, including one containing information on the marine mammals found in Alaskan waters. For each species the report details the stock definitions and geographic ranges, the most current population size estimates, productivity rates, calculation of the Potential Biological Removals (PBR) (the product of a minimum population estimate, a fraction of the maximum net productivity rate (0.02 for cetaceans and 0.08 for pinnipeds) and a safety factor (ranging from 0.1 to 1.0), annual human-caused

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[3]The term <u>Take</u> under the ESA means "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct" (16 U.S.C. §1538(a)(1)(B).

mortality, and status of the stock. Regional Scientific Review Groups (SRGs) were established to provide recommendations and guidance on the assessment reports. These groups will remain in place to provide comment and review as necessary.

Table 4 contains the PBRs for Alaskan marine mammal stocks, as well as the data used to calculate the values and the prioritization level assigned for each stock. The PBRs, the level of human caused mortality and the overall status of the stock were used to prioritize management of marine mammal/fisheries interactions. This step identifies "strategic" and "non-strategic" stocks. Stocks for which total human-caused mortality exceeds the PBR, or which are listed as threatened or endangered (under the Endangered Species Act) or depleted (under MMPA) are said to be "strategic." The short term management goal is to reduce human caused mortality of strategic stocks below their PBRs, while the long term goal is for all fisheries to meet their "zero mortality goal" by April 2001. Under the currently proposed definition, the "zero mortality goal" would be met when total fishery mortality (all fisheries) is less than 10% of the stock's PBR, or in cases where total fishery mortality is above 10%, no individual fishery is removes more than 1% of the stock's PBR.

The MMPA goal of reducing incidental takes in commercial fisheries to levels approaching zero will require a coordinated approach with industry participation. This concern is expressed in the MMPA provisions for the formation of Take Reduction Teams and development of Take Reduction Plans. NMFS is currently seeking expertise in professional environmental dispute resolution to lead the development of these teams. Individuals may be selected to serve on these teams as early as October 1995. One of the teams to be formed will address Alaskan marine mammals, including Steller sea lions.

Efforts to classify fisheries with respect to their impacts on marine mammals are ongoing. Under the old Interim Exemption Program, fisheries were categorized according to whether the fishery had frequent, occasional or remote likelihood of taking marine mammals, whereas the proposed regulations (Federal Register, June 1995) redefines the categories in terms of the percent of the PBR a particular fishery or fisheries annually removes. Observer data were used to determine take levels whenever available, while logbooks, confirmed fisher's reports etc. were use to establish minimum levels for fisheries not monitored. For placement in Category I, a fishery would take 50% or more of the PBR by itself; Category II would be assigned to all fisheries which combined were responsible for over 10% of a stock's PBR and where individually they accounted for 1 to 50% of a PBR; Category III would be assigned to all fisheries responsible for less than 10% of a PBR, provided that no individual vessel is responsible for removing more than 1% of a PBR. The revised list of fisheries categorized by this approach was released for public comment in July. The list is expected to be finalized later this year.

Under the Interim Exemption Program, vessels in Categories I and II were required to report marine mammal incidental takes via logbooks, however, the new program replaces logbooks with postcard data forms to be sent to NMFS after completion of trips where marine mammal takes occurred. This requirement will apply to all categories of fisheries. Observer monitoring provisions have been retained for Categories I and II, while a Category III fishery may also be monitored if a take problem is identified. Fisheries taking ESA-listed species will be required to obtain a separate authorization to take them.

The 1994 amendments placed a prohibition on the intentional taking of marine mammals in commercial fishing operations except when the threat of human injury or death exists. Intentional takes occurred commonly in some fisheries that regularly interacted with harbor seals. The final rule on the provision was published in the Federal Register on February 1, 1995 and took effect 30 days later (3/3/95).

The development of a Bering Sea Ecosystem research plan is ongoing. This effort will draw together elements of the scientific community, government agencies and members of Alaskan subsistence community. A workshop will be held this fall to begin discussions on the plan's scope and content.

LITERATURE CITED

Albers, W. D. and P. J. Anderson. 1985. Diet of Pacific cod, Gadus macrocephalus, and predation on the Northern pink shrimp, Pandalus borealis, in Pavlof Bay, Alaska. Fish. Bull., U.S. 83:601-610.

Anderson, P. J., S. A . Payne, and B. A. Johnson. 1994. Long-term demersal community structure changes in Pavlof Bay, Alaska. Unpubl. manuscr., 28 p. Kodiak Lab., Alaska Fish. Sci. Cent., P. O. Box 1638, Kodiak, AK. 99615,

Anon. 1994. Report of the working group on ecosystem effects of fishing activities. International Council for the Exploration of the Sea, ICES CM 1994/Assess/Env:1, 109p.

Armstrong, D. A., T. C. Wainwright, G. C. Jensen, P. A. Dinnel, and H. B. Andersen. 1993. Taking refuge from bycatch issues: red king crab (Paralithodes camtschaticus) and trawl fisheries in the eastern Bering Sea. Can. J. Fish. Aquat. 50: 1993-1999.

Beamish, R. J. 1994. Climate change and exceptional fish production off the west coast of North America. Can. J. Fish. Aquat. Sci. 2270-2291.

Beamish, R. J. and D. R. Boullion. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50:1002-1016.

Beamish, R. J. and D. R. Boullion. 1995. Marine fish production trends off the Pacific coast of Canada and the United States, p. 585-591. In R. J. Beamish (ed.), Climate change and northern fish populations. Can. Spec. Publ. Fish. Aquat. Sci. 121.

Brodeur, R. D. and D. M. Ware. 1992. Long-term variability in zooplankton biomass in the subarctic Pacific Ocean. Fish. Oceanogr. 1:32-38.

Brodeur, R. D. and D. M. Ware. 1994. Interdecadal variability in the distribution and catch rates of epipelagic nekton in the Northeast Pacific Ocean, p. 329-356. In R. J. Beamish (ed.) Climate change and northern fish populations. Can. Spec. Publ. Fish. Aquat. Sci. 121.

Browder, J. A. 1983. A simulation model of a near-shore marine ecosystem of the north-central Gulf of Mexico. In: K.W. Turgeon (ed.). Marine ecosystem modeling: proceedings from a workshop held April 6-8, 1982 in Frederick, MD, by the U.S. , 274p.

Byrd, G. V., B. C. Murphy, G. W. Kaiser, A. Y. Kondratyev, and Y. V. Shibaev. 1993. In K. Vermer, K. T. Briggs, K. H. Morgan, and D. Siegel-Causey (eds.) The status, ecology, and conservation of marine birds of the North Pacific. Can. Wildl. Serv. Spec. Publ. Ottawa.

Chopin, F.S. , and T. Arimoto. 1995. The condition of fish escaping from fishing gears--a review. Fish. Res. 21:315-327.

Christie, W.J. 1993. Developing the concept of sustainable fisheries. J. Aquat. Ecosystem Health 2:99-109.

Daan, N. 1980. A review of replacement of depleted stocks by other species and the mechanisms underlying such replacement. Rapp. P.-v. Reun. Cons. int. Explor. Mer 177:405-421.

Evans, S.M., J.E. Hunter, Elizal, and R.I. Wahju. 1994. Composition and fate of the catch and bycatch in the Farne Deep (North Sea) *Nephrops* fishery. ICES J. mar. Sci. 51:155-168.

Francis, R. C. and S. R. Hare. 1994. Decadal-scale regime shifts in the large marine ecosystems of the North-east Pacific: a case of historical science. Fish. Oceanogr. 3:279-291

Fritz, L. W. 1993. Trawl locations of walleye pollock and Atka mackerel fisheries in the Bering Sea, Aleutian Islands and Gulf of Alaska from 1977-92. U.S. Dep. Commer., NOAA, NMFS, AFSC Processed Rep. 98-08, 162p.

Fritz, L. W. 1994. Squid and other species. In Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Bering Sea/Aleutian Islands Regions as projected for 1995. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. 14 p.

Fritz, L.W., R.C. Ferrero, and R.J. Berg. 1994. The threatened status of Steller sea lions (Eumetopias jubatus) under the Endangered Species Act: effects on Alaska groundfish fisheries management. Manuscript presented at the Fisheries Management: Global Trends Symposium, June 1994, Seattle, WA.

Haflinger, K.E., C.P. McRoy. 1983. Yellowfin sole (Limanda aspera) predation on three commercial crab species (Chionoecetes Opilio, C. Bairdi, and Paralithodes Camtschatica) in the Southeastern Bering Sea. Institute of Marine Science, UAF, Fairbanks, AK.

Hare, S. R. and R. C. Francis. 1995. Climate change and salmon production in the Northeast Pacific Ocean, p. 357-372. In R. J. Beamish (ed.) Climate change and northern fish populations. Can. Spec. Publ. Fish. Aquat. Sci. 121.

Hatch, S. A. 1993. Population trends of Alaskan seabirds. Pac. Seabird Grp. Bull. 20:3-12. Hatch, S.A., G.V. Byrd, D.B. Irons, and G.L. Hunt, Jr. 1993. Status and ecology of kittiwakes (Rissa tridactyla and R. brevirostris) in the North Pacific. In: Vermeer, K., K.T. Briggs, K.H. Morgan, and D. Siegel-Causey (eds). The status, ecology, and conservation of marine birds of the North Pacific. Can. Wildl. Serv. Spec. Publ., Ottawa.

Hollowed, A. B. and W. S. Wooster. 1992. Variability of winter ocean conditions and strong year classes of Northeast Pacific groundfish. ICES Mar. Sci. Sym.. 195:433-444.

Hollowed, A. B. and W. S. Wooster. 1995. Decadal-scale variations in the eastern subarctic Pacific: II. Response of Northeast Pacific fish stocks, p. 373-385. In R. J. Beamish (ed.), Climate change and northern fish populations. Can. J. Fish. Aquat. Sci. 121.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981. Feeding ecology of seabirds of the eastern Bering Sea. pp. 629-648. In: Hood, D.W. and J.A. Calder (eds). The eastern Bering Sea shelf: oceanography and resources, Vol. II. Office of Marine Pollution Assessment, National Oceanic and Atmospheric Administration.

Jewett, S.C., and C.P. Onuf. 1988. Habitat suitability index models: red king crab. U.S. Fish and Wildlife Service Biological Report 82(10.153).

Jones, J.B. 1992. Environmental impact of trawling on the seabed: a review. New Zealand Journal of Marine and Freshwater Research 26: 59-67.

Kaiser, M.J. and B.E. Spencer. 1994. Fish scavenging behavior in recently trawled areas. Mar. Ecol. Prog. Ser. 112:41-49.

Kerr, R. A. 1992. Unmasking a shifty climate system. Science 255:1508-1510.

Kruse, G.H. 1993. Biological perspectives on crab management in Alaska. Proc. Int.Symp. on Mgmt. Strategies for Exploited Populations. 1993: 357-384.

Kruse, G.H. 1995. King and Tanner Crab Research in Alaska: Executive Summary of Work Completed by the State of Alaska during 7/1/93-6/30/94 and Work Planned for 7/1/94-6/30/95. 5p.

Livingston, P.A. 1989. Interannual trends in Pacific cod, Gadus macrocephalus, predation on three commercially important crab species in the eastern Bering Sea. Fishery Bulletin 87:807-827.

Livingston, P.A., G.M. Lang, R. Pacunski, J. Parkhurst., M-S. Yang. 1991. Groundfish food habits and predation on commercially important prey species in the Eastern Bering Sea from 1984-1986. NOAA/NMFS-F/NWC-207.

Livingston, P.A., A. Ward, G.M. Lang, and M-S. Yang. 1993. Groundfish food habits and predation on commercially important prey species in the Eastern Bering Sea from 1987 to 1989. NOAA-NMFS-AFSC-11.

Livingston, P.A., L-L. Low, and R.J. Marasco. 1994. Eastern Bering Sea ecosystem trends. Paper presented at the Oct. 8-11, 1994, Symposium on Large Marine Ecosystems of the Pacific, Qingdao, China.

McLellan, G.L., and J.K. Leong. 1981. Summer food of Pacific cod, Gadus macrocephalus, in coastal waters of Southeastern Alaska. Fishery Bulletin 78(4):968-973.

McMurray, G., A.H. Vogel, P.A. Fishman, D.A. Armstrong, S.C. Jewett. 1984. Abstract - Distributional of larval and juvenile red king crabs (Paralithodes Camtschatica) in Bristol Bay. VTN, ARCS, NPR.

Messieh, S.N., T.W. Rowell, D.L. Peer, P.J. Cranford. 1991. The effects of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. Continental Shelf Research II: 1237-1263.

Murphy, M.C., W.E. Donaldson, and J. Zheng. 1994. Results of a questionaire on research and management priorities for commercial crab species in Alaska. Alaska Fishery Research Bulletin 1:81-96.

Otto, R. S. 1989. An overview of eastern Bering Sea king and tanner crab fisheries, p. 9-26. In Proc. Int. Sym.. King & Tanner Crabs, Alaska Sea Grant Publ. AK-SG-90-04.

Piatt J. F. and P. Anderson. In press. Response of common murres to the Exxon Valdez oil spill and long-term changes in the Gulf of Alaska marine ecosystem. In S. D. Rice, R. B. Spies, D. A. Wolfe, and B. A. Wright (eds.), Exxon Valdez oil spill symposium proceedings. Amer. Fish. Soc. Sym.. No. 18.

Polovina, J. J., G. T. Mitchum, and G. T. Evans. In press. Decadal and basin-scale variation in mixed layer depth and the impact on biological production in the Central and North Pacific, 1960-88. Deep Sea Res.

Queirolo, L. E., L. W. Fritz, P. A. Livingston, M. R. Loefflad, D. A. Colpo, and Y. L. deReynier. 1995. Bycatch, utilization, and discards in the commercial groundfish fisheries of the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands. U. S. Dep. Commerc., NOAA Tech. Memo., in press.

Reise, K. 1982. Long-term changes in the macrobenthos invertebrate fauna of the Wadden Sea: are polycheates about to take over? Netherlands Journal of sea Research 16:29-63.

Royer, T. C. 1989. Upper ocean temperature variability in the Northeast Pacific Ocean: is it an indicator of global warming? J. Geophys. Res. 94:18175-18183.

Royer, T. C. 1993. High-latitude oceanic variability associated with the 18.6-year nodal tide. J. Geophys. Res. 98:4639-4644.

Shelton, P.A. 1992. Detecting and incorporating multispecies effects into fisheries management in the northwest and southeast Atlantic. In: Payne, A.I.L., Brink, K.H., Mann, K.H., and R. Hilborn (eds). Benguela Trophic Functioning. S. Afr. J. mar. Sci. 12:723-737.

Small, R. J., and D. P. DeMaster. 1995. Alaska marine mammal stock assessments 1995. Natl. Mar. Mamm. Lab., 7600 Sand Point Way N.E., Seattle, WA. 98115, 93 p.

Stevens, B.G. 1990. Survival of king and Tanner crabs captured by commercial sole trawls. Fishery Bulletin 88:731-744.

Stevens, B., R.MacIntosh, G. Walters, K. McGraw. 1992. Cruise results supplement: 1991 Eastern Bering Sea juvenile red king crab survey. NOAA/NMFS Alaska Fisheries Science Center.

Stevens, B.G., and J.A. Haaga. 1994. Ocean dumping of seafood processing wastes: comparisons of epibenthic megafauna sampled by submersible in impacted and non-impacted Alaskan bays and estimation of waste decomposition rate. Unpublished manuscript, National Marine Fisheries Service, Kodiak Laboratory, P.O. Box 1638, Kodiak, AK 99615.

Stevens, B.G., J.A. Haaga, and R.A. MacIntosh. 1994. Report to the industry on the 1994 Eastern Bering Sea crab survey. National Marine Fisheries Service, Alaska Fisheries Science Center Processed Report 94-07.

Tabata, S. 1989. Trends in long-term variability of ocean properties at Ocean Station P in the northeast Pacific Ocean, p. 113-132. In D. H. Peterson (ed.) Aspects of climate variability in the Pacific and western Americas. Geophys. Monogr. 55.

Thomas, G.L. 1994. Economically and ecologically responsible fish waste recycling in Orca Inlet, Prince William Sound, Alaska. Research proposal by Prince William Sound Science Center, P.O. Box 705, Cordova, AK 99574.

Tracy, D.A. 1994. Biological summary of the 1992 manditory shellfish observer program database. Alaska Department of Fish and Game. Regional Information Report 4K94-10.

Trenberth, K. E. and J. W. Hurrell. 1995. Decadal coupling atmospheric-ocean variations in the North Pacific Ocean, p. 15-24. In R. J. Beamish (ed.) Climate change and northern fish populations. Can. Spec. Publ. Fish. Aquat. Sci. 121.

Tyler, A. L., G.H. Kruse. 1995. Report of the modeling workshop on year-class strength formation of red king crab. ADF&G, Juneau, AK.

Urban, D., D. Pengilly, and I. Vining. 1994. The scallop observer program and statewide data analysis summary to the Board of Fisheries. Alaska Department of Fish and Game Report 4K94-28.

Venrick, E. L. 1995. Scales of variability in a stable environment: Phytoplankton in the central North Pacific. Chapter 10, p.. In T. M. Powell and J. H. Steele (ed.), Ecological time series. Chapman Hall, New York.

Venrick, E. L., J. A. McGowan, D. R. Cayan, and T. L. Hayward. 1987. Climate and chlorophyll a: Long-term trends in the central north Pacific Ocean. Sci. 238: 70-72.

Walsh, J.J. 1983. Death in the Sea: Enigmatic phytoplankton losses. Prog. Oceanog. 12:1-86.

Walsh, J.J. and C.P. McRoy. 1986. Ecosystem analysis in the southeastern Bering Sea. Cont. Shelf Res. 5:259-288.

Wassenburg, T.J., and B.J. Hill. 1987. Feeding by the sand crab, *Portunus pelagicus*, on material discarded from prawn trawlers in Moreton Bay, Australia. Mar. Biol. 95:387-393.

Wassenburg, T.J. and B.J. Hill. 1990. Partitioning of material discarded from prawn trawlers in Moreton Bay. Aust. J. Mar. Freshwat. Res. 41:27-36.

Williams, G. H. 1994. Pacific halibut discard mortality rates in the 1993 groundfish fisheries off Alaska. In Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Bering Sea/Aleutian Islands Regions as projected for 1995. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. 13 p.

Witherell, D. 1995. Crab Rebuilding Committee Report: Minutes of the BSAI Groundfish and Crab Plan Team Meeting March 21-22, 1995. North Pacific Fishery Management Council Report. April 1995.

Wooster, W. and A. Hollowed. 1995. Decadal-scale variations in the eastern subarctic Pacific. I. Winter ocean conditions, p. 81-85. In R. J. Beamish (ed.) Climate change and northern fish populations. Can. Spec. Publ. Fish. Aquat. Sci. 121.

Yang, J. 1982. A tentative analysis of the trophic levels of North Sea fish. Mar. Ecol. Prog. Ser. 7:247-252.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22.

Yang, M-S. 1995. Diets of the commercially important groundfishes in the Aleutian Islands in 1991. Unpublished manuscript. Alaska Fisheries Science Center, 7600 Sand Point Wy., NE, Seattle, WA 98115.

Zheng, J. M.C. Murphy, and G.H. Kruse. 1994. A length-based population model and stock-recruitment relationships for red king crab, Paralithodes camtschaticus, in Bristol Bay, Alaska. Can. J. Fish. Aquat. Sci.

Zheng, J. M.C. Murphy, and G.H. Kruse. 1995. A length-based approach to estimate population abundance of Tanner crab, Chionoecetes bairdi, in Bristol Bay, Alaska. North Pacific Symposium on Invertebrate Stock Assessment and Management.

Zhou, S. and T.C. Shirley. 1995. Effects of handling on feeding, activity, and survival of red king crabs, Paralithodes camtschaticus (Tilesius, 1815). Journal of Shellfish Research 14:173-177.

Table 1.--Catch (numbers) of salmon in Alaskan waters by species and year for 1990-94.

		Species						
Year	Area	Chinook	Chinook (small)	Sockeye	Coho	Pink	Chum	Grand Total
1990	Bering Sea	223,820	0	33,648,828	648,723	513,342	2,250,562	37,285,275
	Gulf	97,385	0	16,887,963	1,960,675	55,352,881	3,541,729	77,840,633
	Southeast	344,639	3,776	2,155,677	2,867,270	32,385,512	2,212,913	39,969,787
	Total	665,844	3,776	52,692,468	5,476,668	88,251,735	8,005,204	155,095,695
1991	Bering Sea	186,818	0	26,024,207	845,433	893	2,705,328	29,762,679
	Gulf	93,189	0	16,558,718	2,113,543	66,412,131	3,728,097	88,905,678
	Southeast	333,331	5,591	2,062,586	3,194,323	61,923,461	3,335,297	70,854,589
	Total	613,338	5,591	44,645,511	6,153,299	128,336,485	9,768,722	189,522,946
1992	Bering Sea	261,385	0	32,073,533	1,087,728	592,116	2,093,273	36,108,035
	Gulf	117,795	0	23,542,558	2,310,972	24,962,619	3,193,626	54,127,570
	Southeast	226,394	2,363	2,666,422	3,696,494	35,041,792	4,936,499	46,569,964
	Total	605,574	2,363	58,282,513	7,095,194	60,596,527	10,223,398	136,805,569
1993	Bering Sea	219,702	1,332	40,634,293	810,602	163,669	1,165,589	42,995,187
	Gulf	154,334	0	20,485,449	1,594,057	52,330,222	3,220,154	77,784,216
	Southeast	295,743	3,951	3,193,879	3,665,111	57,257,940	7,878,106	72,294,730
	Total	669,779	5,283	64,313,621	6,069,770	109,751,831	12,263,849	193,074,133
1994	Bering Sea	290,750	554	35,845,461	1,147,372	1,157,385	1,104,626	39,546,148
	Gulf	125,661	0	14,577,987	2,688,184	57,916,324	4,634,794	79,942,950
	Southeast	216,324	6,338	2,392,414	5,715,646	57,646,063	10,395,569	76,372,354
	Total	632,735	6,892	52,815,862	9,551,202	116,719,772	16,134,989	195,861,452

Table 2.--Catch (biomass in kg) of salmon caught in Alaskan waters by species and area for 1990-94.

		Species						
Year	Area	Chinook	Chinook (small)	Sockeye	Coho	Pink	Chum	Grand Total
1990	Bering Sea	1,764,420	0	88,031,461	1,995,556	894,140	6,966,375	99,651,953
	Gulf	812,328	0	44,691,465	6,884,955	75,682,548	12,128,205	140,199,501
	Southeast	2,641,710	7,325	6,149,606	9,309,062	47,017,306	9,398,628	74,523,638
	Total	5,218,458	7,325	138,872,532	18,189,574	123,593,995	28,493,208	314,375,092
1991	Bering Sea	1,540,810	0	68,616,480	2,553,472	1,372	8,026,620	80,738,754
	Gulf	786,386	0	41,994,882	7,043,534	82,545,042	11,602,621	143,972,465
	Southeast	2,554,458	12,703	5,591,351	10,348,137	76,226,346	12,045,580	106,778,575
	Total	4,881,654	12,703	116,202,714	19,945,142	158,772,760	31,674,820	331,489,794
1992	Bering Sea	2,127,276	0	83,591,716	3,604,633	984,642	6,501,516	96,809,784
	Gulf	1,052,728	0	65,087,552	7,919,913	39,135,489	10,153,451	123,349,133
	Southeast	1,714,329	4,851	7,347,890	12,928,879	52,467,643	17,961,052	92,424,643
	Total	4,894,333	4,851	156,027,158	24,453,425	92,587,774	34,616,019	312,583,560
1993	Bering Sea	1,806,437	196	111,250,970	2,450,627	194,029	3,484,544	119,186,803
	Gulf	1,192,451	0	52,324,870	4,878,209	74,644,207	9,067,095	142,106,833
	Southeast	2,161,888	6,695	8,504,077	10,200,800	77,456,428	25,241,604	123,571,491
	Total	5,160,776	6,892	172,079,918	17,529,635	152,294,664	37,793,242	384,865,127
1994	Bering Sea	2,449,423	1,034	90,592,601	3,982,920	1,287,933	3,375,231	101,689,143
	Gulf	1,207,666	0	36,734,764	10,584,020	85,925,548	15,287,291	149,739,289
	Southeast	1,580,652	12,297	6,485,694	19,652,889	78,624,913	35,929,830	142,286,274
	Total	5,237,742	13,331	133,813,058	34,219,829	165,838,394	54,592,352	393,714,705

Table 3.--Estimates of population change at selected large (1,000's) common murre colonies in the Gulf of Alaska and Aleutian Islands before (1975-88) and after (1989-94) the T/V Exxon Valdez oil spill in 1989 (Piatt and Anderson in press). Starred (*) colonies were in the path of the oil spill. "Years" indicates earliest and latest years of census data used in this analysis. "NA" indicates insufficient data available to calculate change.

Colony	Years monitored	Pre-spill (<1989) change %	Post-spill (>1988) change %
Northern GOA			
Middleton I.	1975-91	+12%	-32%
Prince William Sound			
Porpoise Rock	1976-91	NA	-3%
Resurrection Bay*	1976-91	NA	-25%
Chiswell I.*	1976-91	NA	-33%
Cook Inlet			
Gull I.*	1984-90	+136%	-7%
Chisik/Duck I.	1978-94	-59%	-28%
McNeill I.	1976-91	-20%	-90%
Kodiak Area			
Barren I.*	1975-93	NA	-34%
Triplet I.*	1975-89	+4%	-35%
Alaska Peninsula - N			
Puale Bay*	1976-91	-26%	-48%
Ugaiushak	1976-91	NA	-39%
Semidi I.	1977-91	+ 1%	+12%
Alaska Peninsula - S.			
Bird I.	1973-93	NA	-85%
Unga I.	1973-94	NA	-96%
Midun I.	1978-94	NA	-57%
Eastern Aleutian I.			
Aiktak I.	1981-90	NA	-73%

Table 4.--Potential Biological Removals (PBRs) calculated for Alaskan marine mammal stocks (Small and DeMaster 1995)

Species	Stock	N(est)	CV	C. F.	CV	C-CV	N(min)	0.5Rm	F(r)	PBR	CF kill	Subsist	Status
Baird's Beaked Whale	Alaska	N/A					N/A	0.02	0.50	N/A	0.0	0.0	NS
Bearded Seal	Alaska	N/A					N/A	0.06	0.50	N/A	6.2	N/A	NS
Beluga Whale	Beaufort	41610	0.102	2.00	N/A	0.102	38194	0.02	1.00	764	0.0	160	NS
Beluga Whale	Eastern Chukchi Sea	3710	N/A	3.09	N/A	N/A	3710	0.02	1.00	74	0.0	65	NS
Beluga Whale	Norton Sound++	7367	N/A	3.52	N/A	N/A	N/A	0.02	N/A	N/A	0.0*	147	N/A
Beluga Whale	Bristol Bay	1555	N/A	3.09	N/A	N/A+	1526	0.02	1.00	31	0.3*	22	NS
Beluga Whale	Cook Inlet++	1251	0.140	2.90	N/A	0.140	N/A	0.02	N/A	N/A	0.0*	N/A	N/A
Bowhead Whale	Western Arctic	8000	0.073			0.0730	7524	0.02	0.50	75	0.0	42	S
Cuvier's Beaked Whale	Alaska	N/A					N/A	0.02	0.50	N/A	0.0	0.0	NS
Dall's Porpoise	Alaska	83400	0.097	0.20	N/A	0.0970	76874	0.02	1.00	1537	41	0.0	NS
Fin Whale	Alaska	N/A					N/A	0.02	0.10	N/A	0.0	0.0	S
Gray Whale	Eastern N Pacific	23109	0.074			0.0740	21715	0.02	1.00	434	0.3	0.0	NS
Harbor Porpoise	Alaska	29744	N/A			N/A	24635	0.02	0.50	246	33	0.0	NS
Harbor Porpoise	Alaska-aerial	27714	0.129	3.10	0.171	0.215	23172						
Harbor Porpoise	Alaska-vessel	2030	0.392	1.28	0.091	0.404	1463						
Harbor Seal	Southeast Alaska	34652	0.026	1.61	0.062	0.0673	32745	0.06	1.00	1965	6.0*	1643	NS
Harbor Seal	Gulf of Alaska++	19694	0.030	1.61	0.062	0.0689	N/A	0.06	N/A	N/A	35	833	N/A
Harbor Seal	Bering Sea	18322	0.037	1.61	0.062	0.0722	17243	0.06	1.00	1035	12	322	NS
Humpback Whale	Western N Pacific	N/A					N/A	0.02	0.10	N/A	0.0	0.0	S
Humpback Whale	Central N Pacific	1407	0.107				1407	0.02	0.10	2.8	0.0	0.0	S
Killer Whale	Resident	759	N/A				759	0.02	0.50	7.6	0.8	0.0	NS
Killer Whale	Transient	245	N/A				245	0.02	0.50	2.5	0.8	0.0	NS
Minke Whale	Alaska	N/A					N/A	0.02	0.50	N/A	0.0	0.0	NS
N Right Whale	North Pacific	N/A					N/A	0.02	0.10	0.0	0.0	0.0	S
Northern Fur Seal	Eastern N Pacific	1019192	0.059			0.0593	969595	0.043	0.50	20846	6.4	1777	S
Pac White-Sided Dol	North Pacific	931000	0.900			0.900	486719	0.02	0.50	4867	1.1	0.0	NS
Polar Bear	Chukchi/Bering Sea	N/A					N/A	N/A	1.00	N/A	0.0	55	NS
Polar Bear	Beaufort Sea	1717	0.130				1579	0.03	1.00	48	0.0	63	NS
Ribbon Seal	Alaska	N/A					N/A	0.06	0.50	N/A	0.4	N/A	NS
Ringed Seal	Alaska	N/A					N/A	0.06	0.50	N/A	0.8	N/A	NS
Sea Otter	Alaska	150000	N/A				100000	0.10	1.00	10000	0.7	1200	NS
Sperm Whale	Alaska	N/A					N/A	0.02	0.10	N/A	0.0	0.0	S
Spotted Seal	Alaska	N/A					N/A	0.06	0.50	N/A	1.0*	N/A	NS
Stejneger's Beaked W.	Alaska	N/A					N/A	0.02	0.50	N/A	0.0	0.0	NS
Steller Sea Lion	Eastern	23900	0.0184	1.33	N/A	0.0184	23533	0.06	0.75	1059	4.0	4.0	S
Steller Sea Lion	Western U.S.	43200	0.0184	1.33	N/A	0.0184	42536	0.06	0.30	766	41	514	S

C.F. = Correction Factor; C-CV= Combined CV; CF kill = Commercial Fishery Kill; Status: S=Strategic, NS=Not Strategic,*No reported take by NMFS observers; however, observer coverage was minimal or nonexistent. +N_{min} from literature (see text).* ++ not calculated pending co-management

Table 5. Discards (tons) and discard rate (amount discarded/total catch) of each allocated species or group (A), and by each groundfish fishery (B) in the Bering Sea/Aleutian Islands, 1991-94. Other includes squid, octopus, smelts, skates, sculpins, and sharks.

A. Species - Amounts and rates of discard of each species by all groundfish fisheries combined

Year		Atka mackerel	Arrowtooth flounder	Yellowfin sole	Greenland turbot	Rock sole	Other flatfish	Pacific cod	Pollock	Sablefish	Rockfish	Other	Grand Total
1991	tons	3,250	17,710	28,598	2,879	31,413	27,121	17,296	158,220	65	3,100	24,226	313,878
	rate	12.2%	84.2%	24.3%	35.0%	55.3%	74.6%	7.9%	9.7%	1.9%	29.2%	88.3%	14.6%
1992	tons	9,709	11,217	42,940	2,086	30,634	28,705	24,015	130,818	46	4,632	29,784	314,585
	rate	19.4%	93.8%	29.2%	75.3%	59.0%	82.3%	11.7%	9.1%	2.2%	25.1%	91.5%	15.8%
1993	tons	15,758	8,635	29,011	1,786	41,669	19,160	37,068	112,127	60	8,202	22,854	296,331
	rate	23.9%	92.9%	27.4%	21.1%	64.8%	65.9%	22.1%	8.1%	2.2%	33.2%	92.3%	15.7%
1994	tons	10,351	13,641	36,948	2,235	39,945	18,773	33,651	109,202	115	6,608	23,272	294,739
	rate	14.9%	95.6%	25.6%	23.9%	65.6%	63.0%	17.1%	7.7%	4.7%	34.0%	92.5%	14.8%
Average	tons	9,767	12,801	34,374	2,247	35,915	23,440	28,007	127,592	72	5,635	25,034	304,883
	rate	17.6%	91.6%	26.6%	38.8%	61.2%	71.5%	14.7%	8.6%	2.7%	30.4%	91.1%	15.2%

Table 5. (continued).

B. Fishery - Amounts and rates of discard of all species (not including prohibited) by each fishery

Target Species	Gear	1991 tons	1991 rate	1992 tons	1992 rate	1993 tons	1993 rate	1994 tons	1994 rate	Average tons	Average rate
Atka mackerel	Trawl	4,666	15.3%	10,143	19.3%	18,788	26.8%	17,304	21.0%	12,725	20.6%
Arrowtooth flounder	Hook&line	5	62.3%	0	-	14	68.4%	0	-	10	65.4%
	Trawl	673	27.6%	193	51.5%	7	64.6%	0	-	291	47.9%
	TOTAL	678	27.8%	193	51.5%	21	67.1%	0	-	297	48.8%
Greenland turbot	Hook&line	0.00	-	28	21.2%	1,476	18.1%	259	15.2%	588	18.2%
	Trawl	0.00	-	0.00	-	13	45.1%	1,755	23.6%	884	34.3%
	TOTAL	0.00	-	28	21.2%	1,489	18.2%	2,014	22.0%	1,177	20.5%
Yellowfin sole	Trawl	50,910	35.4%	86,588	43.4%	56,521	41.0%	101,994	45.5%	74,003	41.3%
Rock sole	Trawl	51,203	64.2%	32,807	62.4%	58,307	69.0%	51,262	69.6%	48,395	66.3%
Other flatfish	Trawl	8,155	35.0%	3,052	38.8%	10,088	52.5%	12,094	67.9%	8,347	48.5%
Pacific cod	Hook&line	12,864	13.8%	18,195	15.3%	14,666	18.8%	16,889	16.4%	15,654	16.1%
	Pot	413	6.0%	755	5.2%	82	3.8%	393	4.6%	411	4.9%
	Trawl	58,054	37.5%	30,679	37.9%	50,160	49.1%	41,656	45.1%	45,137	42.4%
	TOTAL	71,332	28.0%	49,658	23.1%	64,908	35.6%	59,043	28.8%	61,235	28.9%
Pollock	Bot. trawl	54,025	14.5%	19,409	16.6%	20,459	18.5%	12,737	16.3%	26,657	16.5%
	Pel. trawl	66,515	5.4%	104,696	7.9%	56,619	4.5%	32,924	2.6%	65,189	5.1%
	TOTAL	120,540	7.5%	124,105	8.6%	77,078	5.7%	45,661	3.4%	91,846	6.3%
Sablefish	Hook&line	1,633	34.4%	1,871	45.5%	1,391	35.9%	1,547	43.0%	1,610	39.7%
	Pot	0	62.1%	0	38.1%			24	47.2%	6	36.9%
	Trawl	407	73.8%	3	9.0%	55	74.1%	398	81.0%	215	59.5%
	TOTAL	2,040	38.5%	1,874	45.2%	1,446	36.6%	1,968	47.6%	1,832	42.0%
Rockfish	Hook&line	9	31.9%	2	52.7%	64	41.3%	6	47.7%	21	43.4%
	Trawl	4,284	42.5%	5,753	29.7%	7,193	28.7%	2,997	19.5%	5,057	30.1%
	TOTAL	4,293	42.5%	5,756	29.7%	7,257	28.8%	3,004	19.5%	5,077	30.1%
Other (not assigned to one of the above)	ALL	61	44.5%	395	32.8%	428	85.3%	395	56.0%	320	54.6%
Grand Total		313,878	14.6%	314,585	15.8%	296,331	15.7%	294,739	14.8%	304,883	15.2%

Table 6. Discards (tons) and discard rate (amount discarded/total catch) of each allocated species or group (A), and by each groundfish fishery (B) in the Gulf of Alaska, 1991-94. Other includes squid, octopus, smelts, skates, sculpins, and sharks.

A. Species - Amounts and rates of discard of each species by all groundfish fisheries combined

Year		Atka mackerel	Arrowtooth flounder	Deepwater flatfish	Shallow flatfish	Pacific cod	Pollock	Sablefish	Rockfish	Other	Grand Total
1991	tons	142	19,395	2,120	4,177	2,662	16,033	549	4,264	3,969	53,310
	rate	10.2%	89.9%	18.5%	60.2%	3.5%	14.9%	2.4%	20.1%	69.4%	19.3%
1992	tons	401	20,520	5,210	3,116	3,768	15,669	988	5,854	5,236	60,761
	rate	4.7%	97.6%	38.2%	35.6%	4.7%	16.7%	4.2%	23.5%	51.9%	21.4%
1993	tons	408	17,671	3,116	3,436	5,885	8,264	810	7,340	5,019	51,949
	rate	7.9%	92.0%	29.5%	35.3%	10.4%	7.6%	3.3%	37.3%	73.1%	19.9%
1994	tons	274	22,011	2,016	1,087	3,055	6,785	864	4,708	2,626	43,426
	rate	7.7%	98.0%	21.4%	27.5%	6.4%	6.1%	3.8%	29.4%	97.6%	18.1%
Average	tons	306	19,899	3,116	2,954	3,842	11,688	803	5,541	4,213	52,362
	rate	7.6%	94.4%	26.9%	39.6%	6.2%	11.3%	3.4%	27.6%	73.0%	19.7%

Table 6. (continued).

B. Fishery - Amounts and rates of discard of all species (not including prohibited) by each fishery

Target Species	Gear	1991 tons	1991 rate	1992 tons	1992 rate	1993 tons	1993 rate	1994 tons	1994 rate	Average tons	Average rate
Atka mackerel	Trawl	0	0.0%	0	0.0%	0	0.0%	749	19.6%	749	19.6%
Arrowtooth flounder	Hook&line	0	0.0%	34	98.2%	27	45.2%	0	0.0%	31	71.7%
	Trawl	1,123	38.3%	170	57.1%	888	37.5%	610	48.7%	698	45.4%
	TOTAL	1,123	38.3%	204	61.4%	915	37.7%	610	48.7%	713	46.5%
Deepwater flatfish	Trawl	14,285	59.8%	12,874	58.9%	11,832	62.1%	21,352	72.3%	15,086	63.3%
Shallow flatfish	Trawl	540	32.3%	3,591	39.0%	7,176	49.1%	3,064	52.5%	3,593	43.2%
Pacific cod	Hook&line	238	3.1%	1,200	7.5%	1,043	11.4%	423	6.2%	726	7.0%
	Pot	249	2.3%	261	2.6%	227	2.3%	123	1.3%	215	2.1%
	Trawl	18,192	24.2%	14,903	22.5%	6,014	16.2%	6,154	17.5%	11,316	20.1%
	TOTAL	18,680	20.0%	16,365	17.6%	7,285	12.9%	6,700	13.0%	12,258	15.9%
Pollock	Bot. trawl	3,948	21.5%	2,786	11.9%	5,137	21.0%	430	8.9%	3,075	15.8%
	Pel. trawl	2,777	3.4%	5,800	9.2%	5,354	6.1%	3,523	3.4%	4,364	5.5%
	TOTAL	6,725	6.8%	8,586	9.9%	10,491	9.3%	3,953	3.6%	7,439	7.4%
Sablefish	Hook&line	3,569	14.6%	6,550	23.4%	5,389	19.0%	2,618	11.2%	4,532	17.0%
	Trawl	148	58.1%	26	60.2%	107	51.7%	184	70.0%	116	60.0%
	TOTAL	3,717	15.1%	6,575	23.4%	5,496	19.2%	2,803	11.8%	4,648	17.4%
Rockfish	Hook&line	78	12.1%	18	2.1%	40	5.2%	34	4.9%	42	6.1%
	Trawl	7,549	30.7%	8,940	33.3%	6,143	35.3%	4,156	28.7%	6,697	32.0%
	TOTAL	7,627	29.7%	8,958	31.9%	6,183	33.8%	4,190	27.0%	6,739	30.6%
Other (not assigned to one of the above)	ALL	613	15.0%	3,608	20.6%	2,571	26.8%	4	48.5%	1,699	27.7%
Grand Total		53,310	19.3%	60,761	21.4%	51,949	19.9%	43,426	18.1%	52,362	19.7%

Table 7. Summary of total discards by Bering Sea/Aleutian Islands groundfish fisheries. Calculated discard of Other Species in A is computed using bycatch rates of each 'other' group by each groundfish fishery, gear, and in each area (to compute total catch) and multiplying by the discard rate. This is compared with blend estimate (Table 5 Other Species) from NMFS, Juneau, AK. In B, halibut discards are listed as discarded tonnage, not tons of discard mortality. In C, Total Catch (both I and II) includes catches of prohibited species. Estimates of total discards, total catches, and discard rates labelled I use observer-based estimates of total discards of other species;those labelled II use blend estimates of other species discards from Table 5.

A. Other Species (tons)

Year	Catch of skates*	Catch of sculpins*	Catch of grenadiers*	Caatch of misc.**	Catch of others*	Calculated discard of other spp.	Table 4 discard of other spp.
1991	16,063	11,330	2,393	2,620	32,406	28,605	24,226
1992	16,961	10,788	2,675	2,668	33,092	30,291	29,784
1993	12,226	8,106	8,825	2,068	31,225	28,815	22,854

B. Prohibited Species

Year	Halibut t	Herring t	Chinook salmon #	Other salmon #	Red king crab #	Other king crab #	Bairdi tanner crab #	Other tanner crab #	Total Prohibiteds tons ***
1991	10,798	3,758	48,375	29,507	171,788	83,819	3,773,454	10,724,816	17,419
1992	14,279	1,076	42,438	41,502	183,527	132,261	4,464,007	15,149,446	18,947
1993	8,845	792	46,384	243,384	255,499	133,165	3,502,040	15,379,450	13,662
1994	14,032	1,762	44,414	96,414	281,736	77,700	2,571,711	12,487,317	18,811

Table 7. (continued)

C. Total Discards (tons)

			I. Using Observer-only based estimates of Other Species Catches				II. Using Blend Estimates of Other Species Catches			
Year	Prohibiteds	Groundfish	Total Others *	Total Discards	Total Catch	Discard Rate	Blend Other Species	Total Discards	Total Catch	Discard Rate
1991	17,419	289,652	28,605	335,675	2,176,736	15.4%	24,226	331,297	2,172,358	15.3%
1992	18,947	284,802	30,291	334,039	2,014,784	16.6%	29,784	333,532	2,014,277	16.6%
1993	13,662	273,477	28,815	315,953	1,906,773	16.6%	22,854	309,993	1,900,812	16.3%
1994	18,811	271,468	n/a	n/a	n/a	n/a	23,272	313,551	2,013,080	15.6%

* Observer based estimates of catches of other species.

** Misc = squid, octopus, smelts, sharks, hagfish, ratfish, eelpouts, snipe eels, greenlings, poachers, and lumpsuckers.

*** Prohibited tons calculated using 4.3 kg/chinook salmon, 2.8 kg/other salmon, 1.6 kg/red king crab, 1.1 kg/other king crab, 0.3 kg/bairdi tanner crab, and 0.1 kg/other tanner crab;1994 NMFS observer data

Table 8. Summary of total discards by Gulf of Alaska groundfish fisheries. Calculated discard of Other Species in A is computed using bycatch rates of each 'other' group by each groundfish fishery, gear, and in each area (to compute total catch) and multiplying by the discard rate. This is compared with blend estimate (Table 8 Other Species) from NMFS, Juneau, AK. In B, halibut discards are listed as discarded tonnage, not tons of discard mortality. In C, Total Catch (both I and II) includes catches of prohibited species. Estimates of total discards, total catches, and discard rates labelled I use observer-based estimates of total discards of other species;those labelled II use blend estimates of other species discards from Table 6.

A. Other Species (tons)

Year	Catch of skates*	Catch of sculpins*	Catch of grenadiers*	Catch of misc *,**	Total catch of others *	Calculated discard of other species	Table 5. other species
1991	1,399	1,136	5,678	662	8,875	6,158	3,969
1992	2,019	1,427	19,016	1,263	23,725	12,323	5,236
1993	2,008	1,128	16,449	1,733	21,319	15,581	5,019

B. Prohibited Species

Year	Halibut t	Herring t	Chinook salmon #	Other salmon #	Red king crab #	Other king crab #	Bairdi tanner crab #	Other tanner crab #	Total Prohibiteds tons ***
1991	9,635	1	37,827	14,538	218	2,022	133,651	9,057	9,879
1992	11,034	27	17,137	11,301	97	1,190	140,847	13,938	11,224
1993	12,808	6	19,569	88,234	1,065	2,868	78,958	31,355	13,219
1994	10,577	102	14,027	40,292	73	6,142	53,295	13,409	10,889

Table 8. Continued

C. Total Discards (tons)

			I. Using Observer-only based estimates of Other Species Catches				II. Using Blend Estimates of Other Species Catches			
Year	Prohibiteds	Groundfish	Total Others *	Total Discards	Total Catch	Discard Rate	Blend Other Species	Total Discards	Total Catch	Discard Rate
1991	9,879	49,341	6,158	65,377	287,974	22.7%	3,969	63,188	285,786	22.1%
1992	11,224	55,525	12,323	79,072	302,719	26.1%	5,236	71,985	295,632	24.3%
1993	13,219	46,931	15,581	75,731	285,146	26.6%	5,019	65,169	274,584	23.7%
1994	10,889	40,800	n/a	n/a	n/a	n/a	2,626	54,316	250,904	21.6%

* Observer based estimates of catches of other species.

** Misc = squid, octopus, smelts, sharks, hagfish, ratfish, eelpouts, snipe eels, greenlings, poachers, and lumpsuckers.

*** Prohibited tons calculated using 3.6 kg/chinook salmon, 3.2 kg/other salmon, 1.4 kg/red king crab, 0.2 kg/other king crab, 0.4 kg/bairdi tanner crab, and 0.6 kg/other tanner crab; 1994 NMFS observer data

Table 9.--Chinook and chum/other salmon bycatch in the Bering Sea and Gulf of Alaska. Data from NMFS observer reports. "Chum/other" JV and foreign estimates are for chum salmon. 1995 estimate only includes through August 1995.

		Chinook				Chum/other			
Area	Year	Foreign	JV	Domestic	Total	Foreign	JV	Domestic	Total
BSAI	1980	113,138	1,898		115,036	6,726			6,726
	1981	35,902	316		36,218	5,800			5,800
	1982	13,957	1,687		15,644	7,105	581		7,686
	1983	9,815	519		10,334	8,194	23,939		32,134
	1984	9,530	1,745		11,274	6,440	65,756		72,195
	1985	7,072	2,524	1,500	11,096	2,899	7,699		10,598
	1986	978	4,839	3,420	9,237	621	13,813		14,433
	1987	1,007	8,414	12,800	22,221	2,379	2,420		4,799
	1988		5,620	24,700	30,320		3,709		3,709
	1989		8,594	31,760	40,354		5,545		5,545
	1990			13,990	13,990			16,661	16,661
	1991			35,766	35,766			31,987	31,987
	1992			37,372	37,372			38,919	38,919
	1993			45,964	45,964			243,246	243,246
	1994			44,380	44,380			96,431	96,431
	1995			18,792	18,792			6,055	6,055
GOA	1980	31,579	168		31,747	4,150	0		4,150
	1981	28,570	0		28,570	1,963	0		1,963
	1982	4,716	1,198		5,914	708	180		888
	1983	5,946	3,598		9,544	3,568	594		4,162
	1984	11,102	63,251		74,353	718	524		1,241
	1985	349	13,645		13,994	9	66		75
	1986	0	20,760		20,760	0	54		54
	1987		761		761		456		456
	1988		88		88		59		59
	1989			6,690	6,690				0
	1990			14,830	14,830			4,670	4,670
	1991			37,592	37,592			13,288	13,288
	1992			15,964	15,964			10,126	10,126
	1993			24,465	24,465			56,388	56,388
	1994			13,973	13,973			40,513	40,513
	1995			10,588	10,588			50,294	50,294

Table 10. Estimated amount of offal consumed (mt) by groundfish on the eastern Bering Sea shelf during May through September. ns = not sampled.

	Year			
Groundfish predator	1990	1991	1992	Average
Pacific cod	86,789	82,577	35,067	68,144
Walleye pollock	45,117	51,851	37,023	44,664
Arrowtooth flounder	21,350	3,933	2,977	9,420
Flathead sole	28,656	7,067	32,351	22,692
Yellowfin sole	114	35,853	13,477	16,481
Pacpfic halibut	1,029	0	2,466	1,165
Skates	ns	ns	36,192	36,192
Total	183,055	181,281	159,553	174,630

Table 11. Estimates of percentages by weight of offal in the diets of groundfish in the GOA during 1990 and AI in 1991 (Yang, 1993, 1995). ns = not sampled.

Groundfish predator	Gulf of Alaska	Aleutian Islands
Pacific cod	13	<1
Walleye pollock	0	0
Arrowtooth flounder	1	0
Pacific halibut	7	1
Sablefish	29	ns
Atka mackerel	ns	1
Northern rockfish	ns	9

Table 12. Summary of offal and discard amount in the BSAI and GOA groundfish fisheries for 1994 compared to total and retained catch amounts.

Category	Amount (MT) or fraction
Retained catch (round weight)	1,917,945
Discarded catch	338,166
Total catch (retained + discarded)	2,256,111
Offal (retained wt - product wt.)	1,339,795
Offal + discards	1,677,961
Discard / retained catch	0.18
Discard / total catch	0.15
Offal / retained catch	0.59
Offal / total catch	0.70
(Offal + discard) / total catch	0.74
offal / discard	3.96

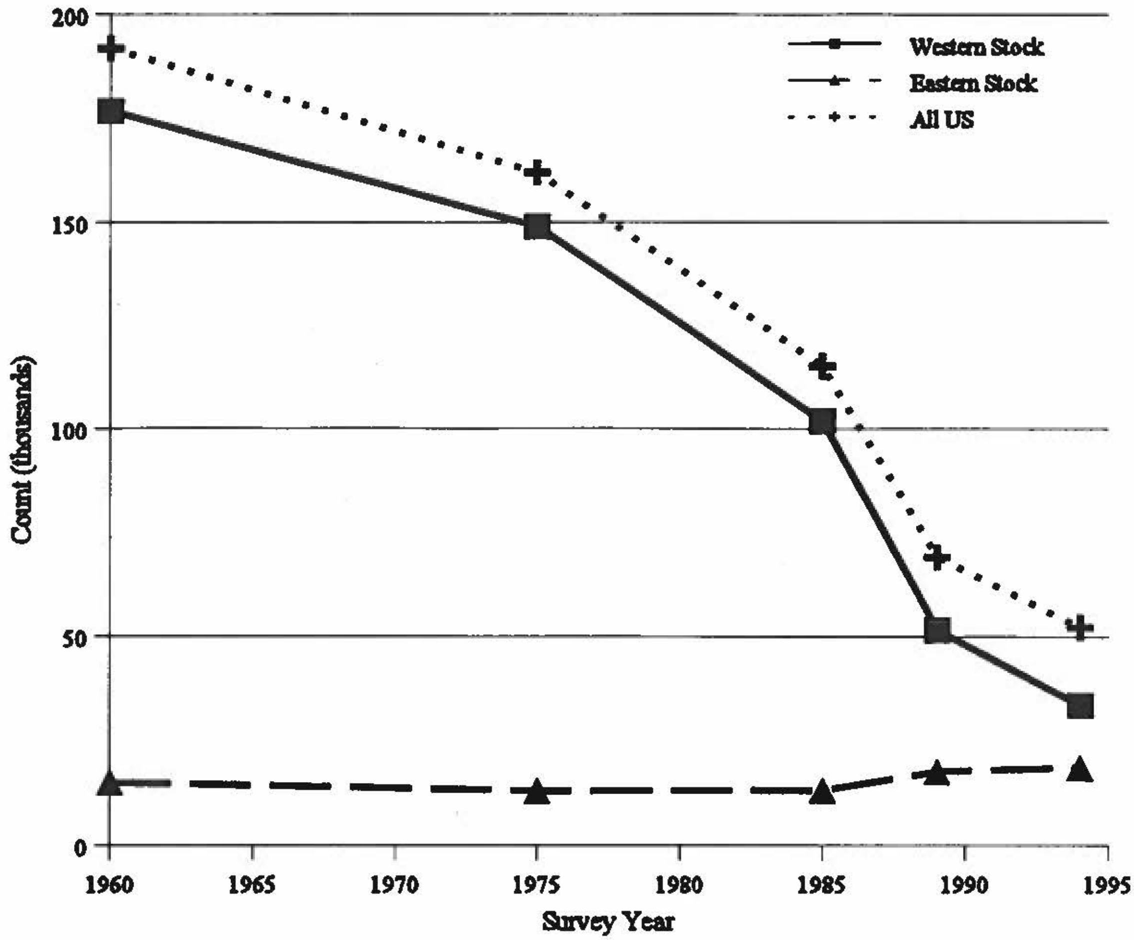

Figure 1.--United States western stock, eastern stock, and total Steller sea lion numbers (adjusted for animals at sea) for the period 1960-94.

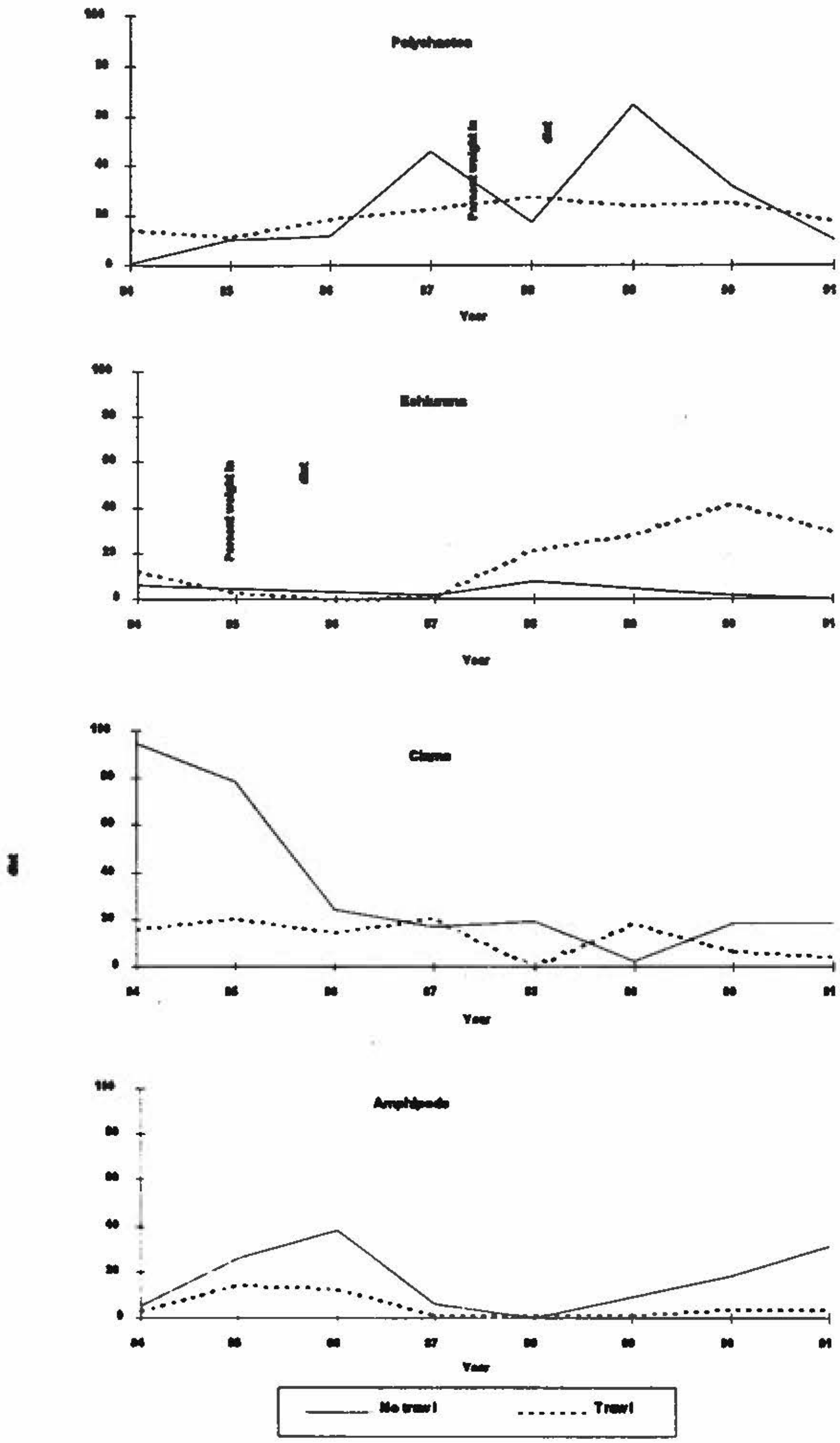

Figure 2.--Diet composition of yellowfin sole in the eastern Bering Sea from 1984 to 1991 in two adjacent areas, one with no trawling from 1986 to 1991 (area 512) and one with trawling from 1984 to 1991 (just west of area 512).

Marine Mammal Protection Act Amended
(as of April 30, 1994)

Fisheries Interaction Data
-Observer reports
-Fisherman's Logbooks
-Confirmed reports
-Strandings

Biological Data
- Stock Identification
- Population Assessment
- Population Growth Rate

Non-fisheries Interaction Data
-Other sources of human-caused mortality

Scientific Review Groups
(established 6/30/94)

Draft Stock Assessment Reports
(August 1994)

Final Stock Assessment Reports
(July 1995)

"Strategic Stocks"
- listed under ESA (threatened/endangered)
- designated under MMPA (depleted)
- Total Human-Caused Mortality > PBR
- In **Alaskan** Waters:
  - **Bowhead Whale**
  - **Fin Whale**
  - **Humpback Whale**
  - **Northern Right Whale**
  - **Sperm Whale**
  - **Northern Fur Seal**
  - **Steller Sea lion**

"Non-Strategic Stocks"
- Total Human Caused Mortality <PBR

Secretary Issues General Permit to Take in Commercial Fisheries

Revised List of Fisheries
- Proposed Regulations Published June 1995
- Final List September 1995
- None in Alaska are Category I

Take Reduction Teams
- To be formed in Fall 1995 to address takes of strategic stocks interacting with Category I or II fisheries)
- One team will address Alaskan marine mammals including Steller sea lions

Take Reduction Plans
- 180 days to submit plans for "strategic" stocks, 11 months for non-strategic stocks
- If zero mortality goal is met, then no take reduction plan is drafted

Figure 3. Implementation Steps for the 1994 Amendments to the Marine Mammal Protection Act