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

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At the August 1994 meetings of the Gulf of Alaska (GOA) and Bering Sea/Aleutian Islands (BS/AI) Plan Teams it was determined that the time was appropriate for an expanded Ecosystems Considerations section to be included with the SAFE documents. This chapter is the result of a collaborative effort by members of the Plan Teams, staff of the NMFS and ADF&G, and others. It is the expectation of the Plan Teams that increased awareness of the natural processes influencing and being influenced by commercial fisheries can contribute to successful long-term management of both target and non-target species.

This chapter combines both the earlier Marine Mammal Considerations and Ecosystem Considerations sections. In addition, it includes discussions of an expanded array of specific topics relevent to ecosystem management. The three main purposes of the new Ecosystem Considerations chapter this year are:

1. To provide a mechanism for the Council to become familiar with some important physical and biological features of the Bering Sea, Aleutian Islands and Gulf of Alaska which should be considered as management begins shifting emphasis from from single species to multi-species.

2. To discuss some of the underlying themes of ecosystem management as defined by different circumstances which can then be drawn from as the Council's approach develops.

3. To summarize administrative actions relevent to Council decisions, particularly with respect to The Endangered Species Act and the Marine Mammal Protection Act.

At this early stage we do not attempt to define ecosystem management, but rather lay the groundwork for it to evolve in the context of Council activities, and provide a place to track its development in the SAFE document. Neither do we consider this document complete. Future editions will expand on Sections included here. Other material presented here may not be included in future SAFEs, but will be referenced or updated as necessary.

Ecosystem Management

The Plan Teams believe that the first step in developing ecosystem management in the groundfish fisheries off Alaska will be to determine a set of agreed-upon objectives. Lacking such a set of objectives, the five goals cited by Grumbine (1994) and ecosystem considerations described in the MCFMA, the ESA, the MMPA, and the NEPA will be used here to provide the framework for a discussion of ecosystem management in the groundfish fisheries off Alaska.

Grumbine (1994) summarizes 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". He also cites general sentiment among scholars in favor of the following five ecosystem management goals:

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 further writes, "The first four of these goals are value statements derived from current scientific knowledge that aim to reduce (and eventually eliminate) the biodiversity crisis. The fifth goal acknowledges the vital (if problematic) role that people have to play in all aspects of the ecosystem management debate."

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? Unfortunately, the ecosystem definitions of the MFCMA, the MMPA, the ESA, and the NEPA are not necessarily synonymous nor clear. Furthermore, ecosystem definitions of resource managers may differ with those of scientists, as may those of overlapping jurisdictions and agencies.

The Plan Teams propose that the large marine ecosystems off Alaska be classified as the Bering Sea proper, the Aleutian Island chain, and the Gulf of Alaska. Within these three large ecosystems are groundfish resources that are targeted upon under the FMPs. Along with the impacts of harvesting on target species are impacts on ecologically related species -- from 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 Council, the NMFS, and other agencies set as their primary ecosystem management goal the maintenance of Alaskan marine biodiversity at the average level observed over the past 100 years, roughly 1900-2000. A period of 100 years is justifiable on the basis that it is about the maximum length of time for which a reasonable amount of knowledge regarding population abundances is available. This 100-year 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 full fisheries resource utilization. Furthermore, all of the important ecosystem components have been prominently visible at one time or another during this period, meaning that the goal of maintaining Alaskan marine biodiversity can be addressed with relative objectivity by scientists and managers.

With regard to the selection of ecosystem components for special emphasis, it may be observed that both the MMPA and ESA provide some guidance as to the type of ecological groups upon which attention should be focused. These include species of seabirds, marine mammals, fish, and other taxa that could be depleted to threatened/endangered status as a result of fishing. However, ecosystem management should not only prevent these species from reaching a threatened/depleted state, but should attempt to maintain 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 constant change.

Given this tendency of nature, 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 ecosystem 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 declines off Alaska? What about the seabird populations that seem to have fluctuated up and down in abundance? 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? Unfortunately, it is clear that the available data and the extent of scientific understanding are, more often than not, insufficient to provide complete answers to these questions.

The fifth goal of Grumbine (1994), accommodation of human use and occupancy within the constraints of the first four goals, is obviously germane to the harvesting of groundfish off Alaska. The FMPs have provided for the use of fishery resources in a conservative manner -- to err on the side of conservation so that biodiversity is preserved in situ and so that human activities do not cause natural populations to reach threatened/endangered status. Within the general framework of the FMPs, specification of particular conservation measures must proceed on a case-by-case basis, taking into consideration the forces of nature and the potential impacts of human activities.

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. Some of these have had "ecosystem management" consequences, while others have consciously been taken to mitigate fishery-induced impacts in situations where natural populations have declined. An example of the former was limiting the upper end of the OY range for groundfish in the BSAI region to 2 million t. This has limited the full utliization of the ABC for the groundfish complex (which has been in the 2.8-3.2 million t range) during the past 10 years. The result has been conservative exploitation rates for some groundfish for which either market or bycatch considerations have limited their utilization (e.g., most flatfish species); other species have been exploited fully (e.g., pollock). Thus, the OY cap for the BS/AI groundfish fishery has resulted in "ecosystem management", even though the action was initally guided more by economic and allocative concerns.

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. Prior to this time, the size of the GOA pollock stock was estimated, and the ABC was set each year using traditional single-species management concepts. In these stock assessment models, predation by marine mammals was considered only to the extent that it contributed some fraction of the fish stock's natural mortality (M); the indirect effects of fishery removals on other fish predators, including marine mammals, was not included. Beginning in 1993, prey availability for other predators, such as marine mammals and birds, was addressed in the model since 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 marine birds. 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 problematic issue pertaining to ecosystem management off Alaska has been the protection of marine mammals, especially Steller sea lions, that are known to be declining. Ten to twenty-mile sanctuary areas have been created around certain key rookeries to protect these 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. However, it is too early to tell whether these actions will help to reverse any declining trends presently observed in dependent populations. The Council and NMFS must continue to monitor the situation, to conduct research into possible mitigating actions, and to seek better methods of managing all of the living marine resources off Alaska.

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 1995 groundfish TACs.

Disproportionate Harvest Rates on Groundfish

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 and increasing. 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, particularly king crabs and *C. biardi* crabs, which 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 groundfishes. 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.

Unharvested forage fish species

In response to the declining trend in GOA pollock biomass and concern for possible ecosystem impacts, the recommended 1995 GOA pollock ABC from the Plan Team is considerably lower than the 1994 ABC. As opportunities to harvest pollock decrease, 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 Stellers sea lions and harbor seals. To this end, the Council should give serious attention to amendment proposals presented this year to the Council concerning the prohibition of target fisheries on forage fish species in both the GOA and BSAI.

Changes in the Gulf of Alaska Ecosystem

Evidence is accumulating that a major ecosystem change has occurred in the GOA since the 1970s. Decreases in marine mammal and pollock populations, and increases in the arrowtooth flounder population have been previously discussed. However, evidence is now accumlating of large decreases in the abundance of forage fish and fish eating seabirds in the GOA (see Ecosystem Change section). Because of the apparent changes in the GOA, the Plan Team encourages the Council to pursue conservative harvest strategies in the GOA.

ENVIRONMENTAL AND PHYSICAL FEATURES

Bering Sea and Aleutian Islands

Bathymetric features

The most prominent and unique feature of the Bering Sea is the extensive continental shelf in the eastern and northern portion of the sea. It constitutes approximately 80% of the total shelf area in the Bering Sea (Hood and Kelly 1974) and is one of the world's largest. For the Bering Sea as a whole, 44% of its 2.3 million square km area is continental shelf, 13% continental slope, and 43% deep-water basin. A number of large bays, including Bristol and Kuskokwim Bays and Norton Sound on the Alaska coast, makes the coastline of the Bering Sea highly irregular. The area of all bays in the Bering Sea makes up 11.1% of the total area of the sea (Gershanovich 1963).

The broad eastern Bering Sea shelf is extremely smooth and has a gentle uniform gradient resulting from sediment deposits (Sharma 1974). The sediments, originating along the coast and transported offshore in graded suspension by storm waves, are predominantly sands over the inner shelf and silt and clay sediments on the other shelf and slope. The continental slope bordering the eastern Bering Sea shelf is abrupt and very steep and is scoured with valleys and large submarine canyons (Sharma 1974).

Forming a partial barrier to the exchange of Bering Sea and Pacific Ocean water is the Aleutian-Commander Islands arc. This chain is made up of more than 150 islands and has a total length of approximately 2260 km (Gershanovich 1963). Shelf areas throughout most of the Aleutians portion of the chain are narrow (and frequently discontinuous between islands) ranging in width on the north and south sides of the island from about 4 km or less to 42-46 km. The shelf broadens in the eastern Aleutians. An additional geographical feature of the Aleutian Islands region of fishery interest is Bowers Ridge. The submerged ridge, forming an arc off the west-central Aleutian Islands, is about 550 km long and 75-110 km wide, becoming even wider in the vicinity of the Rat Islands (Gershanovich 1963). The southern portion of the ridge summit is 150-200 m deep, the central portion is 600-700 m deep, and the northern portion 800-1000 m deep.

Oceanography

Exchange of water between the Bering Sea and the Pacific Ocean occurs through the various Aleutian Island passes with an estimated 14% of the Pacific water remaining in the Bering Sea (Sharma 1974). The net gain from Pacific water and surface runoff from rivers is lost to the Arctic Ocean through the Bering Strait, creating a net movement of water northward.

The dominant water movement on the eastern Bering Sea continental shelf originates from Pacific waters entering the Bering Sea in the vicinity of Unimak Island. These waters move northward toward St. Matthews Island and eastward toward Bristol Bay. The northward stream divides near St. Matthews Island before joining again and passing through the Bering Strait. The eastward flowing current along the Alaska Peninsula upon reaching the head of Bristol Bay is deflected westward by waters from the Kvichak and Nushagak Rivers (Sharma 1974). These westward flowing waters are mixed with Kuskokwim River water near the mouth of Kuskokwim Bay and directed southward, forming a cyclonic gyre in the southeastern Bering Sea.

The Bering Sea is influenced mainly by subarctic climate, except for the southernmost part, which can be included in the temperate zone (Sharma 1974). It lies in a region of moderate to strong atmospheric pressure gradients and is subject to numerous storms. A major environmental feature of the Bering Sea is the pack ice which covers most of the continental shelf in the eastern and northern sections of the sea in winter and spring. The ice edge begins to intrude into the northern Bering Sea in November, and normally reaches it maximum in late March (Potocsky 1975). At its maximum the ice pack may cover the continental shelf south to the Pribilof Islands and extend from the Pribilof Islands eastward to the vicinity of Port Moller. The areas of the outer shelf between the Pribilof Islands and Unimak Island and deeper waters of the Bering Sea are generally ice free throughout the year because of the intrusion of warmer Pacific Ocean water. In April and May the ice edge begins to retreat and by early summer the Bering Sea is normally free of ice.

The physical, climatic, and oceanographic features in the eastern Bering Sea combine to create conditions highly favorable for primary biological productivity. These conditions are only surpassed by some of the upwelling regions in the eastern Pacific and Atlantic Oceans (Hood and Kelly 1974). This productivity supports some of the largest fish, marine mammal, and bird populations in the world. Although the processes for this high productivity are not fully understood, they probably originate from the upwelling of nutrient-rich water along the Aleutian Islands chain (Sharma 1974), the mixing of Pacific Ocean and Bering Sea waters, the seasonable extremes in climate with a buildup of nutrients during the winter months (Gershanovich, et al 1974) and the expansive nature of the continental shelf.

Sverdrup et al. (1942) divide the marine environment into two major realms, the benthic, corresponding to the sea bottom and all animals and plants living directly on or within it (also known collectively as the benthos), and the pelagic, which comprises the whole body of water covering the benthic realm which forms the seas and oceans. They further subdivide the pelagic realm horizontally into oceanic and neritic (coastal) provinces, the border of which is the edge of the continental shelf (approximately the 200 m isobath). The neritic province in the Bering Sea has been further divided into outer, middle and inner shelf domains at approximately the 100 m and 50 m isobaths (see Schumacher 1984; Neibauer 1987). Where the three neritic domains and the two major pelagic provinces meet are important oceanographic frontal features in which nutrients, primary productivity and subsequent secondary productivity are concentrated.

Waters out to a depth of approximately 50 meters are well mixed by a combination of winds and tidal action (Schumacher et al. 1979) and exhibit small mean current flow. This area hosts a nearshore zooplankton community (Cooney 1981) and forage fish populations including herring, capelin, and sandlance. Seaward of the coastal domain lies an inner front--strong gradients of temperature and salinity that separate this water mass from the middle shelf domain.

The middle shelf (50-100 meters) is a vertically stratified system exhibiting almost no mean current (Coachman 1986). During summer these waters experience high rates of primary production, due to occasional mixing of nutrient-rich bottom waters into the surface layer, but large grazing zooplankton are absent so much of this production sinks to the bottom, supporting high abundance of benthic animals including crabs and flounders (Haflinger 1981, Cooney and Coyle 1982). The middle shelf domain is separated from outer shelf waters by another area of high physical gradients, the middle front.

Outer shelf waters (100-200 meters) are vertically stratified, with shelf water overlying a layer of fine structure which itself overlies intruding oceanic waters (Coachman 1986). Due to occasional mixing of nutrient-rich oceanic waters into surface layers, this area also exhibits high rates of primary production, but vertically migrating oceanic zooplankton effectively graze these plants to divert energy into a pelagic ecosystem (Cooney and Coyle 1982). Pollock and Pacific cod are predominant species in outer shelf waters.

An outer shelf front separates waters from the oceanic domain over the continental slope and Aleutian Basin. These oceanic waters are typically poor in nutrients and support less productivity than waters on the shelf and slope. However, localized areas, particularly close to the bottom in areas of topographic irregularity, support concentrations of rockfish and sablefish. Waters particularly along the shelf break exhibit moderate mean current flow parallel to the bathymetry.

Gulf of Alaska

Bathymetric features

The Gulf of Alaska is a large body of water bordered by the Alaska coast from Dixon Entrance to Unimak Pass. This coast is unusually rugged and mountainous and deeply indented by numerous fjords and inlets. Tidewater glaciers flow down into the heads of many bays. Thousands of streams and rivers flow into these waters, including many that are glacier-fed and silt-laden. Marine habitats within the Gulf of Alaska include estuaries, tideland marshes, bays, fjords, sandy beaches, unprotected rocky shores, river deltas, and a variety of continental shelf, slope, seamounts, and deep ocean habitats.

The continental shelf parallels the southeastern Alaska coast and extends around the Gulf of Alaska. Total area of continental shelf in the GOA is about 160,000 km^2, which is more than the shelf area in the Washington-California region but less than 25% of the eastern Bering Sea Shelf. Between Canada and Cape Spencer the Continental Shelf is narrow and rough. North and west of Cape Spencer it is broader. Although its width is less than 10 miles at some points, it is generally 30 to 60 miles wide. Off the Kenai Peninsula and Kodiak Island it is more than 100 miles broad. The continental shelf reflects the rugged coastline; it is irregular and frequently interrupted by submarine valleys. These deep-water valleys, or troughs, separate broad bank areas such as Albatross and Portlock Banks near Kodiak Island and Davidson Bank south of Unimak Island. In the western Gulf of Alaska, these submarine banks are generally covered with sand and gravel, indicating a vigorous current flow in the overlying water. In contrast, the sea valleys adjacent to these banks are usually sediment-laden. Rock out-croppings occasionally occur along the edge of these banks and where the continental shelf meets the deeper water of the slope. A pronounced feature of the western portion of the Gulf is a greater frequency and expansiveness of plateau-like banks and offshore islands than in the eastern part.

The continental shelf extends from the coast seaward to depths of approximately 200 m. At its edge, bottom depths increase rapidly toward the ocean basin or abyssal plain of the Gulf of Alaska. This region of rapidly increasing depth is known as the continental slope, which can be subdivided into an upper slope from 200 to 500 m in depth and a lower slope greater than 500 m. The 2,000-m depth line can be considered the boundary between the continental slope and the abyssal plain. In general, bottom sediment becomes finer with increasing depth so that in the lower slope and abyssal plain the sediment consists mainly of a mixture of clay and silt. The abyssal plain of the Gulf of Alaska contains submarine mountains that rise thousands of meters from the ocean floor. These seamounts, or guyots, are remnants of extinct volcanoes whose peaks have been eroded away to form flat-topped features.

The Southeast Outside District is characterized by a much narrower shelf area than found in other parts of the Gulf of Alaska. Much of the East Yakutat portion is glacial moraine with cobble or large boulders surrounded by a combination of gravel, glacial silt, and sand substrate. The Fairweather Grounds, a large, shallow rocky bank, approximately forty miles offshore, is a major feature of this area. Predominant features of the Southeast portion include rocky ridges, lava plains, offshore pinnacles, and associated hard bottom habitat. The shelf break is very steep and the number of deepwater gullies is limited. The percentage of smooth bottom habitat and the width of the shelf both increase slightly toward the southern half of the area, but the entire area is still much rougher and narrower than the remainder of the Gulf.

There are three major effects of this narrow shelf and extensive rocky hard bottom habitat. The first is that most species normally associated with large areas of smooth bottom such as pollock, Pacific cod, and most flatfish, do not occur in large numbers. Second, the remaining commercial species complex, which is made up primarily of rockfish, sablefish, and halibut, coexist in a limited amount of productive habitat. This has a tendency to compress the population into a smaller area. Third, the bottom topography limits the amount of trawlable area and the trawling which occurs tends to be concentrated in relatively small portions of the entire area. These factors greatly increase the risk of conflicts between gear type and/or grounds preemption problems because both hook-and-line and trawl gear are often competing for limited areas of productive fishing.

Oceanography

Coastal waters overlying the continental shelf are subject to considerable seasonal influences. Winter cooling accompanied by turbulence and mixing due to major storms results in a uniform cold temperature in the upper 100 m. Seaward of the continental shelf, there is a surface flow of water called the Alaska Current which moves in a northwesterly direction in the eastern Gulf of Alaska and swings to the west and southwest off Kodiak Island and westward toward Unimak Pass. Its rate of flow varies by season and is highest during the winter where, off Kodiak Island, its speed may exceed one knot. There is also evidence of an inter-annual eddy off the coast of southeast Alaska named the Sitka Eddy. This is a large (300 km in diameter) clockwise-rotating vortex that is observed in some years centered near 57 degrees North, 138 degrees West. Currents in the eddy can exceed one knot and could affect distribution of fish and larvae (Hamilton and Mysak 1985, and Tabata 1982).

Seasonal changes in temperature and salinity diminish with increasing depth and distance from shore. Along the outer shelf and upper slope, bottom water temperatures of 4 to 5° C persist year-round throughout the periphery of the Gulf of Alaska. With further increase in depth, water temperature shows no significant seasonal change but gradually decreases with depth, reaching 2° C or less at greater depths. Associated with seasonal temperature changes in the bottom water of the shelf habitat are bathymetric shifts in the distribution of many demersal fish and shellfish populations from shallow to deeper water during the winter cooling period and the reverse movement to shallower water during the summer warming period.

ECOSYSTEM COMPONENTS

Trophic Structure

Monitoring the changing states of large marine ecosystems is important in order to understand and predict the effects of stress on those systems. Stress applied to an ecosystem may reduce stability, diversity, and average size of dominant species, and may cause a shift in species composition towards shorter-lived species (Apollonio 1994). Examining time trends in biomass of individual species and the diversity of species grouped into trophic guilds may provide baseline information about the natural levels of variability in species abundance and could be indicators of stress-induced change. Trophic guilds, species grouped because of similarity in prey, could provide extra information about the nature of observed change. For instance, if we knew that fishing removals of one species in a trophic guild were large we might expect to see increases in other members of that guild as competitive pressures were eased. Similarly, if environmental changes or fishing caused a decline in a major prey species of a guild then we might see an overall decrease in abundance of species in the guild and perhaps even decreased mean size at age. Three trophic guilds have been defined for the eastern Bering Sea that encompass some of the main groundfish, marine bird, and pinniped populations in the area (Livingston et al. 1994). Although we do not discuss the GOA here, a similar structure would be reasonable there.

Offshore Pelagic Fish Consumers

This species group consists of fish, mammals, and birds that reside and feed primarily in the 80-250 m bottom depth zone of the eastern Bering Sea near the continental slope. Species were chosen as members of this group if small pelagic or bathypelagic fish (such as herring, capelin, juvenile walleye pollock, or myctophids) constituted over 25% of the diet by weight of the species and if the main feeding grounds or distribution was in the offshore zone. The species included in this guild are: northern fur seal (*Callorhinus ursinus*), Steller sea lion (*Eumetopias jubatus*), black-legged kittiwake (*Rissa tridactyla*), red-legged kittiwake (*Rissa brevirostris*), northern fulmar (*Fulmarus glacialis*), common murre (*Uria aalge*), thick-billed murre (*Uria lomvia*), adult walleye pollock (*Theragra chalcogramma*), arrowtooth flounder (*Atheresthes stomias*), and Greenland turbot (*Reinhardtius hippogloissoides*).

Biomass of the offshore pelagic fish consumer guild is dominated by walleye pollock (Fig. 1). It has undergone at least one interval of biomass increase and decrease during the 1979-93 period. During this period the shelf component of the Greenland turbot population has declined while the arrowtooth flounder population on the shelf has increased. The amount of increase in arrowtooth flounder population biomass is much larger than the observed decline in Greenland turbot biomass. The most abundant piscivorous bird population in this guild is the thick-billed murre (Fig. 2), with the other bird species at much lower relative abundances. All the piscivorous bird populations declined in abundance from 1976 to around 1985, but most appeared to have stabilized by the mid to late 1980's to present. Measures of hatching success on St. George Island for kittiwakes were low during the 1980's and higher in the 1970's and early 1990's while murre productivity did not have a trend. The two pinniped populations (fur seals and sea lions) also showed a decline in the beginning of the time period and, for northern fur seals, a stabilization by the mid 1980's. Species diversity (i.e., the number of species) and evenness (the distribution of species abundance) measures over time in this guild have been fairly constant over time (Fig. 3). Due to the dominance of pollock in the total biomass of the guild the effective number of species in the guild is close to one. Similarly, species evenness is low. Both measures show a slight decline during the middle part of the time period mirroring the increase in pollock biomass.

Inshore Benthic Infauna Consumers

This group consists of fish, crab, and other benthic invertebrates found mainly at bottom depths less than 100 m and whose diet consists mainly of bivalves, polychaetes, and echiurid worms that are part of the benthic infauna and/or of brittle stars that are epifaunal invertebrates. The species included in this guild are: yellowfin sole (*Pleuronectes asper*), longhead dab (*P. proboscidea*), rock sole (*P. bilineatus*), Alaska plaice (*P. quadrituberculatus*), flathead sole (*Hippoglossoides elassodon*), blue king crab (*Paralithodes platypus*), red king crab (*Paralithodes camtschatica*), Tanner crab (*Chionoecetes bairdi*), snow crab (*C. opilio*), and starfish (primarily *Asterias amurensis*).

Total biomass of the benthic infauna consumer group has shown an apparent increase over the 1979-93 time period (Fig. 4). Yellowfin sole, the dominant species, has been fairly constant following a large increase after heavy exploitation during the 1960's, while the next most abundant species, rock sole, has been steadily increasing due to good recruitment throughout the 1980's. Flathead sole biomass has also increased over the time period. Snow crab are the most abundant of the crab species and have undergone two periods of population increase and decrease from 1979-93. Tanner crab also show the same pattern of abundance change as snow crab. Red and blue king crab, however, were more abundant in the beginning of the time period and appear to have stabilized at lower abundance levels from 1985 to 1993. Species richness and evenness indices over the time period for the guild as a whole were fairly stable and slightly increasing (Fig. 5).

Crab and Fish Consumers

The members of this group are groundfish species with a depth range of around 80-250 m, further restricted by food habits information to include only species that consume crab and fish. Species included in this guild are: Pacific cod (*Gadus macrocephalus*), Pacific halibut (*Hippoglossus stenolepis*), two genera of sculpins (*Myoxocephalus sp.*, *Hemilepidotus sp.*), and the skate family (Rajidae).

Total biomass in this trophic guild was highest during the middle part of the 1979-93 period, due mainly to the increase in cod biomass during that time (Fig. 6). Skate biomass began increasing around 1986, peaked in 1990, and has stabilized or decreased slightly from 1991 to 1993. Cod biomass is undergoing another increase, due to above average recruitment from the

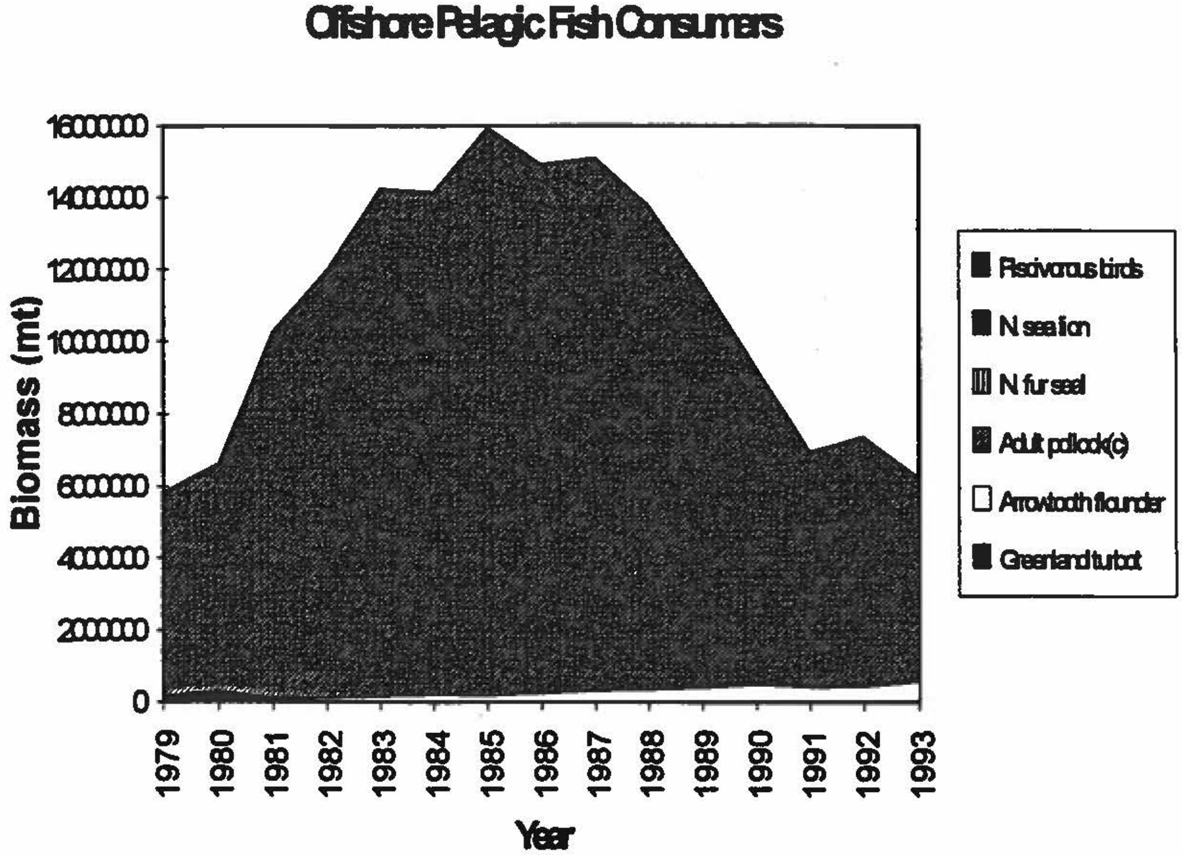

Figure 1a.--Biomass trends of the offshore pelagic fish consumer guild in the eastern Bering Sea from 1979 to 1993.

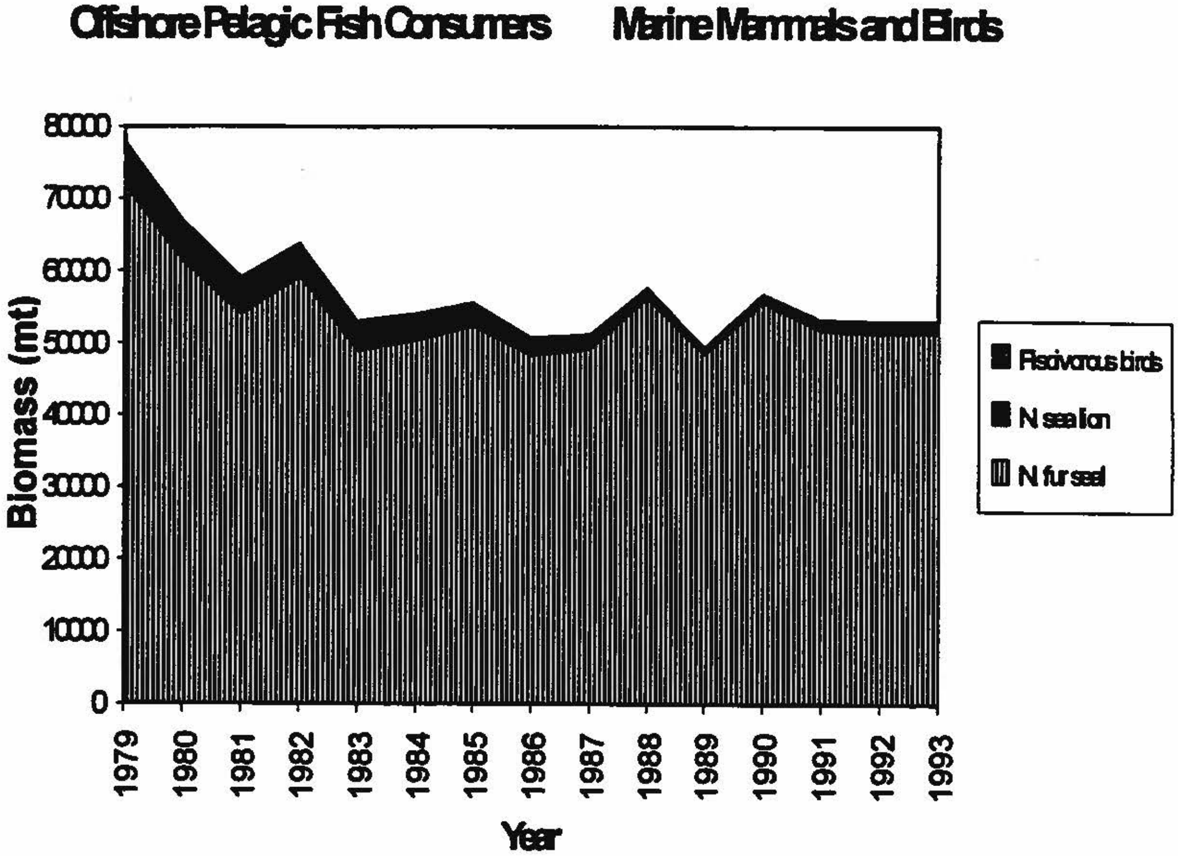

Figure 1b.--Biomass trends of the offshore pelagic fish consumer guild in the eastern Bering Sea from 1979 to 1993.

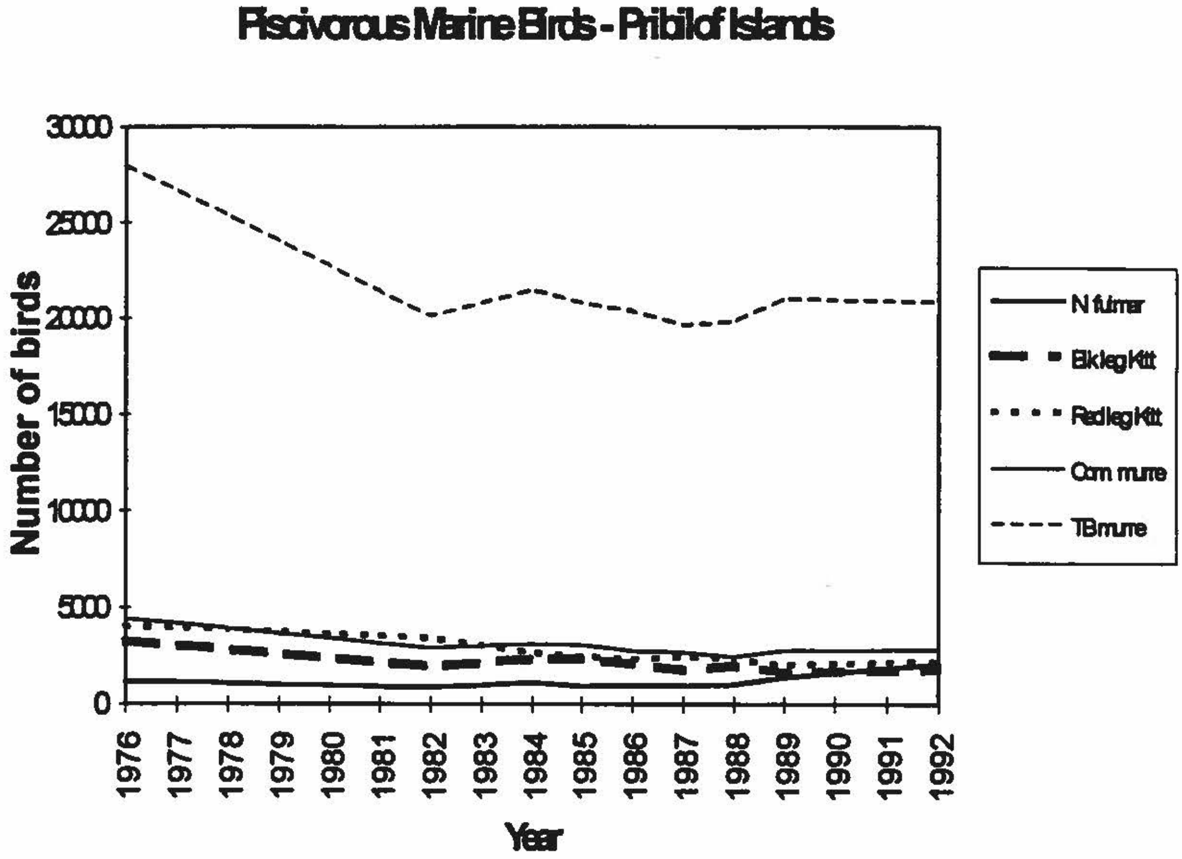

Figure 2.--Abundance of piscivorous marine bird populations on the Pribilof Islands in the eastern Bering Sea from 1976 to 1992.

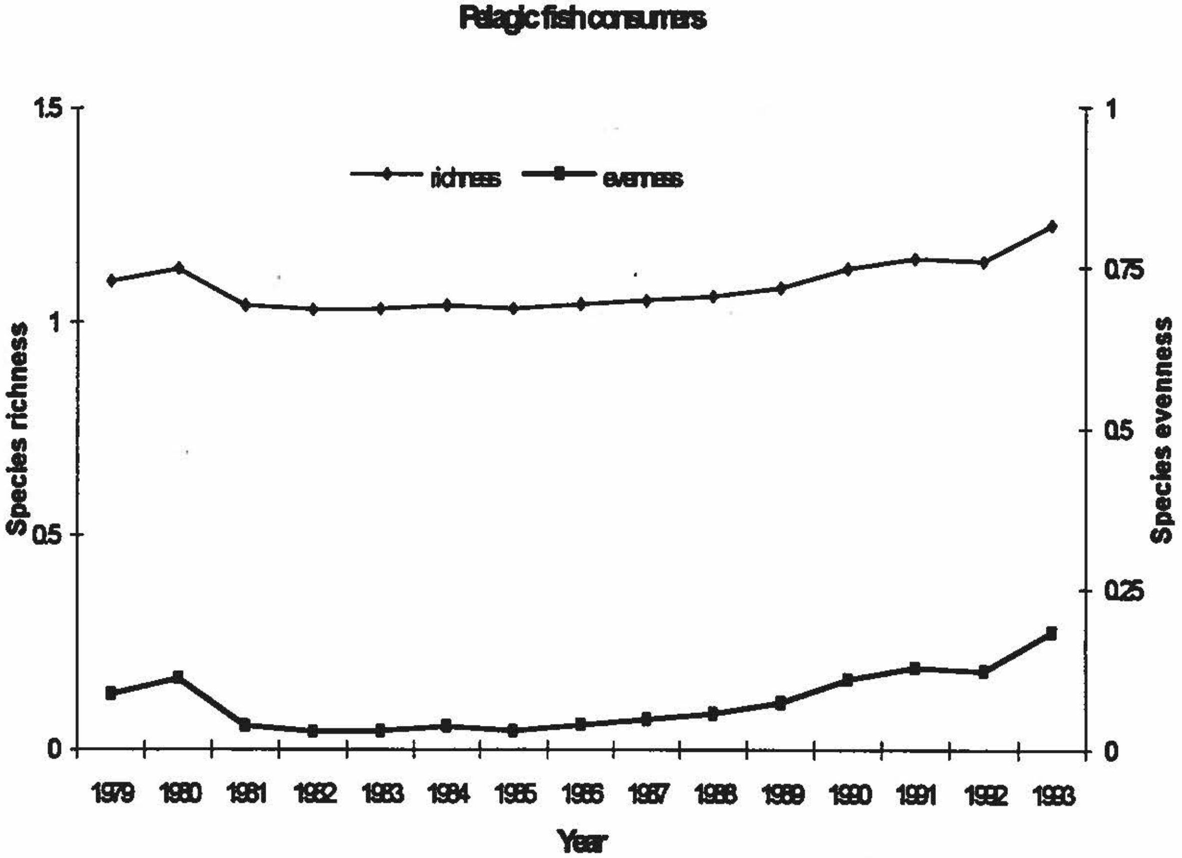

Figure 3.--Species richness and evenness indices for the pelagic fish consumer guild in the eastern Bering Sea from 1979 to 1993.

1989 and 1990 year-classes (1991 and 1992 also may be strong). Cod and skates are the two most dominant parts of this guild and the species richness and evenness indices reflect mainly changes in their biomass (Fig. 7). Both indices increased over the time period mainly due to the decrease in cod biomass and increase in skate biomass.

Summary

Trends shown above in individual species and guild biomasses indicate that most fished populations of fish and crab have been exhibiting periods of increase and decrease. Changes in other upper-level predators such as marine mammals and birds do not appear to be negatively correlated with fishing removals in the Bering Sea, although the effect of localized prey depletion through fishing activities on these predators is still unknown. No dramatic shifts in species composition have been observed, although reasons for declines in some species at the beginning of the 1979-93 period detailed here are not clear.

The dominance of pollock in the pelagic fish consumer guild may not always have been the case. Prior to the 1960's, there were much larger populations of fur seals, sea lions, whales, and birds. However, because we do not have good time series data for all of these species it is difficult to assess the time trend in species composition of this guild prior to around 1979. It is possible that the guild is already a reflection of a dramatic change in species composition prior to the period examined here.

Some declines, such as those noted in Greenland turbot and black-legged kittiwakes, were correlated more with increases in an exploited population (pollock) and thus could not be interpreted as a negative result of pollock fishing. Furthermore, Greenland turbot recruitment was also correlated with the temperature, making it unclear what the actual mechanism controlling Greenland turbot abundance might be. Similarly, the decline in red king crab population size might be due to the natural recovery of a predator population, yellowfin sole, after heavy exploitation in the 1960's or it might be due to the discard mortalities induced by crab and groundfish fisheries. Recent modelling work also shows the possibility that predation on red king crab zoea by outmigrating sockeye salmon smolts could be large. Unless we know the actual mechanism causing population fluctuations, we cannot accurately predict population change. Unfortunately, change may be induced by multiple factors simultaneously and which factor dominates the process may vary across time. The empirical relations presented here are only the beginnings of moving toward an understanding of important factors affecting population change.

Trophic Interactions

Knowledge of a species' food habits is necessary for determining possible effects of trophic interactions. These interactions may be expressed in two ways: predator-prey relationships, and competition between species for similar food items. In Alaskan waters, the majority of food habits studies have been conducted on adult specimens of commercial species during the summer. Consequently, most of the discussion that follows pertains to these studies,

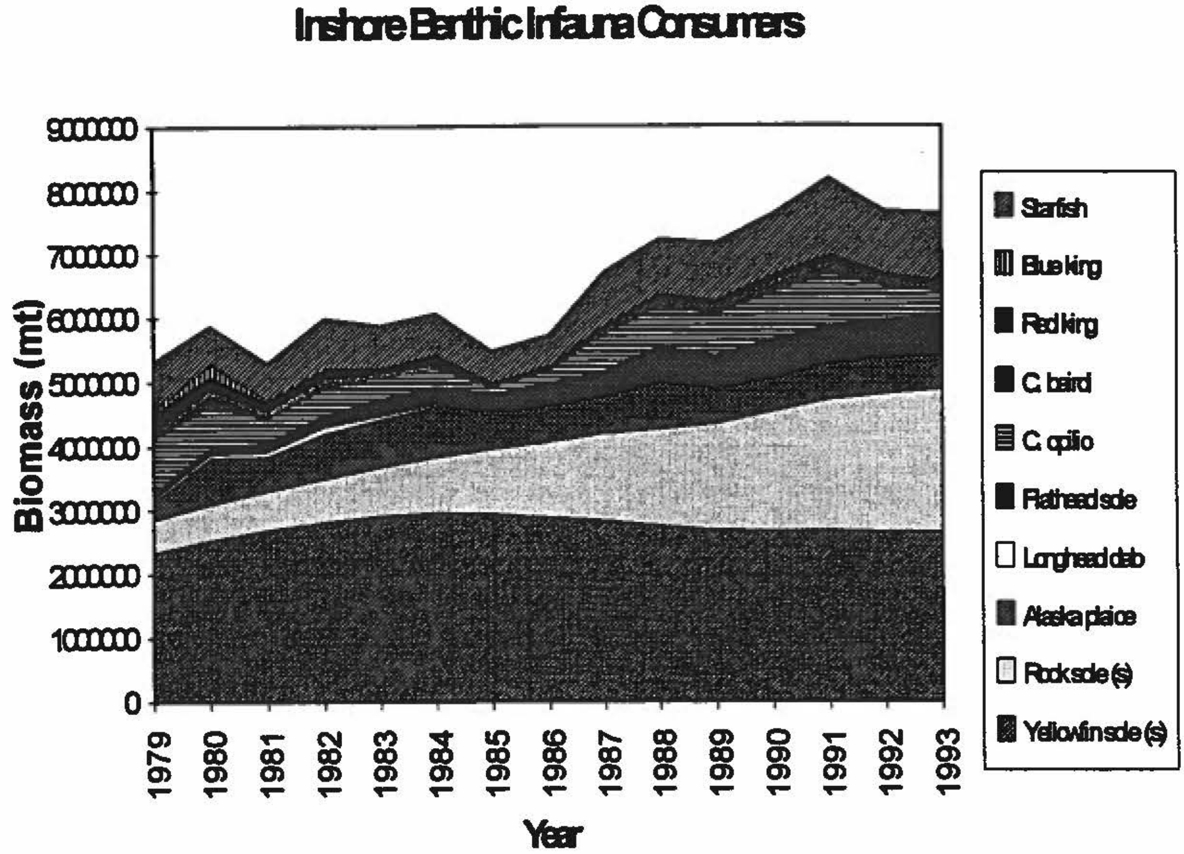

Figure 4.--Biomass trends in the inshore benthic infauna consumer trophic guild from 1979 to 1993 in the eastern Bering Sea.

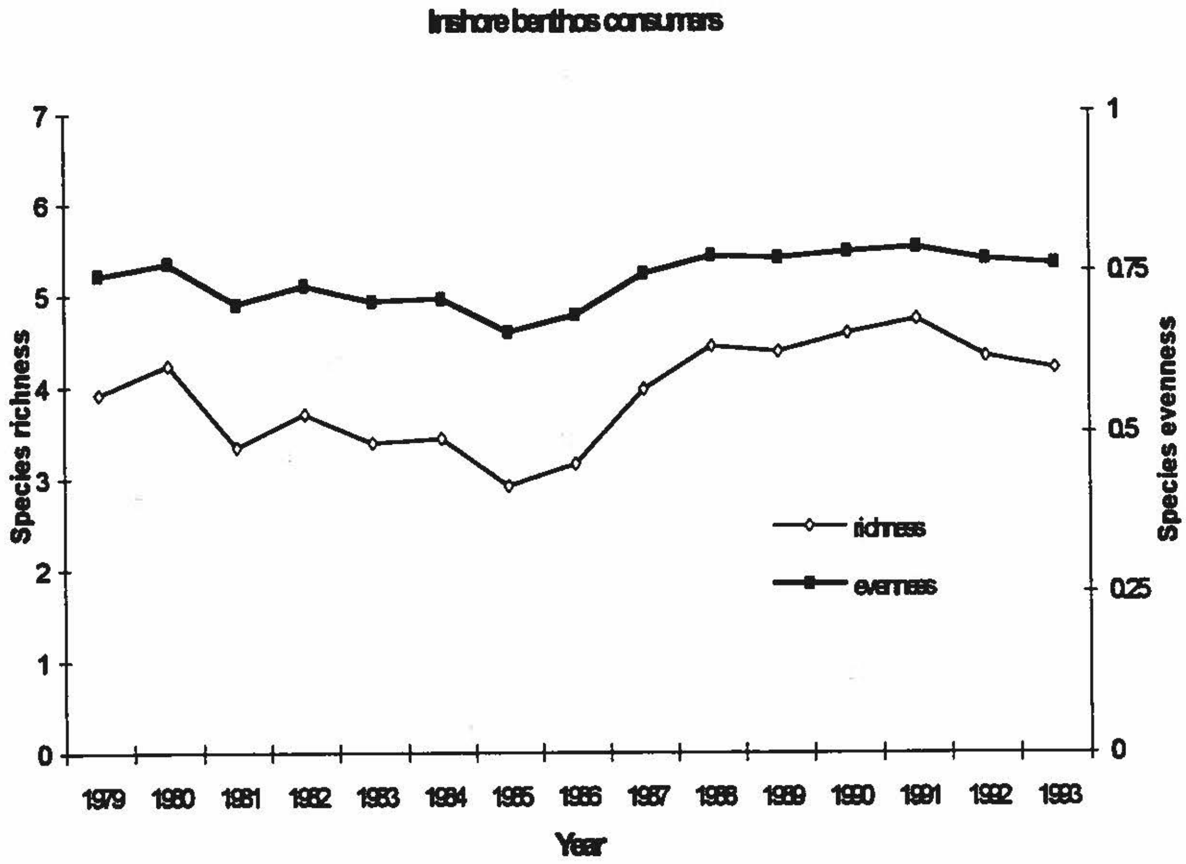

Figure 5.--Species richness and evenness indices for the inshore benthic infauna consumer guild from 1979 to 1993 in the eastern Bering Sea.

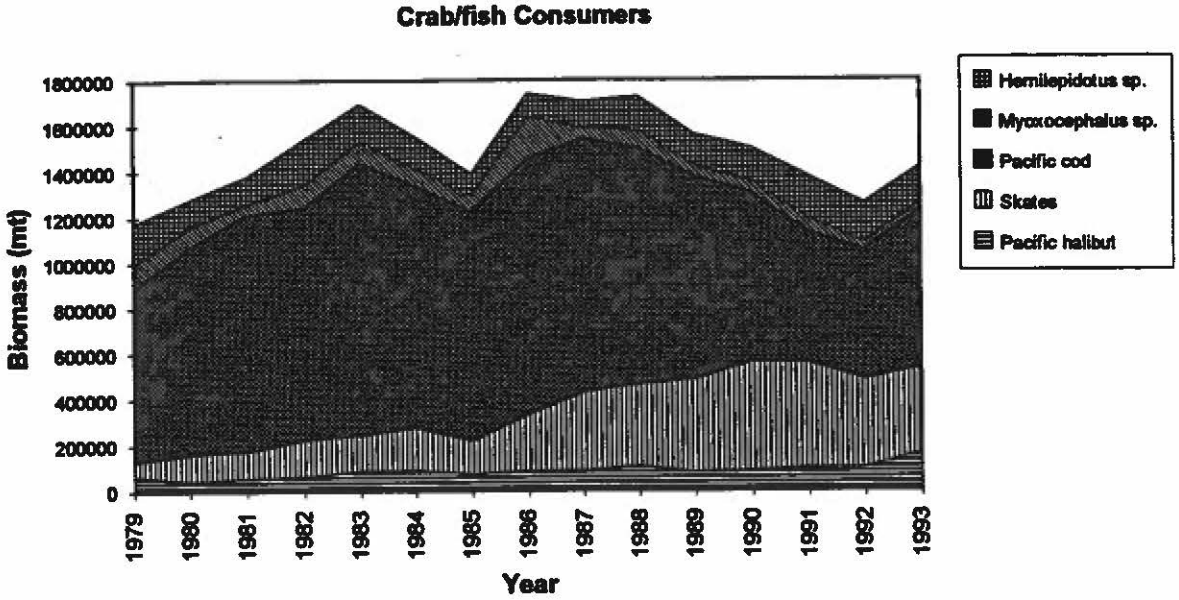

Figure 6.--Biomass trends of the crab/fish consumer guild from 1979 to 1993 in the eastern Bering Sea.

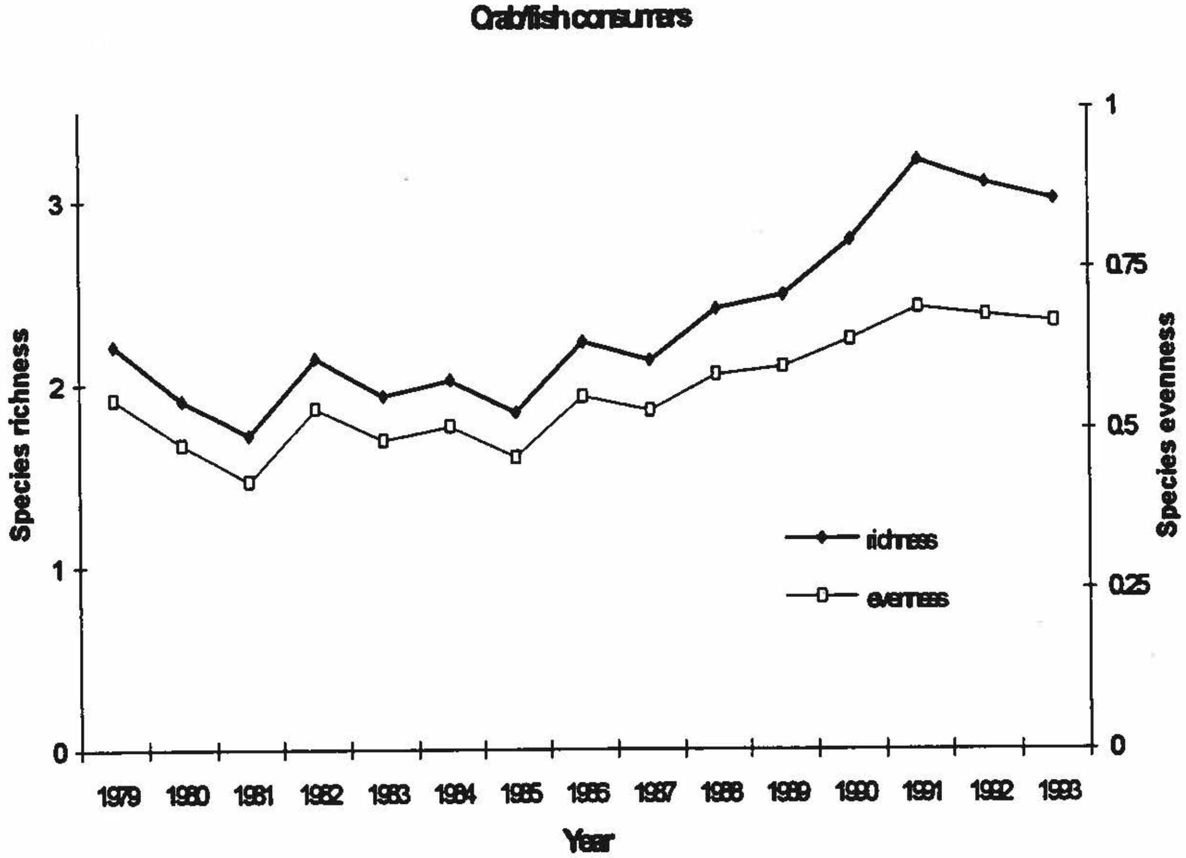

Figure 7.--Species richness and evenness indices for the crab/fish consumer guild from 1979 to 1993 in the eastern Bering Sea.

but it should be acknowledged that important trophic interactions may occur that involve younger life stages, other seasons, or other species.

Many fish species undergo large, seemingly unexplainable fluctuations in abundance. Most of these are r-selected species (e.g. pollock, Atka mackerel, capelin, sand lance), which generally have higher reproductive rates, are shorter-lived, attain sexual maturity at younger ages, and have faster individual growth rates than K-selected species (e.g. , rockfish, many flatfish). Predators which utilize r-selected fish species as prey (marine mammals, birds and other fish) have evolved in an ecosystem in which fluctuations and changes in relative abundances of these species have occurred. Consequently, most of them, to some degree, are generalists who are not dependent on the availability of a single species to sustain them, but on a suite of species any one (or more) of which is likely to be abundant each year.

Bering Sea

Food habits of groundfish have been studied extensively in the eastern Bering Sea since 1985 (Livingston 1989a, 1989b, 1991, 1993; Livingston et al. 1993; Brodeur and Livingston 1988; Yang and Livingston 1985, 1988; Pacunski 1990; Lang 1992). There is also one year of comprehensive groundfish stomach data for the Aleutian Islands (1991) and two years of groundfish stomach data for the western Gulf of Alaska (1990 and 1993)(Yang 1993). The primary sampling area and time for these data sets is the area encompassed by the groundfish bottom trawl assessment surveys that occur during the summer months. Based on these studies, fish that were primarily piscivorous included sablefish, Atka mackerel, adult Pacific cod, Pacific halibut, Greenland turbot, and arrowtooth flounder. All these fish consumed walleye pollock as a major prey item, which indicates the importance of this species in the Bering Sea ecosystem. Other flatfish species, such as yellowfin, rock, and flathead sole and Alaska plaice, fed mostly on benthic invertebrates. The diet of walleye pollock consisted of both plankton (euphausiids) and smaller walleye pollock.

Walleye pollock is an important prey item for many groundfish in all three areas but particularly in the eastern Bering Sea (Table 1). Pollock cannibalism and predation on juvenile pollock by smaller sizes of piscivores is important in the eastern Bering Sea but apparently not in the Aleutian Islands and western Gulf of Alaska. Clausen (1983) also found a low frequency (1%) of cannibalism by pollock in southeastern Alaska. The lack of importance of juvenile pollock as prey in the Aleutian Islands and Gulf of Alaska may be a reflection of the lower abundance of juvenile pollock relative to other prey or a difference in juvenile pollock availability (distribution) relative to groundfish predators. It appears that capelin is an important forage fish for piscivorous groundfish in the Gulf of Alaska while Atka mackerel and myctophids are important fish prey in the Aleutian Islands region.

In the eastern Bering Sea, walleye pollock cannibalism dominates the removals of pollock by fish, pinnipeds and birds (Fig. 8). High diet overlap between piscivorous groundfish species is due to the dominance of walleye pollock as a prey item for groundfish in the eastern Bering Sea

Table 1. -- Rank of walleye pollock as prey of groundfish predators by predator size in the eastern Bering Sea (EBS), Gulf of Alaska (GOA), and Aleutian Islands (AI). LR indicates the prey was less than fifth in terms of percent weight in diet. NS indicates the predator was not sampled in that area.

Predator	Predator size	EBS	AI	GOA
Pacific cod				
	<30	4	NS	3
	30 to 59	2	NS	NS
	>59	1	2	1
Walleye pollock				
	<40	4	NS	NS
	>40	2	NS	NS
Arrowtooth flounder				
	<20	1	NS	NS
	20 to 39	1	2	5
	>39	1	3	1
Pacific halibut				
	<50	1	NS	5
	50 to 79	1	2	1
	>79	1	1	1
Greenland turbot				
	<30	1	LR	LR
	>30	1	1	LR
Flathead sole				
	>20	2	5	LR

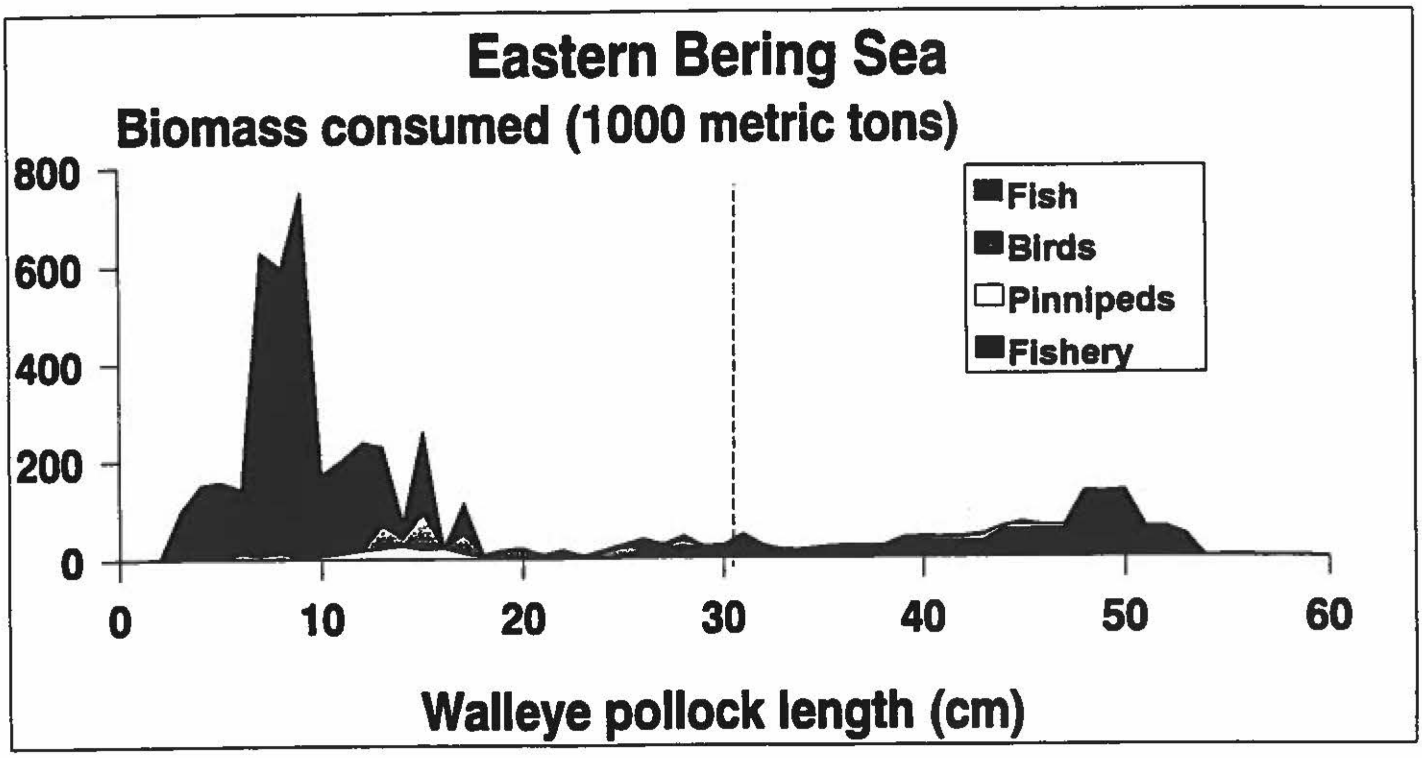

Figure 8.--Estimated removal of walleye pollock by groundfish, birds, pinnipeds, and fishery during 1985 in the eastern Bering Sea.

(Livingston et al., 1986). Most predation removals of pollock tend to be age-0 through age-2 pollock. During 1990 in the Gulf of Alaska, arrowtooth flounder was the main groundfish predator on walleye pollock (Fig. 9), with the relatively more abundant 1988 pollock yearclass at age-2 dominating the pollock consumption by predators. Arrowtooth flounder consumption of pollock in that year was larger than pollock consumption by sea lions and harbor seals (Fig. 10)(Livingston 1994). Stomach samples of arrowtooth flounder from 1993 show similar proportions of fish in the diet as the 1990 samples but a much lower proportion of pollock in the diet of all but the largest arrowtooth flounder. A much broader array of fish species were consumed by arrowtooth flounder in 1993, including eulachon, herring, stichaeids, zoarcids, sand lance, capelin, and salmon. Arrowtooth flounder, and probably other groundfish species, respond to decreases in juvenile pollock abundance by increasing their consumption of alternate fish prey. Similarly, Hatch and Sanger (1992) found that puffin diet in the Gulf of Alaska and Aleutian Islands reflected pollock and other forage fish abundance. Sand lance, capelin, and pollock proportions in the diet of puffins varied by year and location. Thus, some marine birds also respond to changes in fish abundance and species composition and change their diet accordingly.

Gulf of Alaska

Results of a comprehensive food study for demersal fish in the Gulf of Alaska have been recently reported by Yang (1993). Sablefish, Pacific halibut, and arrowtooth flounder predominantly consumed fish. Euphausiids were the primary food of northern and dusky rockfish and Pacific ocean perch, whereas Pacific cod consumed a variety of prey items, including fish, crabs, shrimp, and cephalopods. The diet of walleye pollock was also variable, and was comprised of euphausiids, shrimp and fish. One major difference compared to the Bering Sea was the reduced importance of walleye pollock as a prey item in the Gulf of Alaska. For example, the incidence of cannibalism in walleye pollock, which was substantial in the Bering Sea, was negligible in the Gulf of Alaska.

One way in which trophic interactions could affect abundance of demersal fish is through niche replacement. If two species have overlapping diets and occur in similar habitats, and the abundance of one is substantially reduced by fishing mortality, then numbers of the second species may increase as it expands to fill the vacated niche. Some investigators have speculated that this scenario could be responsible for the increased abundance of walleye pollock that was observed in the Gulf of Alaska during the 1960's and 1970's (Somerton 1994). The increase occurred during a period when Pacific ocean perch stocks in this region were severely depleted by foreign trawlers. The diet of walleye pollock shows a relatively high overlap with Pacific ocean perch, as both species consume euphausiids as their major food (Yang 1993). This suggests that walleye pollock to some extent may have occupied the trophic niche vacated by Pacific ocean perch in the Gulf of Alaska ecosystem in the 1970s (Somerton 1994).

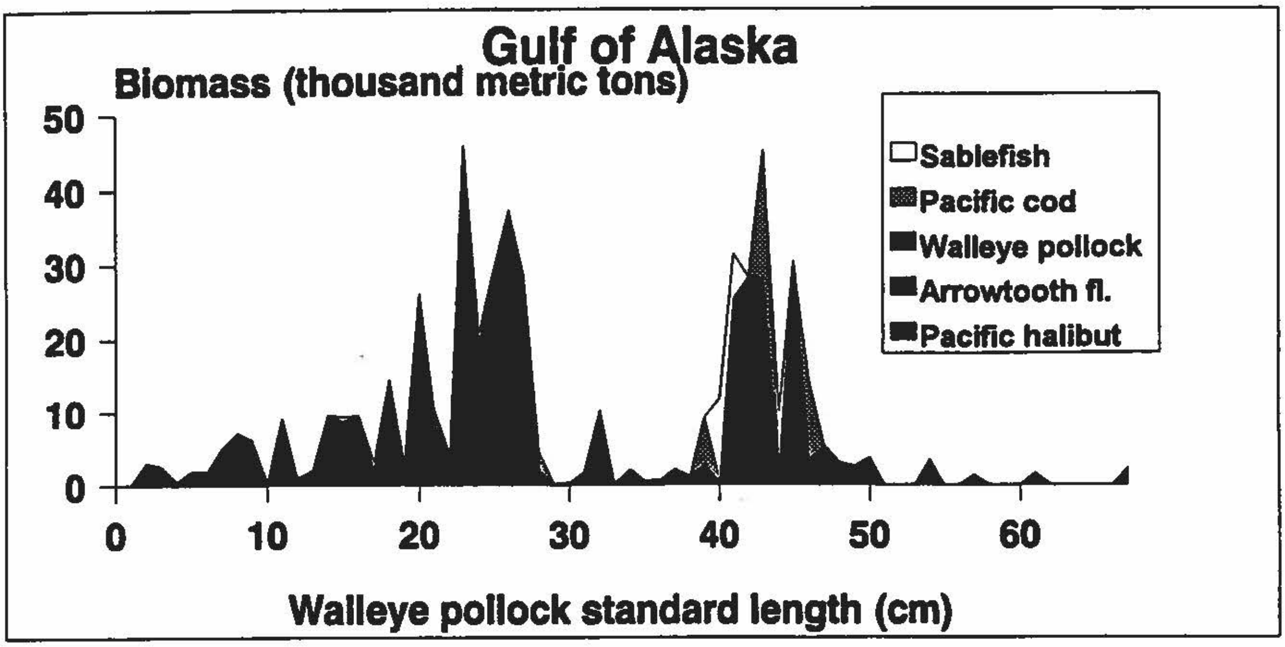

Figure 9.– Estimated consumption of walleye pollock by groundfish during 1990 in the Gulf of Alaska.

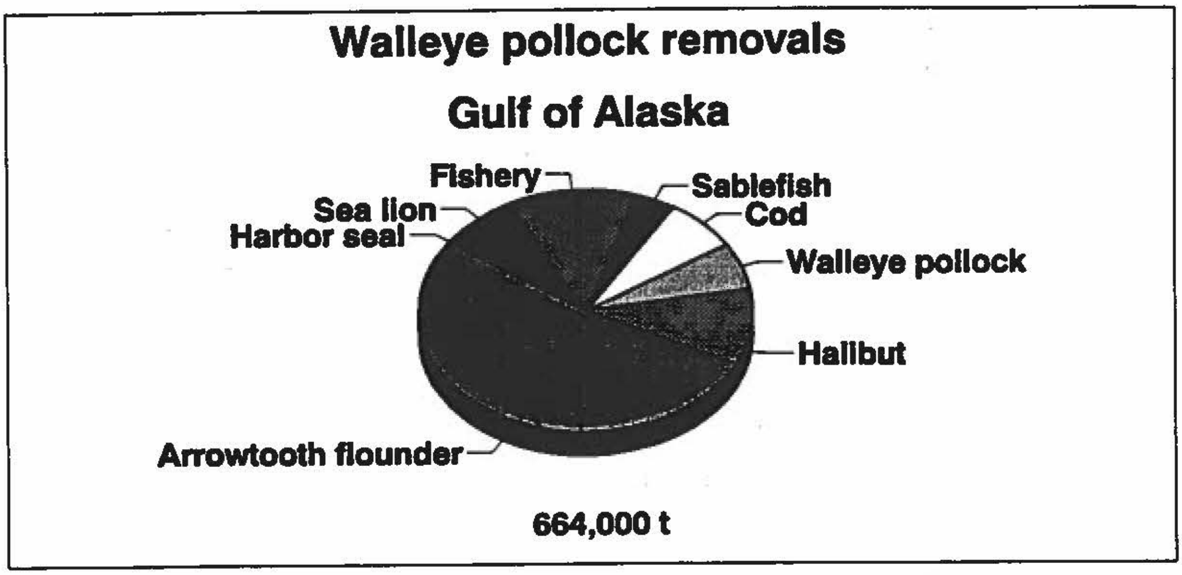

Figure 10.-- Estimated removal of walleye pollock by various sources: groundfish, pinnipeds, and fishery for 1990 in the Gulf of Alaska.

BIOLOGICAL FEATURES

Demersal Resources

Demersal resources can be defined as those organisms (both fish and shellfish) that live on or near the sea bottom. In the northeastern Pacific Ocean off Alaska, the demersal fish category encompasses all the commercially important species of groundfish, including gadids, flatfish, rockfish, sablefish, and greenling. However, it should be noted that certain of these fish, especially walleye pollock, rockfish, and Atka mackerel, may at times have a pelagic distribution. The group also includes other species that are not commercially exploited at this time, but that are of ecological significance, such as sculpins and skates. Commercially important demersal fish species are discussed under the pertinent chapters of the SAFE document.

The invertebrate benthic community can be further divided into infauna (organisms living in the sediments) and epifauna (organisms living on the sediment surface). This section discusses the invertebrate infauna and slow-moving epifauna. Benthic fishes and macro-epifauna (e.g., crabs) are discussed in the next section.

Invertebrate infauna form a vital link between accumulated flora and fauna in the bottom sediments (e.g., detritus) and epifauna, fishes, and marine mammals. The benthic invertebrate community of the Bering Sea is abundant and diverse. At least 472 species of invertebrates comprise the macroinfauna, including 143 species of polychaete worms, 76 species of amphipods, 76 species of gastropods, and 54 species of bivalves (Stoker 1981).

Two trends characterize the distribution of infauna within the Bering Sea: (1) density and biomass increase from south to north (Stoker 1981; Alton 1974; Jewett and Feder 1981), and (2) infaunal biomass is highest in the middle shelf waters (Haflinger, 1981; Nagai and Suda, 1976; Stoker, 1981). The inefficient link between phytoplankton and zooplankton in midshelf waters results in rich standing stocks of infauna, epifauna and demersal fish between the 50- and 100-meter isobaths. Although infaunal biomass is higher in the northeastern Bering Sea, reduced numbers of demersal fishes occur, presumably due to the low bottom water temperatures normally present.

<u>Crustaceans</u>

Red King Crab: The abundance of male red king crabs (*Paralithodes camtschatica*) in the southeastern BS decreased from 1981 through 1985, then increased somewhat, and is declining. The precipitous decline in this stock in the early 1980's may have resulted from the occurrence of weak year-classes recruiting to the fishery and increased mortality among adult, and especially sublegal crabs, of these weaker year-classes (Reeves 1985). Increased mortality of adult crabs may be related to a number of factors, including but not limited to predation by halibut, Pacific cod, and yellowfin sole; competition; fishery effects (handling mortality); disease; and temperature. Recent assessments (Stevens et al. 1993) indicate that numbers of female crabs was at low levels, such that no fishery for red king crab will be allowed in 1994. The causes for this most recent decline remain unknown.

Red king crab inhabit the continental shelf of the GOA and BSAI at depths up to 400 m. Red king crab are concentrated immediately north of the Alaska Peninsula and around Bristol Bay. In the Bering Sea, crab undertake a spring spawning migration and a summer-fall feeding migration. Beginning in January, females move from deep, offshore waters into more shallow, coastal waters (70 m or less) north of the Alaska Peninsula. Males migrate into the more shallow waters about a month later than the females to mate. Spawning occurs in nearshore waters between Unimak Island and Cape Seniavin (Armstrong et al. 1983, McMurray et al. 1984). After mating, the males and the ovigerous females feed in coastal areas before returning to deeper waters in the late summer or fall. Eggs are carried by the females for approximately 11 months before hatching after the females have returned to nearshore waters. Hatching generally occurs from April 1-20, although the timing can vary up to a month (Weber 1967, Haynes 1974).

Red king crab prey on different organisms throughout their life cycle. Planktonic larval crabs feed on phyto- and zooplankton. Juveniles feed on diatoms, protozoa, algae, echinoderms, small mollusks, and other benthic species. Adult king crab are omnivorous and feed on small benthic invertebrates, including bivalves, gastropods, polychaetes, brittle stars, Tanner crab, small fish, and dead organisms.

Environmental conditions are thought to be an important factor influencing year-class strength and subsequent abundance of red king crab in the southeastern BS. Cycles of abundance (every 7 to 14 years) suggest that year-class failure or success may be based on survival of critical life stages (i.e., larvae and young juveniles) in nearshore areas (Armstrong et al. 1983). Instantaneous mortality rates of juvenile and sublegal, sexually mature crab are estimated to be low, approximately 10 percent per year, until entering the fishery (Balsiger 1976, Reeves and Marasco 1980). Consequently, the size of a future fisheries cohort is determined predominantly by reproductive success and survival of larvae and young of the year (0+ crab) in nursery areas. Larval survival is influenced strongly by water temperature (Kurata 1960 1961, McMurray et al. 1983), and also by food supply and predation (Armstrong et al. 1983). Lethal temperatures are those greater than 15° C or lower than 0.5 to 1.8° C (Kurata 1960) and survival is greater between 5 to 10° C (McMurray et al. 1984).

Blue King Crab: Abundance of blue king crab (*Paralithodes platypus*) around the Pribilof islands has been monitored by the NMFS annual trawl surveys. Abundance generally increased from 1974 (20.9 million crab) to a peak of 102.7 million crab in 1980. This was followed by a dramatic decline to only 1.2 million crab in 1984. Abundance has since remained at very low levels, but has shown some marginal increase to about 8 million crab (Stevens et al. 1992). The area around the Pribilofs has been closed to the commercial crab fishery since 1987. The area was also closed to groundfish trawling beginning in 1995 to protect blue king crab.

Blue king crab occur in three isolated populations located at the Pribilof Islands, St.

Matthew Island, and St. Lawrence Island. The life history of the blue king crab is similar to that of the red king crab excepting that reproduction in this species may be only biennial with a later spawning period during the spring (Stevens et al. 1992). Although blue and red king crab use the same general habitat types, the species do not generally co-occur (Somerton 1985). Habitat components may also be more specific as juvenile blue king crab seem to be concentrated over limited areas of rocky habitat covered with shell hash near the Pribilofs during a part of their life cycle (Armstrong et al. 1985). This substrate affects protection from predators and also harbors the food organisms on which these crab subsist.

Brown King Crab: The brown or golden king crab (*Lithodes aequispina*) are distributed in the continental slope water of the North Pacific and Bering Sea from Japan to British Columbia.

Tanner Crab and Snow Crab: Tanner crab (*Chionoecetes opilio*) and snow crab (*C. bairdi*) are two species of commercial importance are distributed widely throughout the southeastern BS. Abundance of snow crab increased dramatically from 1983 to 1991, but has since declined. The 1993 NMFS Bering Sea trawl survey indicated the total abundance of large males (over 4 inches) at 135 million crab, a 48% decrease from 1992. Small (3-4") males also declined in abundance, consistent with the decline in large males observed since 1991. A continued westward shift of the population was also observed, with the highest sampling densities north and west of the Pribilof Islands. Abundance of small female crab increased 66% in 1993 and sublegal (<3.1") male crab showed a 92% increase in abundance. Recruitment of these small crab should result in increased snow crab landings in 1996 (Stevens et al. 1993, Morrison and Gish 1994).

These two species generally occur at depths of 40 to 100 meters and greater (Lewbel 1983). *C. opilio* are common throughout the southeastern BS, but are virtually absent from the GOA. *C. bairdi* are concentrated around the Pribilof Islands and immediately north of the Alaska Peninsula (Jewett and Feder 1981), and are found in lower abundance in the GOA. In the southeastern BS, this species was common only at depths below 100 m. Tanner crab populations are cyclic. The stocks have been depressed, but are currently stable and recovering slowly. Both species may have distributions and abundances inversely related to the densities of king crabs (Gusey 1978).

Tanner and snow crab larvae feed on phyto- and zooplankton. As demersal juveniles, they feed on benthic diatoms, hydroids, and detritus. Adult Tanner and snow crab feed on an extensive variety of benthic organisms including bivalves, brittle stars, crustaceans (including other snow crabs), polychaeta and other worms, gastropods, and fish. In turn they are consumed by a wide variety of predators including Pacific cod, halibut and other flatfish, eel pouts, sculpins, and skates. In the northern part of their range, snow crab are preyed upon by bearded seals and sometimes make up all of the seal's stomach contents.

Dungeness Crab: Dungeness crab (*Cancer magister*) are a nearshore species found in the GOA and as far north as the north side of the Alaska Peninsula. They inhabit bays, estuaries, and open-ocean, nearshore areas from the intertidal zone to depths of 90 m. Juveniles seek shelter among stands of eelgrass or with masses of detached algae.

Korean Hair Crab: The Korean Hair Crab (*Erimacrus isenbeckii*) occurs in water depths of 10 to 360 m. The largest concentrations of this species are found in the shallow waters along the northern shore of the Alaska Peninsula and around the Pribilof Islands. Hair crabs hatch in the spring, and the larval stage lasts approximately 5 months (Armstrong et al. 1983).

Shrimp Species: Two commercially important species of shrimp are pink shrimp (*Pandalus borealis*) and humpy shrimp (*P. goniurus*). They are most abundant along the central outer shelf and slope of the BS. The pink shrimp inhabits depths of 85 to 110 m in zones of deep, warm waters and is found concentrated near Nome and northwest of St. Paul Island (Lewbel 1983). The humpy shrimp is found at similar depths, but in cooler waters, with a concentration between the Pribilof Islands and Bristol Bay. Juveniles inhabit waters less than 40 m deep in the winter and deeper waters in the summer (University of Alaska, AEIDC 1974).

Pink shrimp constituted a major commecial fishery in the Gulf of Alaska though the late 1970s. However, stocks are presently depressed with no signficant commercial landings since the early 1980s.

Adults feed on benthic organisms, including polychaetes, and small crustaceans. Pandalid shrimp make diurnal feeding migrations, rising in the water column at night to feed (Thorsteinson 1984).

Mollusks

Scallops: Commercial fisheries for weathervane scallops (*Patinopecten caurinus*) occur in relatively shallow waters (< 200 m) of the continental shelf in both the GOA and the BSAI. Weathervane scallops are found from intertidal waters to depths of 300 m (Foster 1991), but abundance tends to be greatest between depths of 45-130 m on beds of mud, clay, sand, and gravel (Hennick 1973). Although weathervane scallops are widely distributed along the shelf, the highest densities in Alaska have been found to occur off Kodiak Island and along the eastern gulf coast from Cape Spencer to Cape St. Elias. Testimony from fishermen indicate that the Kodiak stocks are currently depressed.

Only limited information on biological productivity is available for weathervane scallops. Much of this information (Haynes and Powell 1968; Hennick 1970, 1973) was collected during the early years of the fishery, but has been summarized more recently by Kaiser (1986). The only assessment survey since 1972 was conducted in 1984 in lower Cook Inlet, although the fishery has been prosecuted every year since 1967 except 1978 (Hammarstrom and Merritt 1985). Total scallop biomass in the Yakutat and Kodiak area ranged from 12,335 to 17,445 tons (Ronholt et al. 1977), but these estimates were based on inefficient shrimp trawls and were considered by Kaiser (1986) to be a minimum biomass estimate. In addition to a lack of good abundance estimates, there have been no routine biological or fishery sampling programs conducted on weathervane scallops.

Although the weathervane scallop has been the principal commercial species, several other species of scallop found in the EEZ off Alaska have commercial potential. These scallops, thought to be closely related to the Icelandic scallops (*Chlamys islandica*) of the North Atlantic, grow to smaller sizes than weathervanes, and thus have not been extensively exploited in Alaska. *Chlamys behringiana* inhabit the Chukchi Sea to the Western Bering Sea. *Chlamys albida* are distributed from the Bering Sea and Aleutian Islands to the Japan Sea. Pink scallops, *C. rubida*, range from California to the Pribilof Islands. Spiny scallops, *C. hastata*, are found in coastal regions from California to the Gulf of Alaska. Rock scallops, *Crassadoma gigantea*, range from Mexico to Unalaska Island. The abundance of this species is unknown, and a commercial fishery has never been developed. Because they attach themselves to rocks, trawls and dredges are not efficient in capturing rock scallops. As suggested by the species name, these scallops attain a large size (to 250 mm) and exhibit fast growth rates (Bourne 1969). Rock scallops are found in relatively shallower water (0-80 m) with strong currents. Apparently, distribution of these animals is discontinuous, and the abundance in most areas is low. Rock scallops may spawn during two distinct periods, one in the autumn (October -January), and one in the spring-summer (March-August) (Jacobsen 1977).

Little is known about the causes of natural mortality for scallops. Scallops are likely prey to various fish and invertebrates during the early part of their life cycle. Flounders are known to prey on juvenile weathervane scallops, and sea stars may also be important predators (Bourne 1991).

Bivalves: Although bivalves are widely distributed on the shelf, they are concentrated in the midshelf region of the Bering Sea (Lewbel, 1983). Some species are found in the nearshore surf zones. The Pacific razor clam (Siliqua patula) is found on sand beaches of the Alaska Peninsula, including Izembek Bay and Bechevin Bay (Nickerson, 1975). Other clams inhabiting the Alaska Peninsula include the surf clam (Spisula polynyma), distributed between Port Moller and Ugashik Bay; the Great Alaskan Tellin (Tellina lutea); two species of cockle (Serripes groenlandicus and S. laperousii); and other less frequently taken species. The surf clam biomass has been estimated at 286,184 metric tons and the Great Alaskan Tellin biomass has been estimated at 82,000 metric tons (Hughes et al., 1977).

Clams are important prey of Pacific walrus. Mussels and clams are both imporant prey for sea ottes.

Large Gastropods: These snails are concentrated along the outer shelf at depths from 40 to 100 meters. Neptunea heros and N. ventricosa are the dominant species. Neptuniids prey on polychaetes, bivalves, barnacles, crustaceans, and fish (MacIntosh and Somerton, 198l).

Snails are also important walrus prey.

Corals

Alaska corals include those in the orders Alcyonacea (soft corals), Gorgonacea (sea fans or horny corals), and Scleractinia (cup corals, stony corals, or hard corals) in the class Anthozoa, and the order Stylasterina (hydrocorals) in the class Hydrozoa. Thirty-four species of corals are found in Alaska waters; 21 species of octocorals, 2 species of hexacorals, and 11 species of hydrocorals (Cimberg et al. 1981). Two of the more abundant species in waters less than 100 fathoms are red tree (*Primnoa wailleyi*) and sea raspberry (*Eunephtya* sp). These species occur in areas of rugged habitat consisting of boulders and bedrock.

Coral distribution and abundance is affected by substrate size, currents, depth, and temperature. Most coral species require a solid, rocky substrate to survive, however, a few can live on sandy and muddy bottoms. Currents bring food, reduce sedimentation, and may assist in larval dispersal. Depth is important because of its relationship with other factors such as light, temperature, salinity, oxygen, and wave action. Corals are often found in association with other species and can provide a habitat for fish and invertebrates that fish might feed on. Southeast Alaska probably has the largest number of coral species due to the variety of habitats in terms of depth, substrate, temperature, and currents. *Primnoa*, or red tree corals are more abundant in southeast Alaska than in any other region. Other species of fan corals have been observed as well as bamboo corals, cup corals, soft corals, and hydrocorals. The greatest number of distributional records for red tree corals are from the Gulf of Alaska, in particular from the inside waters of Southeast Alaska. In southeast Alaska, red tree corals have frequently been reported in Chatham Strait, Frederick Sound, and Behm Canal. The frequency of occurrences increases towards the ocean entrances and further away from the fjords. This trend is likely due to swifter currents near the entrances and/or greater turbidity and lower salinities in the fjords. Areas of highest densities are found in regions where currents are 3-4 knots (Cimberg et al. 1981). Bamboo corals also occur in the waters of both the inside passages of southeast Alaska and in the southeast Gulf of Alaska. These corals have a lower temperature tolerance, about 3 °C, and exist in depths from 300-3,500 m. These corals are also expected to exist in a rocky, stable substrate and have a low tolerance for sediments.

Recolonization of tropical coral communities requires at least several decades to recover from major perturbations. Alaskan corals would likely take much longer to recolonize following similar disturbances. For example, given a predicted growth rate of 1 cm/year for *Primnoa*, a colony 1 m high would require at least 100 years to return to the pre-impacted state, regardless of the origin of the impact.

In the 1990 and 1991 domestic operations in the Southeastern Gulf of Alaska, observer and logbook information reported a combined coral catch of 0.047 mt. All of the catch was reported by one observer aboard a trawler in 1990. No coral was reported by observers in 1991. Coral might have been included in either the miscellaneous or unidentified invertebrates categories, or accidentally in the sponge category, thus observer reports of these species categories were also checked. No amounts of miscellaneous or sponge were recorded at all, and unidentified invertebrates accounted for only 0.079 mt in the 1991 trawl fishery and were not recorded in any of the 1990 fisheries. These data are collected from observed vessels (i.e., "30% boats") which, however, can determine when observers monitor their fishing activity.

Observer data from 1980 and 1981 were also checked for reports of coral. These were the only two years in the 1980's in which foreign operations were allowed in Southeast Alaska (and longliners were not allowed even in these two years). Only 0.003 mt of coral were reported. No unidentified invertebrates were found, but miscellaneous and sponge accounted for 0.414 mt and 0.420 mt, respectively. Coverage in those years was very spotty.

Pelagic Resources

Sverdrup et al.'s (1942) classical definition of the pelagic realm is too broad for this discussion of pelagic resources in the North Pacific Ocean and Bering Sea, which will be confined to euphausiids, squids, and non-commercially exploited fish (including juveniles of exploited species), particularly those that are prey or forage species for upper trophic level predators (e.g. marine mammals, marine birds and commercially-exploited fish). Very little is known about absolute or trends in abundance of this group of animals, with the exception of juveniles of commercially exploited species, because of a lack of dedicated survey effort for them. Other pelagic resources are discussed in the section on salmon in this chapter, as well as the individual commercial species stock assessments in this document. Most of the discussion on euphausiids was summarized from Boden et al. (1955) and Ponomareva (1963); on squids from Fiscus (1982) and Roper et al. (1984); and on forage and juvenile fish from Wespestad (1987) and Fritz et al. (1993).

Euphausiids

Along with many copepod species, the euphausiids form a critical zooplanktonic link between the primary producers (phytoplankton) and all upper pelagic trophic levels. These crustaceans, also known as krill, occur in large swarms in both neritic and oceanic waters. Members of at least 11 genera of euphausiids are known from the North Pacific, the most important (in terms of numbers of species) being *Thysanopoda, Euphausia, Thysanoëssa* and *Stylocheiron*. Euphausiids are generally thought to make diurnal vertical migrations, remaining at depth (usually below 500 m) during the day and ascending at night to 100 m or less. However, this is complicated by the fact that as euphausiids grow they are found at deeper depths, except during spawning, which occurs in surface waters. Spawning occurs in spring to take advantage of the spring phytoplankton bloom, and the hatched nauplii larvae live near the surface (down to - about 25 m). By fall and winter, the young crustaceans are found mainly at depths of 100 m or less, and make diurnal vertical migrations. Sexual maturity is reached the following spring at age 1. After spawning, adult euphausiids gradually descend to deeper depths until fall and winter, when they no longer migrate daily to near-surface waters. In their second spring, they again rise to the surface to spawn; euphausiids older than 2 years are very rarely found.

While euphausiids are found throughout oceanic and neritic waters, their swarms are most commonly encountered in areas where nutrients are available for phytoplankton growth. This occurs primarily in areas where upwelling of waters from depth into the surface region is a consistent oceanographic feature. Areas with such features are at the edges of the various domains on the shelf or at the shelf-break, at the heads of submarine canyons, on the edges of gullies on the continental shelf (e.g., Shumagin, Barnabus, Shelikof gullies in the Gulf of Alaska), in island passes (on certain tides) in the Aleutian Islands (e.g., Seguam Pass, Tanaga Pass), and around submerged seamounts (e.g. , west of Kiska Island). It is no coincidence that these are also prime fishing locations used by commercial fishing vessels seeking zooplanktivorous groundfish, such as walleye pollock, Atka mackerel, sablefish and many species of rockfish and flatfish (Livingston and Goiney 1983; Fritz 1993; Yang 1993).

The species comprising the euphausiid group occupy a position of considerable importance within the North Pacific food web. Euphausiids are fed upon by almost all other major taxa inhabiting the pelagic realm. The diet of many species of fish other than the groundfish listed above, including salmon, smelts (capelin, eulachon, and other osmerids), gadids (Arctic cod and Pacific tomcod), and Pacific herring is composed, to varying degrees, by euphausiids (Livingston and Goiney 1983), while euphausiids are the principal item in the diet of most baleen whales (e.g. minke, fin, sei, humpback, right, and bowhead whales; Perez 1990). While copepods generally constitute the major portion of the diet of planktivorous birds (e.g. auklets), euphausiids are prominent in the diets of some predominately piscivorous birds in some areas (e.g. kittiwakes on Buldir Island in the Aleutians, Middleton Island in the Gulf of Alaska, and St. Matthew Island in the Bering Sea; Hatch et al. 1990). Euphausiids are not currently sought for human use or consumption from the North Pacific ocean on a scale other than local, but large (about 500,000 mt per year) krill fisheries from Japan and Russia have been operating in Antarctic waters since the early 1980s (Swartzman and Hofman 1991).

Squids

Squid are members of the Mollusca, and are in the same class (Cephalopoda) as octopus, cuttlefish and nautiloids. In the North Pacific ocean south of the regions (BSAI and GOA) of concern in this document, there are large (several hundred thousand tons per year) squid fisheries operated principally by the Japanese that target *Todarodes pacificus* and other ommastrephid squid, such as *Ommastrephes bartrami*. Furthermore, in the eastern North Pacific, *Loligo opalescens* (family Loliginidae) is an important food for fish, marine mammals and birds, many of the latter two of which migrate to the Bering Sea and Gulf of Alaska. The squid species that occur in the Bering Sea, Aleutian Islands and Gulf of Alaska that are of particular importance in the food web are members of the family Gonatidae and Onychoteuthidae that inhabit both neritic and oceanic pelagic realms. The most commonly encountered species in each family are: Gonatidae - *Berryteuthis magister* (mostly in the Bering Sea), *B. anonychus, Gonatopis borealis, G. makko, Gonatus middendorfi, Gonatus modokai* and *Onychoteuthis borealjaponicus* (mostly in the Aleutian Islands). A Japanese fishery for *B. magister* in the Bering Sea and *O.*

borealjaponicus in the Aleutian Islands caught up to 9,000 mt of squid annually until the early 1980s . Since then, there has been little targeting on squid in the area (less than 1,000 mt caught annually in the BSAI), and the only catches occur as bycatch in other fisheries (e.g., midwater pollock fishery) near the continental shelf break and slope.

Some squid species are thought to migrate seasonally, moving northward in summer and southward for winter, particularly in the western north Pacific. Many species of oceanic squids undergo diurnal vertical migrations similar to euphausiids, ascending to surface waters at night. The principal prey items of squid are crustaceans, such as euphausiids and shrimp, small forage fish, and other cephalopods; cannibalism is not uncommon.

Squid are preyed upon by marine mammals, seabirds, and, to a lesser extent by fish, and occupy an important role in marine food webs worldwide. Perez (1990) estimated that squids comprise over 80% of the diets of sperm whales, bottlenose whales and beaked whales, and about half of the diet of Dall's porpoise in the eastern Bering Sea and Aleutian Islands. Seabirds (e.g., kittiwakes, puffins, murres) on island rookeries close to the shelf break (e.g., Buldir Island, Pribilof Islands) are also known to feed heavily on squid (Hatch et al. 1990; Byrd et al. 1992; Springer 1993). In the Gulf of Alaska, only about 5% or less of the diets of most groundfish consisted of squid (Yang 1993). However, squid play a larger role in the diet of salmon (Livingston and Goiney 1983).

Forage Fish

The major pelagic, forage fishes (other than salmon, *Oncorhynchus* spp.) of the North Pacific Ocean and Bering Sea include Pacific herring (*Clupea pallasi*), capelin (*Mallotus villosus*), eulachon (*Thaleichthys pacificus*), rainbow smelt (*Osmerus mordax*), Pacific sand lance (*Ammodytes hexapterus*), myctophids (e.g., *Stenobrachius leucopsarus*) and juvenile walleye pollock (*Theragra chalcogramma*). Other important forage species, which usually occur either inshore and seasonally or in the northern Bering Sea, include other osmerids (e.g. surf smelt, *Hypomesus pretiosus*), juvenile Pacific sandfish (*Trichodon trichodon*), and cods (Arctic cod (*Boreogadus saida*), saffron cod (*Eleginus gracilis*), and juvenile Pacific cod (*Gadus macrocephalus*). Large fisheries have existed for adult pollock, Pacific cod and Pacific herring for decades in the North Pacific Ocean and Bering Sea. To support fisheries for these species and others, research programs utilizing biological surveys and fisheries observers have collected data to support stock assessments, quota establishment, and fisheries management (Funk and Harris 1992; NPFMC 1993a, b). Consequently, there are databases and reports available for information on population age structure hindcasts (variations in yearclass strength), basic biological parameters (maturity schedules, fecundity, size at age), absolute and trends in abundance of the exploited, adult population, and fisheries (distribution, age structure of catches, and size of catches). However, comparatively little is known about the physical and biological processes that affect the availability of juvenile gadids and herring both as recruits to the adult population (to support fisheries and their species' populations) and as prey for marine mammals and birds. Similarly, except for basic biological information (see recent reviews of Wespestad (1987; 1991) and Fritz et al. (1993)), little is known about the trends in abundance and distribution of non-commercial pelagic species, nor the reasons for them.

Along with euphausiids, the pelagic forage fishes as a group occupy a nodal or central position in the North Pacific food web, being consumed by a wide variety of fish, marine mammals and seabirds. Livingston (1993) recently estimated the tonnage, numbers and sizes of walleye pollock and herring consumed by each of the three principal predators and fisheries in 1985. Groundfish removed the most pollock both in terms of biomass and numbers, with marine mammal and bird removals being about 15-100 times less. Most of the pollock removed by groundfish were age 0 and 1, resulting in direct competition with seabirds (Hunt et al. 1981; Springer 1993) and some marine mammals (e.g. northern fur seals, juvenile Steller sea lions, harbor seals, and cetaceans (Kajimura and Fowler 1984; Lowry and Frost 1985; Castellini 1993)). The fishery takes primarily age 3+ pollock (Wespestad 1993; Fritz, in press)) and may compete less directly with seabirds and some marine mammals than with other groundfish predators of adult pollock (e.g., Pacific halibut, arrowtooth flounder; also see Yang 1993 for GOA data). However, the indirect effects of fisheries, such as reduction in integrity and density of fish schools and disturbance of benthic habitats, may be as important as direct removal of prey, and certainly much less quantifiable.

Forage fish form a small part of the bycatch of commercial groundfish fisheries. Fritz (in press) recently reviewed juvenile pollock bycatch rates by trawl fisheries in the BSAI and GOA, and reported that very few pollock < 20 cm (0 and 1 year-olds) are caught; pollock between 20 and 29 cm accounted for < 2% of the GOA and <5% of the BSAI pollock measured by observers between 1977-92. Osmerid bycatch (principally capelin caught by the yellowfin sole fishery) has ranged between 30-300 mt, while herring bycatch (principally by the midwater pollock fishery) has ranged between about 800-3,000 mt in 1990-93 in the BSAI. As noted above, however, the direct removal of prey may only describe a portion of the effects fisheries have on forage fish availability to piscivores.

There is some evidence, mostly anecdotal, that osmerid abundances, particularly capelin and eulachon, have declined significantly since the mid 1970s. Evidence for this comes from marine mammal food habits data from the Gulf of Alaska (Calkins and Goodwin 1988), as well as from data collected in biological surveys of the Gulf of Alaska (not designed to sample capelin; Anderson et al. 1994) and commercial fisheries bycatch from the eastern Bering Sea (Fritz et al. 1993). It is not known, however, whether smelt abundances have declined or whether their populations have redistributed vertically, due presumably to warming surface waters in the region beginning in the late 1970s. This conclusion could be drawn from the data presented by Yang (1993), who documented considerable consumption of capelin by arrowtooth flounder, a demersal or semi-demersal feeder, in the Gulf of Alaska. Regardless of the cause of the reduction in forage fish availability to marine mammals and seabirds, if a reduction has indeed occurred, the effects on predators may be exacerbated by pollock recruitment failures in both the eastern Bering Sea and Gulf of Alaska in the late 1980s.

Salmon Resources

Seven species of salmon are found in the North Pacific Ocean and Bering Sea. Salmon are generally anadromous, returning to fresh water streams to spawn, and five species reproduce in both North American and Asian freshwater systems, with two species reproducing only in Asian streams. The five species which reproduce on both sides of the Pacific Ocean are *Oncorhynchus nerka* (Walbaum) commonly known as sockeye or red salmon; *O. gorbuscha* (Walbaum) commonly known as pink salmon; *O. keta* (Walbaum) known as chum or dog salmon; *O. tshawytscha* (Walbaum) commonly called king or chinook salmon; and *O. kisutch* (Walbaum) commonly known as coho or silver salmon. The two species from exclusively Asian systems are *O. masou* (Brevoort) known as masu or sakura-masu salmon and *O. rhodurus* (Gunther) commonly called amago salmon or biwamasu. Two species of trout have recently been reclassified into the same genus as salmon, rainbow trout (or steelhead) is currently listed as *O. mykiss*, and cutthroat trout is classified as *O. clarki*. Atlantic salmon (*O. salar*) is also occasionally found in Southeast Alaska, and is believed to be straying from net pens in British Columbia. It is unknown whether the species will become established or to what extent its presence might impact other species in the area.

As adults, salmon range broadly from the nearshore to the offshore areas across the entire North Pacific Ocean and into the Bering Sea and Sea of Okhotsk. Generally, salmon from all systems of origin mix in the North Pacific, and the tendency is for salmon to move north into the Bering Sea during the summer and south into the North Pacific and Gulf of Alaska during the winter as pelagic feeders. Upon reaching maturity, adult salmon return to the freshwater systems from which they originated, albeit some straying occurs. The adults deposit and fertilize eggs in gravel beds. After hatching, salmon fry rear for a period of time, which varies by and within species, in the freshwater environment and then undergo a process known as smoltification by which they prepare for the marine environment. Salmon are dependent on freshwater in early life stages, and survival depends upon water and habitat quality, water flow, temperature, as well as food availability and numbers of competitors and predators. Outmigrant salmon fry and smolts depend heavily on the estuarine and nearshore environment, and remain in shallower waters until large enough to compete and survive in the open ocean. Outmigration from freshwater to the marine environment occurs in the spring or early summer. As young juveniles, salmon pass through the near-shore areas where they grow rapidly, and move into the open ocean as pelagic feeders until maturation when they return to fresh water for spawning.

In addition to natural populations of salmon, hatcheries contribute fry and smolts to the marine environment. Alaska has 38 hatcheries which released 1.5 billion fish in 1993, and hatcheries in Japan release approximately 2 billion fish annually. The early survival of these fish are unknown and the number of hatchery-produced adults in the marine environment in any given year is difficult to estimate.

Predators on sockeye salmon smolts in the early marine phase include beluga whale, seals and porpoise, diving birds and adult chinook and coho salmon. Other fish, particularly small coho and chinook salmon feed on chum and pink salmon fry. Predators of coho in estuaries include Dolly Varden, cutthroat trout, herons, mergansers, sharks, gulls, loons and marine mammals. Adult salmon in the marine environment are prey for other fish, marine mammals and birds.

Several populations of salmon have been listed under the Endangered Species Act. Snake River sockeye and fall chinook are listed as endangered, and Snake River spring/summer chinook are listed as threatened. A fourth species, winter-run chinook from the Sacramento River, is listed as threatened but is not believed to migrate into the Gulf of Alaska.

Pink salmon: These are the most abundant of the seven Oncorhynchus species, and individuals are the smallest salmon in size as adults. Pink salmon eggs are deposited in the fall of the year and the hatched fry migrate to the estuarine environment the following spring. Fry spend a period in the estuarine environment prior to smolting and migrating to the marine environment. Having a fixed two-year life cycle, this species spends 18 months in the ocean before returning to spawn as adults. Because of the fixed two-year cycle, the pink salmon originating from even or odd-numbered years have become genetically distinct. Juvenile pink salmon feed on larvaceans, copepods, euphausiids, arrowworms and amphipods. The adult diet consists of fish, squid, euphausiids, amphipods and other prey.

Chum salmon: These are the second most abundant salmon and the adults are the second largest in size after chinook salmon. Like pink salmon, fry move directly into the estuarine/marine environment in the spring, however, rather than returning 18 months later, chum salmon spend between 1 and 5 years in the marine environment. Chum salmon have the widest distribution across the Pacific rim of any salmon. Juvenile chum salmon in the near-shore environment feed largely on harpacticoid copepods, gammarid amphipods and chironomid larvae depending on location. In the pelagic environment, chum salmon feed on prey such as planktonic copepods, amphipods, larvaceans, and euphausiids. As adults chum salmon feed primarily on pteropods, euphausiids, amphipods and copepods, as well as some fish, and squid larvae.

Sockeye salmon: The third most abundant salmon species is the sockeye salmon. This species of salmon is the most adapted to lake rearing in the juvenile stages, prior to migration into the marine environment. Although sockeye salmon in some systems spawn and rear in streams and do not utilize lakes, and some sockeye salmon, known as kokanee, are landlocked and never enter the marine environment, the majority of sockeye salmon rear from one to three years in lakes prior to outmigration, and spend from one to four years in the marine environment prior to returning to freshwater to spawn. In the ocean, sockeye salmon feed on euphausiids, amphipods, small fish, squid and copepods, although the diet and size of prey items can differ spatially and temporally.

Coho salmon: Coho are the fourth most abundant salmon species. Like pink salmon, coho salmon normally spend one winter in the ocean and return to spawn the following fall. Unlike pink salmon, however, coho can remain in the riparian environment to rear for an additional year prior to outmigration into the marine environment. In the more southerly latitudes of its range, coho salmon mainly spend only one year in fresh water and one year in the ocean, and increases in latitude to the north also correspond to an increasing percentage of coho spending a second year in fresh water prior to migration to the marine environment. Juvenile coho salmon in the nearshore environment initially feed on marine invertebrates, but the diet changes mainly to fish and some marine invertebrates as they grow. As piscivores, coho feed on herring, smelt, sandlance, and chum and pink fry, among many other fish species.

Chinook salmon: These are the least abundant of the five salmon species found on both sides of the Pacific Ocean, and chinook salmon reach the greatest size of any salmon. Chinook salmon typically have relatively small spawning populations compared to other salmon species, and these populations span numerous systems. The largest river systems tend to have the largest populations of chinook salmon. Chinook salmon can migrate to the marine environment the spring after they hatch or can spend up to two years in the riparian environment prior to outmitgration to the ocean. The timing of outmigration can vary with the system and within system, although this generally occurs during the spring. Chinook salmon can spend up to five or more years in the ocean prior to spawning. In the estuarine environment, chinook salmon are largely opportunistic feeders on chironomid larvae, copepods, and amphipod prey depending on location. In the marine environment chinook salmon prey on small fish such as herring and sand lance, squid, and pelagic amphipods with herring usually being the major component of the diet.

Masu and amago salmon: These two Asian-reared salmon species are closely related and tend to be oriented to more southerly streams than other species of salmon. Masu salmon return to streams as adults earlier than other salmon species in the spring and early summer, but do not spawn until the fall. Most masu salmon spend one or more years in fresh water as juveniles and spend one year in the ocean as adults. Upon entering the near-shore waters as juveniles, masu salmon feed on crustaceans and fish with sand lance and sand eels being the primary diet. As adults in the ocean, Masu salmon feed on amphipods, euphausiids, small fish and squid.

Seabirds

The Bering Sea and Gulf of Alaska support the largest and most diverse assemblages of marine birds in the northern hemisphere. These populations have been the focus for much investigation on ecology, population dynamics, and general distribution of marine bird species. Yet, relatively little is known about these species compared to other avifaunal assemblages. An overview of general information on Alaska seabirds and related management concerns has been prepared by the U.S. Fish and Wildlife Service (USFWS 1992). The status and trends of seabird populations in Alaska from this and other publications is summarized below.

The most numerous breeding seabirds in Alaska are northern fulmars, storm-petrels, kittiwakes, murres, auklets, and puffins. These groups, and others, represent 38 species of seabirds that breed in Alaska. Eight species of Alaska seabirds breed only in Alaska and Siberia. Populations of five other species are concentrated in Alaska but range through the North Pacific region. The marine waters off Alaska provide critical feeding grounds for birds which breed in Alaska, birds which breed in other areas in the boreal winter and migrate to Alaska in the boreal summer (albatrosses and shearwaters), and birds which breed in other areas in the boreal summer and spend the boreal winter in Alaska.

Important seabird species

Northern fulmar: This species breeds in the BSAI and GOA, Canada, and Eurasia. Most of the Alaska population, approximately 2 million birds, breeds at four colonies: St. Matthew Island, Chagulak Island, the Semidis Islands, and the Pribilof Islands. Northern fulmars feed on small fish, squid, zooplankton, and jellyfish. They also gather behind vessels where they feed on processing wastes. Their status is stable.

Storm-petrels: The Leach's storm-petrel and the fork-tailed storm-petrel breed throughout southern coastal Alaska. They feed on zooplankton and squid, but in some areas, diets include small fish (sand lance and capelin). Alaskan populations of both species are roughly estimated to be around 6 million, although censusing for these burrow-nesting species is very difficult. Their status is unknown, but they are believed to be far below their original numbers in Alaska due to predation by mammals introduced to nesting islands.

Shearwaters and albatrosses: These species do not breed in North America but they migrate to Alaskan waters during boreal summer. They feed on fish, particularly capelin, squid, and zooplankton. They gather behind vessels where they feed on processing wastes. The status of shearwaters and albatrosses, except for one species, is stable. The short-tailed albatross is listed as endangered under the ESA.

The short-tailed albatross forages near the Aleutian Islands (AI) Bering Sea (BS), and the Gulf of Alaska, and breeds on two islands near Japan. The world breeding population of this species was estimated to be 400 birds in 1988, and has since increased to over 700 birds at a rate of about 7 percent per year (Richardson 1994; USFWS 1993). As the population increases, the potential for interactions between this species and commercial fisheries increases. However, the short-tailed albatross population is steadily increasing due to its protection on the breeding grounds and there is currently no evidence that groundfish fisheries in Alaskan waters are impeding the short-tailed albatross' recovery.

Past observations indicate that older short-tailed albatrosses are present in Alaska primarily during summer and fall months along the shelf break from the AI to the GOA, although 1- and 2-year old juveniles may be present at other times of the year (USFWS 1993). Consequently, these albatrosses generally would be most often exposed to fishery interactions during summer and fall.

Two juvenile short-tailed albatross are known to have drowned in fishing gear (presumed longline), one in the BS in 1983 and one in the GOA in 1987. The USFWS received eight short-tailed albatross observations in the BSAI and GOA fisheries in 1992, six of which came from commercial fishing vessels. Ingestion of plastic debris has become an increasing phenomenon for short-tailed albatrosses, with unknown population effects (USFWS 1993).

In regard to competition for food resources, albatrosses are surface feeders that take principally small fish (e.g., larval and juvenile walleye pollock and sablefish), squid, and zooplankton, much of which is presumed to be of little commercial interest. The importance of commercial fish species in the short-tailed albatross's diet and the effects of the commercial fishery on this species are not well known, but direct competition for food supplies is probably not a substantial problem for this seabird species (USFWS 1993).

In summary, the short-tailed albatross population is steadily increasing, and there is no evidence that groundfish fisheries in Alaska have diminished the species' recovery. The short-tailed albatross could be affected by direct mortality in fishing equipment or from discarded plastics, and indirectly through changes in the marine food webs and water quality. Although any mortality caused by commercial fishing would be a cause for concern, the expected incidental take of up to two short-tailed albatrosses during harvest of 1993 groundfish TACs is not expected to jeopardize the continued existence of the species.

Cormorants: Four cormorant species breed in Alaska. Red-faced (approx. 150,000 birds), pelagic (approx 150,000), and double-crested (approx 20,000) cormorants breed in the BS and GOA. Brandt's cormorants (approx. 200) breed in Southeast Alaska and southward. They feed on bottom fish and also on surface fish such as herring and sand lance. Little is known about their statuses, but red-faced cormorants may have declined on the Pribilof Islands during the past decade.

Jaegers: Three jaeger species breed in Alaska. The parasitic jaeger is a common breeder in the BSAI and GOA. Pomarine jaegers breed on the tundra north of the Arctic Circle, and long-tailed jaegers breed in the high Arctic. Compared to other seabirds, jaegers feed mostly on land during the breeding season where they often prey on nestling birds and small rodents. When at sea, they feed on fish such as capelin and sand lance, which they sometimes steal from other birds. Little is known about their population trends.

Gulls: Six gull species breed in Alaska. Several other gull species are also found in Alaska but do not breed there. Approximately 500,000 glaucous-winged gulls breed in the BSAI and GOA. Glaucous and Sabine's gulls both commonly breed in the BS. Mew, herring, glaucous-winged, and Bonaparte's gulls breed in the GOA. Most gulls feed at sea on fish such as herring, capelin, and sand lance, and also along the shore on crustaceans and mollusks. Some gull species gather behind vessels where they feed on processing wastes. Local populations near on-shore fish processing plants may increase due to available fish processing waste as a food source. The status of these gull species is not accurately known but there are no indications of decline.

Kittiwakes: Two species of kittiwakes breed in Alaska. The estimated world population of the red-legged kittiwake is approximately 170,000 birds (Byrd and Williams 1993), down from and estimated 260,000 birds in the mid-1970s. About 74% of the population breeds on St. George Island. The remainder breed on St. Paul, Buldir, and Bogoslof Islands, and on the Russian Commander Islands. There is evidence that the number of breeding areas used by this species has declined over this century (Hatch 1993). Populations on St. George and St. Paul Islands have declined significantly since the late 1970s with several years of almost complete breeding failure. A small breeding population on Bogoslof Island has remained stable or increased slightly since the mid-1970s, while numbers on Buldir Island in the western Aleutians have more than doubled (Byrd and Williams 1993). The species has been added to the ESA candidate list as a Category 2 species. Reasons for the declines are not understood, although declines in available prey have been discussed.

Red-legged kittiwakes primarily feed on juvenile pollock, lanternfish, and zooplankton. Because these birds typically feed on juvenile prey that are not of commercial interest to the groundfish industry, direct competition with commercial fisheries should be minimal and the TAC level should not affect these seabirds. Indirect effects of commercial fisheries remain to be studied.

Black-legged kittiwakes breed in the BSAI and GOA, and also in Canada and Eurasia and the AI at Buldir Island. There are an estimated 2.6 million black-legged kittiwakes in the North Pacific and adjacent seas (Sowls et al. 1978, Golovikin 1984). Black-legged kittiwakes feed on juvenile pollock, capelin, sand lance, and zooplankton. They may gather in large numbers to feed on dense prey that may be located near vessels and on discharged fish offal. Numbers of kittiwakes have declined on the Pribilof Islands since the 1970's. Black-legged kittiwakes appear to have experienced almost complete reproductive failure on St. George Island (6% fledge success) in 1994 (A. Sowls, pers. comm., 1994, U.S.F.W.S., Homer, AK). The status of black-legged kittiwake populations varies among regions but is generally stable. Reproductive failures may relate to food availability for these surface feeding species. There appears to be a relation between surface temperatures and food availability, but observations are not consistent throughout the Bering Sea and Aleutian Islands (Hatch et al. 1990).

Terns: Two species of terns breed in Alaska. Approximately 50,000 Arctic terns breed on the coasts of the BS and GOA. Other populations occur in Canada, northern continental United States, and Eurasia. Approximately 20,000 Aleutian terns breed in the BS and GOA. Terns feed on small fish, capelin, sand lance, and zooplankton near shore. Status of tern populations in Alaska is unknown.

Murres: Both common and thick-billed murres breed in the BSAI and GOA. Their Alaskan populations are both roughly estimated at 6 million. They are the deepest diving Alaskan seabirds (more than 100 m). They feed on pollock, capelin, sand lance, Arctic cod, shrimp, and zooplankton. Most populations are stable, but declines have been reported at colonies in the Chukchi Sea, Norton Sound, and St. Paul Island in the Pribilofs, possibly as a result of fluctuations in prey species on which breeding or wintering birds depend.

Guillemots: Two species of guillemots breed in Alaska. The pigeon guillemot (approx. 200,000 birds) breeds in the BSAI and GOA. The black guillemot (approx. 2,000) breeds north of Cape Thompson in the Chukchi Sea. They feed in relatively shallow water (less than 25 m deep) on capelin, sand lance, Pacific cod, sculpins, crab, and shrimp. The status of guillemots is unknown in most areas, but numbers have declined in Prince William Sound since the 1970's.

Murrelets: Three species of murrelets breed in Alaska. The Kittlitz's murrelet breeds from the Chukchi Sea throughout the GOA. Marbled (250,000 to 1,000,000 birds) and ancient (approx. 800,000) murrelets breed from the AI through the GOA, and southward along the Pacific Coast into California. The ancient murrelet may occur at sea over the continental shelf. Murrelets occur near shore and in quiet bays. All species feed on pollock, capelin, sand lance, and zooplankton. The Kittlitz's murrelet is rare, and its population trends are unknown. This species has been added to the ESA candidate list as a Category 2 species.

Population trends of the marbled murrelet in Alaska are unknown, although they have declined in Prince William Sound since the 1970's. Populations in the Pacific Northwest have been reduced severely by removal of old-growth forest, and the species is now listed as threatened within that range. Marbled murrelet was listed as threatened in its Washington, Oregon, and California range (57 FR 45328, October 1, 1992), principally due to loss of breeding habitat, but remains a Category 2 candidate species in Alaska pending further evaluation of their status. This species is most numerous in Alaska. Although no one has systematically surveyed marbled murrelet numbers in Alaska, the USFWS estimates that at least 124,000 marbled and Kittlitz's murrelets were in Alaskan waters in 1992. The USFWS determined in a technical assistance memorandum to NMFS accompanying the 1989 biological opinion that marbled murrelets may suffer extensive mortalities in nearshore gillnet fisheries from California to Alaska. Since marbled murrelets typically forage within a few kilometers of shore on small prey (e.g., sand lance and herring), there is no indication that offshore fisheries adversely affect this species. While high mortality in nearshore (within waters of the State of Alaska) gillnet fisheries has been recorded, there is little evidence that off-shore fisheries have been detrimental to the species.

Ancient murrelet populations have probably been depressed by predations from introduced mammals on the breeding grounds.

Auklets: Six species of auklets breed in Alaska. Least and crested auklets breed in Alaska from the Bering Strait to the Alaska Peninsula and the AI. The parakeet auklet, also a crevice nester, breeds from the Bering Strait south along the AI and western GOA. The rhinoceros auklet (actually a puffin) is a burrow nester, breeding from the AI and Alaska Peninsula south to the coast of central California. The Cassin's auklet, a burrow nester, breeds from the AI and southern coasts of GOA, south to Baja California. The whiskered auklet, a crevice nester, only breeds only in the central AI and the Russian Commander and Kuril Islands. Auklets feed near the coast over the continental shelf, although parakeet auklets may go over the shelf edge and least auklets may go over deeper water. All feed on zooplankton, except the parakeet auklet, which also feeds on herring, capelin, and sand lance; and the rhinoceros auklet which feeds primarily on small fish.

Because auklets nest in crevices and burrows, they are difficult to census, and only crude population estimates are available. The least auklet is the most abundant seabird in Alaska, comprising one-fifth of the total Alaska seabird breeding population. The whiskered auklet is the rarest auklet. Its small numbers and limited distribution suggest it is vulnerable to human-induced and natural environmental perturbations. While there is generally little information on trends in auklet populations, drastic declines are not indicated by available data.

Puffin: Two species of puffins breed in Alaska. Horned and tufted puffins breed from the Chukchi Sea, Bering Sea, AI and GOA southward to Southeast Alaska. Both are regarded as burrow nesters, using crevices when conditions require. Both species feed by diving on juvenile pollock, capelin, and sand lance as well as zooplankton, squid, shrimp, and worms. Both species depend on fish and squid to feed their young. In Alaska, tufted puffins may number around 4 million while horned puffins number around 1.5 million. The overall population trends of these species is unknown.

Marine Waterfowl: A number of duck species are common to the open waters of the BSAI and/or GOA. These include common, king, spectacled, and Steller's eiders; black, white-winged and surf scoters; harlequin duck; oldsquaw; Barrow's and common goldeneye; and bufflehead. Most species depend on crustaceans, mollusks, other invertebrates, and sometimes small fish. Numbers of these diving ducks appear to be in general decline throughout their ranges in Alaska, a trend that has continued since the mid-seventies.

Since the early 1970s, spectacled eiders have experienced a precipitous decline (94-98%) on their primary known nesting grounds on the Yukon-Kuskokwim Delta (58 FR 27474). The species was listed as threatened on May 10, 1993 (58 FR 27474-27480). The spectacled eider's marine range is not known, although Dau and Kistchinski (1977) review evidence that they winter near the pack ice in the northern Bering Sea. This eider is rarely seen in U.S. waters except during molting in northeast Norton Sound (August-September) and in migration near St. Lawrence Island. The lack of observations in U.S. waters of the BSAI suggests that, if not confined to sea ice polyneas, they likely winter near the Russian coast (USFWS 1993). Spectacled eider breeding populations have declined steadily in Alaska, to a current estimate of a few thousand pairs compared with as many as 70,000 pairs 20 years ago. These sea ducks feed on benthic mollusks and crustaceans taken in shallow marine waters or on pelagic crustaceans. Based on current information and hypotheses, the BS groundfish fishery is outside their normal marine range. Thus, the USFWS concluded that the 1993 TACs are not likely to adversely affect this threatened species. The spectacled eider may be indirectly affected by increased predation by populations of large gulls which expand in relation to fish processing wastes.

The Steller's eider is a Category 1 "warranted but precluded" species which warrants listing, but is awaiting the ESA processing of other higher priority species. The Steller's eider may be listed in late 1994 or early 1995 (Cochrane, pers. comm., 1994). The USFWS estimated that at least 140,000 Steller's eiders spent the fall and winter of 1992 in nearshore waters along the Alaska Peninsula and from Kodiak Island to Kachemak Bay in Cook Inlet. Most of the world's Steller's eiders migrate from Siberian breeding grounds to lagoons on the north side of the Alaska Peninsula in the fall. They then winter on the south side of the Alaska Peninsula from Kodiak Island to Unalaska Island. Steller's eiders typically feed on benthic mollusks and crustaceans taken from shallow waters of lagoons and bays. Consumption of fish is very limited. Feeding habits indicate the species would not come into direct contact with groundfish vessels. While indirect impacts are possible from vessel groundings or discharges that affect nearshore lagoons, the potential for interaction with the commercial groundfish fishery is low and the USFWS concluded that 1993 groundfish TACs are not likely to adversely affect this Category 1 candidate species.

The status of king and common eiders in Alaska are unknown.

The USFWS recceived reports of unidentified eiders colliding with intensely illuminated crab vessels in the winter Bering Sea opilio crab fishery. These species could include king, common, and/or spectacled eiders. Observer and volunteer data from forthcoming crab fisheries should provide an indication of the species involved and the magnitude of the take.

The three species of scoters are not easily differentiated in aerial surveys, but scoters are generally declining throughout Alaska. Since aerial surveys began in 1957, populations have declined by 70%.

Coastal nesting populations of Harlequin ducks in Prince Sound have experienced nesting failures since the 1989 Exxon Valdez oil spill. The status of inland breeding and other coastal breeding populations elsewhere in Alaska are not well known.

Barrow's and common goldeneye have declined by 45% and Bufflehead have declined by 42% since 1977 (Hodges, unpubl. rept.). The breeding populations of oldsquaw in Alaska are also believed to be declining.

Marine Mammals

As with seabirds, the BS/AI and GOA support the richest assemblage of marine mammals in the world. This includes at least eight species of pinnipeds (seals, sea lions, and walrus). one species of sea otter, and twenty or more species of cetaceans (whales, doplhins and porpoises). Salient characterisics of the most common species are presented below.

Pinnipeds and sea otters

Eight pinniped species and the sea otter occupy a variety of Bering Sea and Gulf of Alaska habitats on either an annual or seasonal basis: Steller sea lions (*Eumetopias jubatus*), northern fur seals (*Callorhinus ursinus*), Pacific harbor seal (*Phoca vitulina*), spotted seal (*Phoca largha*), ringed seal (*Phoca hispida*), ribbon seal (*Phoca fasciata*), bearded seal (*Erignathus barbatus*), Pacific walrus (*Odobenus rosmarus*), and sea otter (*Enhydra lutris*). Recent population estimates are shown in Table 2.

Northern fur seals occupy the southern Bering Sea in summer, with most females and juveniles migrating to the North Pacific Ocean and Gulf of Alaska for the fall through spring. Steller sea lion, harbor seal, and sea otter populations are concentrated in the Aleutian Islands and coastal areas of the Gulf of Alaska, although some sea lion haul-outs also exist further north in the Bering Sea. Walrus and spotted, bearded, ribbon and ringed seals are associated with the southern ice edge during the winter and spring, and coastal areas from Bristol Bay north during the remainder of the year. In spring these species move inshore (often following prey) and north as the ice retreats.

Although all nine species interact with commercial groundfish fisheries, only four have a documented pattern of consistent interactions. Steller sea lions, harbor seals and northern fur seals interact with the fishery because of competition for the same prey and because they are taken in commercial trawls (especially the Steller sea lion). The fourth species (walrus) interacts by being caught in trawl gear and through noise disturbance at their Round Island haul out by trawlers in the yellowfin sole fishery. Table 3 summarizes the number of animals taken during 1990-93 in the commercial trawl and longline groundfish fisheries in Alaska.

Pinnipeds (basically sea lions, fur seals, and harbor seals) have been estimated to consume 306.2 x 10^3 mt and 399.4 x 10^3 mt of walleye pollock in the eastern Bering Sea and Gulf of Alaska, respectively (Lowry et al. 1989). Most of this consumption is concentrated on age 1-3 fish.

Steller Sea Lion: Population trends from 1990 through 1993 and the 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. During the 90 day comment period, a number of comments were received from government agencies, representatives of natives groups, the fishing industry and the environmental community, as well as from individual citizens. Responses to these comments will be included in the proposed rule scheduled to be published in early 1995.

As part of this review, the NMFS is preparing a status review document which incorporates most of the available information on the biology and status of the species in U.S. waters. This document will be available at the time the proposed rule is published.

Population Assessment: In the 1960s, the worldwide population of this species was around 250,000 adult and juvenile animals (nonpups). Subsequent declines in the Kuril Islands, Aleutian Islands, and Gulf of Alaska reduced the worldwide population to 91,000 by 1989 (Merrick et al. 1987; Loughlin et al. 1992). The Alaska population, which numbered close to 157,000 nonpups in the 1970s, had declined to less than 64,000 nonpups by 1989, a decline of almost 60% (Loughlin et al. 1992). 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)

Table 2.--Summary of the status of Alaska stocks of marine mammals managed by the NMFS. Depleted, threatened, and endandered species are all considered strategic.

Species	Stock	Pop. size	CV (N)	Pop. size (min)	Rate of increase	Safety factor	PBR	Fishery take	ZMR Goal	Subsist. take	Status
Pinnipeds											
Steller Sea Lion	Western U.S.	43,200	0.02	42,536	0.06	0.5	1,276	36	Yes	541	Threatened
	Eastern U.S.	23,900	0.02	23,533	0.06	0.5	706	8	Yes	7	Threatened
Northern Fur Seal	N Pacific	984,000	0.13	885,322	0.06	0.5	26,560	2.6	Yes	1,837	Depleted
Harbor Seal	SE Alaska	22,447	0.03	22,447	0.06	1.0	1,347	Unk	Unk	1,671	Strategic*
	GOA/BS	25,183	0.19	21,490	0.06	0.5	645	25	Yes	1,196	Strategic*
Spotted Seal	Alaska	59,214		59,214	0.06	0.5	1,776	Unk	Unk	1,000	Nonstrategic
Bearded Seal	Alaska	N/A		N/A	0.06	0.5	N/A	1	Unk	>1,000	Nonstrategic
Ringed Seal	Alaska	N/A		N/A	0.06	0.5	N/A	0.6	Unk	>3,000	Nonstrategic
Ribbon Seal	Alaska	N/A		N/A	0.06	0.5	N/A	0.2	Unk	100	Nonstrategic
Cetaceans											
Beluga Whale	Bristol	1,800		1,800	0.02	1.0	36	Unk	Unk	8	Strategic*
	Beaufort	21,000		21,000	0.02	1.0	420	0	Yes	0	Nonstrategic
	E. Chukchi	2,500		2,500	0.02	1.0	50	0	Yes	92	Strategic*
	Norton/Yukon	4,000		4,000	0.02	0.5	52	0	Yes	168	Strategic*
	Cook Inlet	332		332	0.02	1.0	7	Unk	Unk	13	Strategic*
Killer Whale	AK/WA/OR	1,046		1,046	0.02	0.5	14	0.8	Yes	0	Nonstrategic
Harbor Porpoise	Alaska	11,722		10,652	0.02	0.5	138	20	NO	N/A	Nonstrategic

Table 2.--Summary of the status of Alaska stocks of marine mammals managed by the NMFS. Depleted, threatened, and endandered species are all considered strategic.

Species	Stock	Pop. size	CV (N)	Pop. size (min)	Rate of increase	Safety factor	PBR	Fishery take	ZMR Goal	Subsist. take	Status
Dall's Porpoise	Bering Sea	62,200		55,777	0.02	1.0	1,116	4.2	Yes	0	Nonstrategic
Dall's Porpoise	N Pacific	339,200		311,353	0.02	1.0	6,227	29	Yes	0	Nonstrategic
N Right Whale Dol	Cent N Pac.	68,000		39,733	0.02	0.5	517	0	Yes	0	Nonstrategic
Pac white-sided Dol	North Pacific	931,000	0.9	486,719							
Gray Whale	East N Pac.	20,869		20,110	0.02	1.0	402	0	Yes	0	Nonstrategic
Humpback Whale	Cent N Pac.	1,407		1,286	0.02	0.1	3	0	Yes	0	Endangered
N Right Whale	N Pacific	N/A		N/A	0.02	0.1	N/A	0	Unk	0	Endangered
Bowhead Whale	West Arctic	8,000		7,524	0.02	0.1	15**	0	Yes	42	Endangered
Fin Whale	N Pacific	N/A		N/A	0.02	0.1	N/A	0	Unk	0	Endangered
Sperm Whale	East N Pac.	N/A		N/A	0.02	0.1	N/A	0	Unk	0	Endangered

* Due the likely bias of N(min) it is not possible at this time to predict the impacts of human related removals on this stock.
** Alternatively, F(r) could be set at 0.65, within the range of values for cetacean stocks increasing with takes greater than the PBR calculated with F(r) = 0.1; when F(r) = 0.65, PBR = 98.

Table 3.--Observed and expected (within parentheses) number of marine mammals incidentally killed by domestic tawl, long-line, and pot groundfish fisheries in Alaska during 1990-93. Excludes animals observed as decomposed or caught alive and released (NMFS unpubl. data). Expected number may be less than observed number because some observed animals were not included in calculations of expected numbers. Code "nc" indicates no correction was performed.

Species	1990	1991	1992	1993
Steller sea lion	16 (18)	14 (16)	15 (23)	6 (8)
Northern fur seal	0	3 (5)	3 (5)	1 (nc)
Pacific harbor seal	2 (1)	1 (nc)	4 (5)	1 (4)
Spotted seal	0	0	0	0
Ringed seal	0	0	2 (3)	0
Ribbon seal	1 (1)	0	0	0
Bearded seal	0	3 (5)	0	0
Northern elephant seal	3 (3)	0	0	1 (nc)
Pacific walrus	0	5 (6)	4 (6)	4 (3)
Unidentified pinniped	0	3 (nc)	1 (nc)	1 (nc)
Sea otter	0	0	8 (25)	0
Killer whale	0	2 (2)	1 (2)	1 (nc)
Harbor porpoise	0	0	0	0
Dall's porpoise	6 (7)	1 (2)	5 (7)	5 (6)
Pacific white-sided dolphin	0	0	1 (2)	0
Unidentified cetacean	1 (nc)	1 (nc)	0	1 (nc)
Unidentified marine mammal	0	1 (nc)	0	0

published a final rule 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 45,000 nonpups (-30%) by 1994. Total abundance (pups and nonpups) in 1994 was estimated as 57,900 animals. Of these, 43,200 were in the western stock (southwestern Alaska; Table 2) and 14,700 were in the eastern stock (southeastern Alaska). An additional 9,200 pups and nonpups were in Oregon and California in 1994.

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 also declined at a rate of 8% per year during 1990-94, but Southeast Alaska and Oregon pup production remained stable.

During the 1994 NMFS and ADF&G aerial survey declines were observed in overall (haul-out and rookery) trend site nonpup numbers in all Alaskan regions except SE Alaska and the western GOA (numbers were stable or increasing at almost all sites in the area from the Shumagin Islands through Ugamak Island). Kenai-Kiska (K-K) area overall trend site sea lion numbers declined by 9.6% (from 20,679 to 18,702) during 1992-94 (-4.9%/year). This is a continuation of the trend observed during 1989-92 (-4%/year). Declines were observed in rookery numbers in all Alaskan regions except SE Alaska. Rookery numbers in the K-K area declined 12.6% (from 16,589 to 14,500) during 1992-94 (-6.5%/yr). This decline was greater than observed during 1989-92 (-4%/yr).

NMFS and ADF&G also conducted a survey of Steller sea lion pups for all of the state except for the western Aleutian Islands. Pup numbers decreased in all regions from 1991/92 to 1993/94 (including SE Alaska). Excluding the central AI, pup numbers in the K-K area decreased 19.5% from 1991/92 to 1993/94. These declines reverse apparent stability in pup numbers observed in 4 regions (SE Alaska, eastern GOA, western GOA, and eastern AI) from 1989/90 to 1991/92. Since the last range-wide survey (1989/90) there has been a 29.2% decrease in K-K pup numbers, and a 20.7% decrease in the area from SE Alaska to the central AI.

Population Viability Analysis: A revised population viability analysis was prepared to evaluate future population trends should the 1985-94 or 1989-94 trends persist. Two models were developed based on a stochastic model of exponential growth using the 1985-94 and 1989-94 population trends. One model (an aggregate Kenai-Kiska model) was based on the trajectory of the sum of the rookery populations within the area. The second model was based on a simulation of the population trajectories of individual rookeries in the Kenai-Kiska area. All models predicted the Kenai-Kiska population would be reduced to low levels (< 500 adult females) within 100 years from the present, if the 1985-94 and 1989-94 trends persist into the future. The Kenai-Kiska models predicted the probability the population would reach 100 adult females was greater than 0.65 at 100 years. The individual rookery simulation predicted a longer time to extinction due to the persistence of small populations on several rookeries. The probability the population would reach 100 adult females in 100 years was 1.00 for the 1985-89 trend and 0.01 for the 1989-94 trend. Mean times to this population size were 53 and 86 years for the 1985-94 and 1989-94 trends, respectively. Results indicated that, if either trend persists, the next 20 years would be crucial to the survival of the Alaska population. Populations on individual rookeries would be reduced to low levels (mean size would be less than 100 adult females). After 20 years, rookeries would rapidly begin to disappear as the population contracts to the core of the range in the western Gulf of Alaska and eastern Aleutian Islands. At about the time most rookeries have been vacated, extinction probabilities would increase rapidly. Thus, in 100 years most of the Steller sea lions remaining in the U.S. would be in the area between southeastern Alaska and northern California.

Genetic Studies: Stock differentiation studies using mitochondrial and nuclear DNA analyses continued during 1994. Tissue samples were collected from flippers of adults and pups at sites in SE Alaska, Prince William Sound, Gulf of Alaska, Aleutian Islands, and Russian waters. Analysis of these samples and those collected in 1991-93 continue. However, based on genotypic dissimilarities found to date as well as associated distributional, population response (e.g., common population trajectories), and phenotypic information it appears that the species can be split into two stocks at Cape Suckling, Alaska--an eastern stock (southeastern Alaska to California) and a western stock (the Gulf of Alaska, Aleutian Islands, and Bering Sea).

1993-94 Foraging Studies: Recent food habits studies indicate that walleye pollock is the major prey of Steller sea lions in Southeast Alaska, the Gulf of Alaska, and the Bering Sea (Calkins and Goodwin 1988; Lowry et al. 1989; Merrick and Calkins 1994), and that Atka mackerel is presently the major prey in the Aleutian Islands (NMFS unpubl. data). The sea lion's diet also includes squid, octopus, and a variety of forage fish such as Pacific herring, capelin, and sand lance (Lowry et al. 1982). Studies during 1985-86 in the Gulf of Alaska found that sea lions consumed a greater proportion of walleye pollock than during 1975-78, although octopus and flatfish were also important (Calkins and Goodwin 1988). Size of pollock consumed by sea lions ranges from age 1 fish to adults greater than age 10, however most of the pollock consumed are ages 1 to 3 and the average size is under 30 cm (Lowry et al. 1989). Juvenile sea lions consumed smaller and a less diverse assemblage of prey than adults.

Steller sea lion scats have been collected annually in the GOA during 1990-1994 by NMFS at rookeries and haul-outs in the area between the Barren Islands and the Sandman Reef Area. Results from 54 scats collected during 1990-93 (Table 4) indicated walleye pollock remains the most common prey there (64.8% of scats). Atka mackerel has, for the first time since at least the 1970s, begun to appear in the diet (16.7%of scats). Salmon was ranked as the second most common prey (24.1% of scats) from this summer time collection. The apparent increase in salmon consumption may, however, be an artifact of sampling methods. Pervious samples were only analyzed for otoliths, while the scat samples were checked for a variety of bones.

NMFS conducted echo integration-midwater trawl surveys to assess Steller sea lion prey availability within 10 nm of rookeries and haul-outs during summer. Three rookeries (Marmot,

Table 4.--Major fish prey identified from stomachs of Steller sea lions collected in Southeast Alaska, Kodiak Island, and the Gulf of Alaska during 1975-93. Rank is determined from the percent frequency of occurrence (shown in parentheses) of a prey in stomachs with contents (n). Kodiak Island 1990-93 rank is determined from the percent frequency of occurrence (shown in parentheses) of a prey in scats with contents (n).

Rank	Gulf of Alaska 1975-78 n=178	Kodiak 1975-78 n=63	Kodiak 1985-86 n=67	Kodiak 1990-93 n=54	Southeast Alaska 1986 n=14
1	walleye pollock (69.1%)	walleye pollock (49.2%)	walleye pollock (68.7%)	walleye pollock (64.8%)	walleye pollock (64.3%)
2	capelin (13.4%)	capelin (28.1%)	flatfish (13.4%)	salmon (24.1%)	flatfish (28.6%)
3	Pacific cod (12.8%)	Pacific cod (14.1%)	Pacific cod (10.3%)	Atka mackerel (16.7%)	Pacific herring (14.3%)
4	Pacific herring (8.9%)	flatfish and salmon (7.9%)	sand lance (7.4%)	flatfish (14.8%)	-
5	flatfish (5.1%)	-	-	sand lance (7.4%)	-

Atkins, and Akun Islands) and one haul-out (Latax Rocks as a control site) were surveyed during 1994. As with previous surveys, only 0-aged fish and euphausiids were found in the water column. However, this year bottom trawl surveys will also conducted in association with researchers from the University of Alaska. A variety of small fish were collected as part of this work, the most common of which were age 0 and 1 flatfish, and a variety of sculpins.

Incidental Take: Six Steller sea lions were reported killed in groundfish fisheries during 1993 (Table 3).

Northern Fur Seal: Since the mid-1700s, the northern fur seal population in Alaska has gone through a series of cycles driven largely by harvest practices. Population size in the late 1940s was estimated to be over two-million animals. The population then began a decline which continued through the early 1980s. The population size in 1983 was estimated to be 877,000 animals (NMFS 1993). From 1975 to 1981 the Pribilof population declined at a rate of 4-8% per year (Fowler 1985) as indicated by decreasing numbers of pups born and adult males present. Entanglement in nets, net fragments and other debris may have been an important contributing factor in this decline (Fowler 1985, 1987). The population has been stable since 1981, however, their numbers were sufficiently low to be listed as depleted under the MMPA on June 17, 1988. The population size estimated for 1992 was 984,000 pups and nonpups (Table 2).

In 1994 the number of fur seal pups born in the Pribilof Islands (St. Paul and St. George Islands) was not statistically different from the number counted in 1992 (NMFS unpubl. data). A total of 182,437 (sd = 8,918) and 204,995 (sd = 2,257) pups were born at St. Paul Island in 1992 and 1994, respectively. At St. George Island, 25,160 (sd = 707) and 20,775 (sd = 337) pups were born in 1992 and 1994, respectively. The decrease at St. George Island during 1992-94 was statistically significant. Overall, the Alaskan population remains below OSP and thus is considered depleted.

Although the fur seal's geographic range is throughout the North Pacific Ocean, they only breed at a few sites - Commander, Bogoslof, and Pribilof Islands in the Bering Sea, Robben and Kuril Islands in the Sea of Okhotsk, and San Miguel Island in southern California. Fur seals are highly migratory and lead a pelagic existence in the nonbreeding season from November to May or June (Kajimura et al. 1980; Kajimura 1984). Most fur seals begin their southward migration in late October-early November and the majority have departed the Pribilof Islands by mid-December. During this period, they are widely dispersed in offshore waters of the North Pacific (70-130 km offshore), with various age- and sex-class segments of the population found from the southern Bering Sea south to the California/Mexico border in the west and to Japan in the east. Habitats of major importance to fur seals include: (1) rookeries and haul out areas on the Pribilof Islands; (2) outer shelf and shelf break areas where fur seals forage; (3) a broad corridor including the shelf break between the Pribilof Islands and eastern Aleutian passes; and (4) eastern Aleutian passes, primarily Unimak Pass, utilized as migratory routes in spring and fall. Fur seals typically forage over the outer shelf and shelf break as far as 400 km away from the Pribilof Islands (Loughlin et al. 1987). Fur seals forage mainly at night and early morning on various schooling fishes which congregate in areas of nutrient upwelling. Greater than 400,000 individuals, including females and nonbreeding individuals, may be foraging in the Bering Sea at any given time from June to November.

Extensive studies of the diet of northern fur seals indicate variation by season and location. Important prey include pollock, capelin, squid, and other pelagic fishes (Perez and Bigg 1986). Much of the pollock eaten by fur seals is from younger age classes (Sinclair et al. 1994a, b).

One northern fur seal was reported killed in groundfish fisheries during 1993 (Table 3).

Pacific Harbor Seal: The Alaskan harbor seal population was estimated at 270,000 animals prior to 1973 (Pitcher and Calkins 1977). Numbers have ben relatively stable in southeast Alaska with the population there in 1993 estimated to be 22,447 seals. However, numbers in areas of Southwest Alaska have declined significantly since 1973. Numbers at haul-outs declined by more than 57% from 1984 to 1992 in Prince William Sound (Pitcher 1989; Frost and Lowry 1993. A steady decrease in numbers has been reported throughout the Kodiak Archipelago since 1976 with rates similar to the 85% decrease at Tugidak Island common throughout the area (Pitcher 1990; Loughlin 1993). Numbers along the Alaska Peninsula seem to have fluctuated but no trend was apparent (Loughlin 1992). An Aleutian Island survey was completed in 1994, but numbers are not presently available. The present estimate of harbor seal abundance in Southwest Alaska (excluding the Aleutian Islands) is 25,183. Although, harbor seals are not listed as depleted under the MMPA, a Conservation Plan is being drafted.

Harbor seals range throughout the subarctic waters of the northern hemisphere. Harbor seals are common residents of coastal areas throughout southeast Alaska, coastal Gulf of Alaska, Aleutian Islands, Alaska Peninsula, and north through Kuskokwim Bay and the Pribilof Islands (Pitcher and Calkins 1977; Everitt and Braham 1980). Apparently, some individuals also disperse to ice floes in winter, especially when the pack ice advances further into the southern Bering Sea than usual. While generally a coastal species (water depths less than 55 m), harbor seals have been observed up to 80 km offshore.

Harbor seals feed primarily on schooling fishes and cephalopods (Pitcher 1980). In the Bering Sea, major fish prey include sand lance, smelt, sculpins, pollock, and Pacific cod (Lowry et al. 1982). Most pollock consumed apparently are ages 1 to 3, although some larger pollock are taken (Frost and Lowry 1986).

One harbor seal was reported killed in groundfish fisheries during 1993 (Table 3).

Pacific Walrus: The Pacific walrus comprises about 80% of the world's walrus population. Three subspecies are recognized, and the Pacific walrus is the only one with a population approaching historical levels. However, the population has undergone several episodes of reduction and recovery since the late 1880's. Based on the 1990 survey, the current minimum population estimate for the Alaska stock is 188,316 animals (Table 2). The recent survey data are not useful for evaluating trends; however, there are some indications from trends in life history patterns that the population may be beginning to decline (Fay et al. 1989).

The Pacific walrus ranges from the Chukchi and Beaufort Seas to the southeastern Bering Sea and northern Kamchatka Peninsula (Fay 1982). Most of the animals migrate north in summer and south in winter in association with seasonal movements of the pack ice. During winter months (January - March) walrus may be found wherever openings are numerous in the drifting pack ice; but most animals occur in the relatively thin ice west and as much as 300 kilometers southwest of St. Lawrence Island (including St. Matthew Island), and in the Bristol Bay area. As the seasonal pack ice melts and the ice edge recedes northward in spring, pregnant females and those with young move north with it. Adult and subadult males then move to coastal haul-outs, mostly in Bristol Bay and the Bering Strait. In early spring, densities of 13.0 individuals/nm^2 between St. Lawrence and St. Matthew Islands and 4.2 individuals/nm^2 west of this area have been recorded (Burns et al. 1980). Calves are born on the ice in the northern Bering Sea from April to June (peak in early May) during the northward migration. Some haul-outs along the Chukchi Peninsula and on St. Lawrence Island are used primarily during the full migration.

Walrus are bottom feeders, feeding mainly on bivalve mollusks at depths of 80 meters or less (Fay 1982). Other prey include gastropods, polychaetes, echiuroids and other benthic invertebrates (Lowry et al. 1982).

Other species: Sea otters and spotted, ringed, ribbon, and bearded seals also occasionally interact with commercial trawl fisheries. Abundance of each of these species appears to be high; however, there have been no new complete estimates of ice seal abundance since the mid-1970s (Table 2). All are rarely caught in commercial nets (1-2 animals are reported a year, NMFS unpub. data 1976-1989; Table 3). At least spotted and bearded seals may be significant seasonal predators for groundfish (Lowry et al. 1989; NMFS unpubl. data); however other prey appear to be more important on an annual basis. Distribution of the ice seals is closely associated with ice, and sea otters with land. Thus, the potential for direct interaction with trawl fisheries is relatively low.

Cetaceans

There are at least nine cetacean species which occur in the Alaskan waters and have a potential for interaction with groundfish fisheries. Three of these species are listed as endangered species: fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), and Sperm whale (*Physeter macrocephalus*). The remaining five species are nonendangered small to medium sized cetaceans: Minke whale (*Balaenoptera acutorostrata*), beluga (*Delphinapterus leucas*), Killer whale (*Orcinus orca*), Dall's porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*), and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)

These species interact with trawl fisheries either through a common prey such as walleye pollock (Lowry et al. 1989) or are occasionally caught in trawl nets (NMFS unpublished data). The former includes all eight species while the latter includes only the small to medium sized cetacean species.

Fin Whales: Fin whales range from the North Pacific Ocean to the Bering Sea and, rarely, the Chukchi Sea. The North Pacific population has been estimated from 14,620 to 18,360 individuals (Braham 1984); it is estimated that about 5,000 enter the Bering Sea during summer (Morris 1981). Population trends are unknown.

Fin whales generally winter off southern California and Baja California, although a few whales overwinter in the Gulf of Alaska and near the Commander Islands (Berzin and Rovnin 1966). Fin whales entering the Bering Sea are generally separated into two groups (Nasu 1974). A group consisting mostly of mature males and females without calves migrate along the shelf break to Cape Navarin and more northern waters. A group of lactating females and immature whales summer along the shelf break between the Pribilof Islands and Unimak Pass. Other summer concentrations occur in the Gulf of Alaska and along the Aleutian Chain. Historically, a summer concentration was located between St. Matthew and Nunivak Islands (Berzin and Rovnin 1966). Although the fall migration may begin in September, some fin whales may remain in the Aleutians and the Gulf of Alaska until November and possibly overwinter in these areas. Observations by Brueggeman, Grotefendt, and Erickson (1984) during four seasonal surveys in the Navarin Basin, found fin whales to be the most abundant whale. Fin whales were observed in the area throughout the year and may be classified as a resident species. From spring throughout fall, fin whales were observed only in the shallow-shelf areas (200 meter). During the winter, they were observed along the marginal-ice front on the shallow side of the shelf break.

Fin whales feed by engulfing large concentrations of euphausiids, anchovies, capelin, herring, and juvenile walleye pollock.

Humpback Whale: In the North Pacific, humpback whales are distributed from the tropics north to 70° N latitude in the Chukchi Sea. In the North Pacific, the humpback population is estimated at 1,407 individuals (Table 2), and Morris (1981) estimated that up to 200 humpbacks were distributed throughout the Bering Sea in the summer. Population trends are unknown.

Summer range extends from the coast of California northward to the southern portion of the Chukchi Sea. The whales migrate from wintering grounds off Hawaii and Mexico north to the Gulf of Alaska (early April), the eastern Aleutian Islands (late June), and northward to the Bering and Chukchi Seas (July through September). The whales are found in the Bering Sea from May through November; the autumn migration begins in September. Photo-identification of humpbacks indicates that migratory routes exist between Hawaii and Prince William Sound and southeastern Alaska, and between Mexico and California and southeastern Alaska. Soviet and Japanese tagging and whaling records indicate that humpbacks heading for the St. George Basin area migrate between Japan and the southeastern Bering Sea (Hameedi 1981). Berzin and Rovnin (1966) postulated that the summering humpbacks along the Soviet coast overwinter off Japan but that some mingling occurs with whales that overwinter around Hawaii and Mexico.

Euphausiids, Arctic cod, herring, capelin, saffron cod, walleye pollock, mysids, pelagic amphipods, and shrimp comprise the most important humpback food (Tomilin 1957).

Sperm Whales: Sperm whales are the most abundant large cetaceans in the North Pacific and the only toothed whale listed as endangered. Their North Pacific population is estimated at approximately 930,000 individuals with approximately 15,000 distributed in the Bering Sea during the summer months (Morris 1981; Braham 1984). Population trends are unknown.

Sperm whales are distributed in the Pacific from the equator north to Cape Navarin in the Bering Sea (Berzin and Rovnin 1966). Whales entering the Bering Sea are mostly males because females and juveniles seldom migrate north of the 10° C isotherm (approximately 50° N). They enter the Bering Sea primarily through Unimak Pass and migrate along the shelf break between the Pribilof Islands and Cape Navarin. They are found in pelagic waters near the continental shelf edge. Sperm whales have been captured in the region centered at 56° N, 170° W just south of the Pribilof Islands. Sperm whales are likely to be in the Bering Sea from March through November.

They feed largely on squid, although deepwater bottom fish are common on their diet (Caldwell et al. 1966).

Minke Whale: Minke whales are one of the smaller baleen whales, and inhabit all oceans of the world except equatorial regions. The North Pacific population is classified as abundant.

The species occurs broadly over the North Pacific and into the southern Chukchi Sea during the summer months and migrates to lower latitudes during the winter. Minke whales apparently occur in the Bering Sea on a year-round basis, with concentrations near the Aleutian Islands and the Pribilof Islands during the summer. Over 95% of minke whale sightings in the NMFS data base were within the 200-meter isobath, and most were in shallow coastal waters (Morris 1981).

Minke whales feed locally on abundant fish, euphausiids, and copepods. Euphausiids are the preferred prey in the North Pacific, followed by schooling fish, and copepods. From March through December, minke whales are seen feeding most frequently in the lagoons and coastal waters along the northern shore of the Alaska Peninsula (i.e., Port Moller and Nelson Lagoon).

Beluga: Belugas are circumpolar in Arctic and subarctic waters, numbering at least 30,000 individuals in the North American Arctic (Sergeant and Brodie 1975). Belugas are abundant in Alaska waters, especially above 60° N latitude. Five stocks are currently recognized in U.S. waters--Cook Inlet (332 animals), Bristol Bay (1,800), Norton Sound-Yukon Delta (4,000), Beaufort Sea (21,000), and Chukchi Sea (2,500)(Table 2). Populations are generally considered stable.

Although belugas have been observed near the Pribilof Islands, they are generally characterized as a nearshore and estuarine species, where they feed and calve during the summer months.

Belugas feed from midwater to the bottom, primarily on fish (such as salmon, smelt, herring, cods and flatfish) usually in shallow waters of the continental shelf and at the mouths of major rivers (Seaman et al. 1982).

Killer Whale: Killer whales are observed in all major oceans and seas of the world and appear to increase in abundance shoreward and toward the poles of both hemispheres (Mitchell 1975).

Surveys conducted during 1992-93 found at least 857 killer whales in Alaskan waters from SE Alaska through the Unimak Pass area. Population trends are unknown.

Killer whales have been observed as far north as the Chukchi and Beaufort Seas (Braham and Dahlheim 1982; Lowry et al. 1987). Year-round occurrence may occur within Alaskan waters; however, their movements are poorly understood (Braham and Dahlheim 1982). Whales are forced southward from the Chukchi and northern Bering Seas with the advancing pack ice and, under such circumstances, long-range movements may occur. Killer whale concentrations have been noted in coastal waters, continental shelf waters, and neritic zones. These areas of killer whale abundance are of particular interest as they overlap areas of high abundance of prey.

Killer whales are top-level carnivores of the marine ecosystem with diets that vary regionally (Heyning and Dahlheim 1988). Although primarily fish eaters, killer whales are known to prey on other cetaceans, pinnipeds, and seabirds (Dahlheim 1981). Killer whales may feed upon fish when locally abundant and then switch to marine mammals when fish are less available.

Dall's Porpoise: This species ranges from northern Baja California, along the western coast of North America, and across the North Pacific Ocean to the coastal waters of Japan. The estimated size of the North Pacific Dall's porpoise population was 339,200 animals in 1987-91 (Table 2). An additional 62,200 animals were estimated to reside in the Bering Sea during 1987-91 (Table 2). Population trends are unknown.

The northern limit of the species is generally Cape Navarin in the Bering Sea, although they have been observed as far north as 66° N latitude (Morris et al. 1983). Dall's porpoise are sighted in Bristol Bay through the year and in the Navarin Basin area from spring through fall (Brueggeman et al. 1984). They can occur in shallow waters but have been most frequently sighted in waters over 100 meters deep. Concentrations occur from June through November along the shelf break from the Pribilof Islands to Cape Navarin. Migratory movements are not well understood, but available information suggests local migrations along the coast and seasonal onshore/offshore movements. However, data from throughout the North Pacific and Bering Sea show that Dall's porpoise reproduce annually and seasonally, starting in late July or early August to September (Jones et al. 1985).

Dall's porpoise feed predominantly on squid and mesopelagic fish.

Harbor Porpoise: The harbor porpoise is a boreal-temperate species along the North Pacific coast from Point Barrow, Alaska, to central California. The Alaska population was estimated to be at least 11,722 animals in 1992-93. Population trends are unknown.

Harbor porpoise are generally sighted singly or in pairs. Sightings in the Bering sea are reported in Frost et al. (1982). Neave and Wright (1969) reported that harbor porpoise in the western North Atlantic move north in late May and south in early October. Harbor porpoise are generally seen in coastal environments such as harbors, bays, and the mouths of rivers.

They feed primarily on small gadoid and clupeoid fish, such as cod and herring.

Pacific White-Sided Dolphin: This species ranges is from Baja California to the Aleutian Islands, as well as off the coast of Japan. Most abundant in the summer months, this species concentrates in areas of high fish abundance, such as along the shelf break. Traditionally, the dolphins shifted their distribution farther north during the summer season and also may move offshore (Morris et al., 1983). However, since the mid- 1980s the species has been a common year-around occupant of inside waters of Southeast Alaska. They are frequently observed in groups exceeding 100 individuals; groups of between 500 and 2,000 individuals have been sighted. The population estimate for the North Pacific Ocean is 931,000 animals. Population trends are unknown, although abundance in Alaska appears to be increasing.

They are opportunistic feeders that eat a variety of fish and squid.

ECOSYSTEM CHANGE

Ongoing Research

Considerable research has taken place in the past decade concerning changes that have occurred and are continuing to occur in North Pacific marine ecosystems. The GOA and BS FOCI programs are examples. We will not summarize this research at this time. Rather we wll briefly focus on features of this and other research of particular concern to fisheries management--recruitment processes and recently documented changes in the GOA ecosystem.

<u>Environmental Factors Influencing Year Class Strength</u>

Annual recruitment of fish in Alaska to exploitable populations is highly variable, and unusually successful year classes often contribute greatly to increased stock abundance. For example, one study in the eastern Bering Sea estimated that annual recruitment of walleye pollock varied as much as 22-fold in the years 1979-85 (Bakkala et al. 1987). Year class strength is usually determined during a cohort's first year of life, and environmental conditions that affect the egg, larval, and early juvenile stages are thought to be major factors that determine the fate of a year class. Many environmental causes have been proposed to explain good survival during this period. In a global survey of various commercial species, Shepherd et al. (1984) reported that these proposed causes have included changes in temperature regimes that increase abundance of prey, stable weather conditions that concentrate food items, ocean current patterns that carry larvae into favorable feeding locations or away from predators, and many others, most of which are concerned with mechanisms that optimize the availability and usage of prey.

In the northeast Pacific from California to Alaska, Hollowed and Wooster (1992) identified periodic, synchronous strong year classes for a diversity of commercial groundfish stocks over the past 40 years. In most cases, these years corresponded to warm water "El Niño" events characterized by strong circulation in the Gulf of Alaska and weak upwelling off the U.S. west coast. Exactly how these climatic changes translate into abundant year classes is as yet unknown for this region, but the mechanisms presumably include reasons such as those listed in the previous paragraph. It is important to realize, however, that large scale changes in environmental conditions may have substantial effects upon the productivity or species composition of the ecosystem, and that one result of these changes will continue to be variable recruitment in stocks of demersal fish.

Changes in the GOA ecosystem

Seabirds: Recent unpublished surveys of GOA piscivorous seabirds (murres, puffins, kittiwakes, comorants, other alcids) have found that large declines in abundance have occurred in the area from the Barren Islands to the Shumagin Islands since the mid- 1970s. This includes the complete dissappearance of a number of smaller bird colonies. These declines have occurred during the same period that marine mammal populations declined in the same area. Because of the similarlities in the feedings habits between seabirds, Steller sea lions and harbor seals in the area, this suggests that both declines may be linked to a change in the availability of a shared prey.

GOA forage fish abundance: The Plan Teams have previously related to the Council that the analysis of a long term time series from fisheries surveys in Pavlof Bay by NMFS, Kodiak has found that a pronounced shift in species composition occurred there in the late 1970's (Anderson et al. 1994). The bay changed abruptly from an ecosystem characterized by invertebrates (mostly Pandalid shrimps) to one now characterized mostly by flatfish and pollock. Between 1972-80 and 1981-92, shrimp fell from 71.7% to 2.7% of the biomass, while flatfish rose from 2.3% to 39.1% and pollock rose from 18.0% to 51.4%. Capelin abundance fell from 1.9% to 0.1% of the biomass. Overall biomass in the upper trophic levels (as measured by a shrimp trawl) declined roughly one-half during the period.

Analysis of trawl data collected by ADFG from the 1970s through early 1990s is currently underway (P. Anderson, NMFS, pers. commun.). Preliminary results indicate that the change observed at Pavlof Bay may be representative of changes that occurred throughout the western and central GOA.

GOA arrowtooth flounder predation and abundance: Analysis of predation on herring, capelin, and juvenile walleye pollock by various groundfish predators in the Gulf of Alaska during 1990 indicated that arrowtooth flounder was the dominant groundfish predator on these species during that year (P. Livingston, pers. comm.) Of five predators (arrowtooth flounder, pollock, sablefish, Pacific cod, and Pacific halibut), arrowtooth flounder predation accounted for 98.5% of the herring consumed and 68.5% of the capelin. Arrowtooth consumed 41.5% of all pollock consumed by the 5 predators and >81% of juvenile pollock (<40 cm).

This predation, coupled with increases in arrowtooth abundance in the 1980s and 1990s, point towards this species playing a dominant role in controlling the species diversity and abundance in the GOA ecosystem.

Traditional Knowledge on Ecosystem Changes

Management of marine resources has typically been driven by information obtained solely from scientific and econometric studies. Traditional knowledge of native groups, and the anecdotal observations of local residents, fishermen, and scientists have rarely been included as part of the process. Yet such knowledge can provide important supplemental information where science based knowledge is lacking. Local knowledge is also frequently lost if not recorded in a timely fashion. We provide this section as a means of recording such information as a means of better understanding changes which have occurred and are continuing to occur in Alaska's large marine ecosystems. In the this first attempt, we focus on changes observed in the Kodiak area since the 1970s. Other groups in Alaska are encouraged to provide knowledge to this section in future editions.

The 1970s were a period during which the Gulf of Alaska underwent, what was to coastal residents, a dramatic change. Species composition switched from shellfish to finfish; marine water temperatures warmed. Such changes have also been documented by Anderson et al. (1994). In the early 1970s, larval and juvenile finfish began "contaminating" the tows of Kodiak area shrimp fishermen. During the 1960s, tows had been almost pure shrimp. The finfish contamination problem (mostly pollock and Pacific cod) continued and worsened throughout the 1970s, with larger pollock making up a greater portion of the catch as time passed.

In the summers of 1976-77 shrimp fishermen fishing off Kodiak Island reported that a "green slime" was plugging their nets. Nets had to be hung and cleaned every second tow. At about this same time, Steller sea lions began diving on and tearing up trawl nets when the fleet was fishing Pacific cod. Mending sea lion damage to the nets became a frequent and regular routine on deck. This problem, like the green slime, only lasted a few years.

ADF&G shrimp and crab trawl data, as well as the NMFS annual shrimp trawl at Pavlof Bay, document a decline of forage fish (e.g., capelin) simultaneous to the decline of the shrimp population. The appearance of Pacific cod and disappearance of shrimp occurred first in offshore areas, then in bays which could be entered through deep gullies, and finally, in bays with shallow sills. By the early 1980s, the shrimp (and king crab) populations were below threshold levels, and the fisheries were closed. To date the stocks show little signs of recovery. Capelin, which was traditionally observed spawning on beaches in the Kodiak area, has rarely been observed on beaches since then.

During 1993-94, a number of anomalies were observed by Kodiak area fishermen. Starting in October 1993, the Kodiak trawl fleet had great difficulty locating fishable concentrations of rock sole. However, vessels did report many small (15 cm) rock sole on the grounds. The lack of rock sole persisted through at least the first three quarters of 1994. Dover sole also proved difficult to find in fishable concentrations. During April 1994, vessels reported Rex and Dover sole in 80 m of water, which they considered unusually shallow. The fleet also reported a new groups of 30 cm halibut on the grounds. Halibut bycatch rates in the 1994 Pacific cod fishery was much greater than in 1993.

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

Bycatch Considerations

Bycatch in fisheries can be considered to be the catch of any non-target species regardless of its commercial value. Fisheries bycatch reflects the fact that species do not live in pure, discrete, exploitable patches, but as members of communities. Each species occupies a different niche within that community, and a single trawl haul or longline set may cut across many spatial/functional niches resulting in mixed species catches. In the North Pacific and Bering Sea groundfish fisheries, bycatch considerations can be divided into three areas: (1) catches of allocated groundfish species other than the target; (2) catches of other commercial species managed by agencies other than the Council; and (3) catches of non-commercial species or unmarketable sizes/sexes of commercial species.

Bycatches of Allocated Groundfish

Bycatch of non-target groundfish species in fisheries managed by the Council is essentially an accounting problem to prevent over-fishing of individual species. The Alaska regional office of NMFS keeps track of all catches of groundfish species for which allocations are made, regardless of the target fishery that makes the catch. This is accomplished through the use of fish tickets, weekly processor reports and observer data to obtain a "blend" estimate of in-season total catch. For instance, in 1993, the total catch of rock sole in the Bering Sea was about 64,000 mt. Only about 60% of this was caught by the directed rock sole fishery, and the remaining 40% was caught by bottom trawl fisheries for pollock, Pacific cod, yellowfin sole and other flatfish. This pattern of catch reflects the structure of demersal fish communities on the shelf, which are composed of a large number of species vulnerable to bottom trawls. Similarly, Greenland turbot and sablefish, which are both found on the continental slope and have coincident depth distributions, are caught together. This creates the possibility of preemption of a directed fishery for one species due to bycatch in another directed fishery, particularly if one occurs prior to the other.

By contrast, other species are caught almost exclusively by the directed fishery for that species, either because of the geographic area or depth zone in which the species resides. Examples of these are Atka mackerel, which is a semi-demersal species found over rough, rocky bottom in the Aleutian Islands, and pollock, which is caught principally in mid-water by pelagic trawls.

Some similar species are managed as a group, such as the shallow and deep-water flatfish, and various rockfish assemblages (slope, pelagic and demersal shelf) in the GOA. While management of a group of similar species makes "bookkeeping" of catches easier and may make some sense ecologically, there is a risk of overfishing of one or more species in a group. This can occur when their individual populations are in decline or are prized over other members of the group, creating the possibility that directed catches and bycatches exceed a single species ABC while catches of the group do not exceed the group ABC. These concerns have led to setting of ABCs for individual species formerly managed as groups within the slope (Pacific ocean perch, northern and shortraker/rougheye) and pelagic shelf (black rockfish) rockfish assemblages.

Bycatches of Species Managed by Other Agencies

There are a number of commercially exploited fish and crustacean species in the North Pacific whose fisheries are managed by agencies other than the Council, but which are caught in significant numbers by Council-managed fisheries. These include Pacific halibut, managed by the International Pacific Halibut Commission, and Pacific herring, salmon, red king crab, tanner crab and opilio crab managed by the state of Alaska. These species are termed prohibited species for the groundfish fisheries, and must be discarded. Since most groundfish fisheries (particularly trawl fisheries) are efficient at capturing these species, they could displace the directed fisheries for the the species if they were allowed to retain and market them.

Currently, there are limits established each year on the amount of some prohibited species that can be caught by each groundfish fishery in the Bering Sea, Aleutian Islands and Gulf of Alaska. When a prohibited species cap (PSC) for a species has been reached (in an area), regardless of how much of the target species TAC has been landed, the fishery is closed (in that area). Therefore, bycatches of some prohibited species have had tremendous economic impact on groundfish fisheries. Furthermore, to protect herring and red king crab during critical stages in their life histories, trawls are excluded from certain areas during all or parts of the year.

Since bycatches of prohibited species are, to a large degree, unavoidable in groundfish fisheries, it is important that the amount and size composition of the bycatch are known for proper management of the directed fisheries for each prohibited species and for setting PSCs. Overfishing of prohibited species because of bycatch in groundfish fisheries would not be likely assuming that bycatch is accurately represented in the stock assessments for each prohibited species and that groundfish fisheries do not exceed their PSCs. Recently, stocks of red king crab in the Bering Sea have declined to such low levels that the directed fishery was closed in 1994. To protect red king crabs and promote their recovery, certain groundfish fisheries may be restricted from fishing in certain areas in 1995.

Bycatch of Non-Commercial Species

Non-commercial species include all other species caught by groundfish fisheries for which there currently is no market. These include individuals of unmarketable sex or size of commercial species (particularly rock sole and the gadids, pollock and cod), the group of species considered in the "Other Species" assessment in the Bering Sea/Aleutian Island SAFE document (skates, sculpins, smelts, squid, octopus, and grenadiers), as well as other benthic marine life (corals, anemones, other cnidarians, echinoderms, crustaceans, etc.), and, to lesser extents, marine mammals and birds. Whatever groundfish fisheries catch of this very large and diverse group of species, sexes and sizes is generally discarded dead (with the exception of some marine mammals). Observer data in combination with stock assessments are useful in monitoring and accounting for catches and discards of unsuitable sizes and sexes of commercial species. Similarly, there is some survey biomass data available for "other species" for comparison with bycatches in groundfish fisheries. In almost all cases (with the possible exception of octopus), bycatches of each species in the "other species" complex accounted for less than 5% of their respective survey biomasses.

While bycatches of juvenile and unmarketable sexes of commercial fish and some non-commercial species are either accounted for in single species stock assessments or represent small fractions of their estimated single species biomasses, very little is known about the effects of aggregate removals of this marine life. Our lack of knowledge of the effects of groundfish fisheries is even larger when it is considered that (1) there are no survey data on which to place in perspective removals of other benthic marine life, and (2) there are only limited data available on how fishing, particularly trawling, affects both benthic and pelagic marine communities. Recent declines in some marine mammal and bird populations sizes have been attributed by some on commercial fisheries, particularly the removal of prey and disturbances to marine ecosystems. However, because so little is known about the specific effects of commercial fisheries in aggregate, not just on each species alone, the management community (NMFS and the Council) will continue to have difficulty identifying the optimal management strategies for all living marine resources that are affected.. More research should be directed at understanding the effects of annual removals of millions of metric tons of fish and other marine life from the North Pacific and Bering Sea ecosystems.

Habitat Alterations

The habitat of marine resources may be affected by commercial fishing operations, pollution, and habitat loss related to development. Since most of Alaska is considered lightly developed, the primary focus of this section will be on commercial fishing and on pollution related to oil exploration and development.

Trawl Effects

Although studies elsewhere have been conducted to quantify the habitat effects of commercial fishing operations, there have been few studies in Alaskan waters. The effects of commercial fishing gear on demersal fish habitat are presumably linked to the level of fishing effort within an area, the type of bottom being fished, and the gear type. Derelict fishing gear such as traps (pots) and sunken gill nets may cause substantial injury or mortality to demersal fishes, whereas the effects of longline gear may be slight (Carr et al. 1985; High 1985). Trawling can disrupt the habitat of demersal fishes in four ways (Jones 1992): 1) scraping and plowing the sea-floor, (2) sediment resuspension, (3) damaging or removing non-target benthic organisms, and (4) dumping of processing waste. For example, benthic invertebrates such as corals and sponges that some demersal fishes use as refuge may be removed or damaged by trawling. The extent and duration of the impact is related to the rate of recolonization and whether recovery is allowed to occur. Repeated trawling over the same area would presumably result in slow or no recovery of the lost habitat. Numerous studies document the destructive impact of trawling on coral habitat (Graham 1955, Wilson 1979, de Groot, 1984, Van Dolah et al. 1987; 1994, Rijnsdorp 1988, Hutchings 1990, NISR 1990, Jones 1992) but none specific to the North Pacific.

The reports available on trawl impacts indicate a potential threat to soft-bottom habitat and to the bottom-dwelling invertebrates living in the soft-bottom areas. Much of the impact is a direct result of suffocation from disturbed and redeposited bottom substrate. In some studies a change in composition of bottom-dwelling invertebrates was directly attributed to trawl activity.

Substrate indentations caused by trawl doors were common at many of the dive sites in submersible studies conducted by the NMFS Auke Bay Lab (ABL) . The depth of the indentations ranged from a few inches on hard, pebble substrate to three feet on soft sand. Trawl marks were numerous on hard substrate. No obvious differences were noticed in kinds or amounts of fauna and flora within or without the trawl paths.

Trawl marks were also common at some soft bottom sites off Yakutat (videos shown at council meeting in Sitka). These marks were probably of recent origin because silt had not filled in the furrows dug by the trawl doors, and displaced habitat was evident -- boulders and cobble were displaced, silt was brushed off the habitat, and flora were knocked down or missing. Displaced habitat and flora between the trawl door marks were obvious at these sites. Some red tree coral was observed on rocky ridges at these sites. Two broken pieces of red tree coral were observed near trawl door marks. These sites contained sparse populations of shortraker rockfish and other rockfish. A few pieces of trawl net and rope were seen on smooth bottom. Derelict longline gear was seen in coral forests and other rugged rocky areas.

Over the past 10 years there have been at least four documented reports of longline vessels retrieving portions of trawl nets off Southeast Alaska with sablefish in them. In at least two of the instances fish were in various stages of decomposition from fresh to highly decomposed suggesting that the nets had continued to capture or entangle fish over an extended period. Again, the extent of this problem is unknown, but it is included as a consideration since lost gear is one documented impact of trawling on the habitat in the Southeast Outside District.

Potential Fisheries Impacts on Marine Mammals and Seabirds

Impacts of fishing activity on marine birds occurs through direct mortality from (a) collisions with vessels, (b) entanglement with fishing gear, (c) entanglement with discarded plastics and other debris, and (d) shooting. Indirect impacts include (a) competition with the commercial fishery for prey, (b) disruption of the food web due to commercial removals, (c) disruption of feeding habits resulting from dependence on fishery waste (d) increased predation and nest site usurpation of other marine birds by large gull eruptions supported on fish processing wastes, and (e) marine pollution and changes in water quality.

Effects of commercial fisheries are generally unknown. However, in accordance with procedures outlined by NMFS and USFWS to minimize negative interactions between groundfish activities and endangered or threatened species, NMFS will continue to (1) maintain and improve observer training in identification of marine mammals and seabirds and in reporting of such encounters; (2) encourage fishermen to recognize and avoid situations likely to be hazardous to these species; and (3) foster improved compliance regarding disposal of debris by ships at sea as required by Marine Plastic Pollution Research and Control Act and with the International Convention on the Prevention of Pollution by Ships, 1973, and the subsequent protocol known as MARPOL 73/78.

Fishing activity inflicts mortality on seabirds that are caught in trawl nets or on hooks. During 1990, observers monitored 28,762 trawls hauls, 6,826 longline sets, and 1,437 pot sets. Seabirds were observed taken in BSAI midwater trawl hauls (an estimated 649 birds for BSAI midwater trawls) and in longline sets in both the BSAI (estimated 3,287 birds taken overall) and GOA (estimated 38 birds overall). No birds were observed taken in bottom trawls, pots, or midwater trawls in the GOA.

Table 3 provides a summary of takes of marine mammals in the longline, trawl, and pot fisheries since 1990.

Seabirds and marine mammals consume commercially important fish species such as walleye pollock, Atka mackerel, and herring. However, noncommercial fish and invertebrate prey (for sea birds, ice seals, walrus, and otters) such as capelin, sand lance, squid, and zooplankton generally make up a large portion of the diet in most areas. Those species for which marine seabirds and mammals directly compete with commercial fishermen usually involve different age classes of fish. Seabirds and marine mammals consume juvenile groundfish, while fisheries target adult-sized groundfish. Thus, the likelihood of direct competition for prey is reduced. In this regard, the levels of TAC may be irrelevant to mammals and seabirds, although the TAC may reflect of the magnitude processing wastes and its effect on localized gull populations. There is also concern that commercial fisheries may disrupt prey availability either through bycatch of small fish or through general disruption of the food web. Analysis of commercial bycatch has indicated that the take of age-0 through age-2 pollock is generally low compared to the biomass of these fish. The significance of the take of noncommercial fish and cephalopod species cannot be assessed, because the biomass of these species remains unknown. Disruption of the pelagic food web by boat traffic and trawling remains a concern, but there is no data to indicate this has affected prey availability.

Finally, there is the issue of fish processing waste and its potential to create a dependence on artificial food sources. Gulls, sea lions, and killer whales are attracted to the fish wastes discharged by processing vessels and plants. Gulls may be subject to population expansion in response to sustained processing and discharge activities. Such artificially expanded gull populations increase predation on other seabird species and displace other species from nesting sites. Finally, closures of commercial fisheries and curtailment of processing can stress localized populations of fish-waste dependent seabirds which then suffer mortality resulting from weakened physical condition or aberrant behaviors (USFWS to EPA, September 13, 1994, NPDES Permit AK-G52-0000).

Pollution Effects

The most likely effects of pollution upon marine resources in Alaska come from oil exploration and development. Results of studies following the Exxon Valdez oil spill in Prince William Sound provide the best assessment of potential effects of an oil spill on fishes, marine mammals, and seabirds. After the oil spill, there was evidence of exposure to oil for walleye pollock, flatfish, and rockfish (Collier et al. 1993; Marty et al. 1993). In the case of pollock, there was evidence of exposure at a site 400 miles from the origin of the spill, suggesting that spilled oil affected the water column or food supply at a great distance from the spill (Collier et al. 1993). Mortality of rockfish was directly attributed to spilled oil (Hoffman et al. 1993). Greenling, sculpins, and young of the year (YOY) Pacific cod were more abundant at oiled sites compared to control sites (Laur and Haldorson 1993). The higher abundance of YOY Pacific cod was apparently related to increased diversity and abundance of prey taxa at oiled sites.

Benthic resources are particularly vulnerable to pollution, even in offshore habitats where ocean dumping and runoff can have an effect (Goulde and Fowler 1991). Ocean dumping of sediments may bury or damage invertebrates by abrasion and gill clogging (Larsen and Lee 1978). Nutrient loading can cause low dissolved oxygen (hypoxic) conditions (Sindermann 1979), increase bacterial infections (Leibovitz et al. 1984), or cause algal (Wassman and Ramus 1973) and dinoflagellate blooms (Shumway 1990). Naturally occurring toxins, such as that from the dinoflagellate *Gonyaulax catenella*, concentrate in exposed scallops, and incidence of paralytic shellfish poisoning (PSP) from eating scallops have been documented (Hudgins, 1981).

Invertebrates can also be affected by oil spills, via decreased gill respiration, but the effects are considered to be short-lived (Gold and Fowler 1991). Spiny scallops were found to be moderately sensitive to acute exposures (96 hour) to Cook Inlet crude and No. 2 fuel oil (Rice et al. 1979). Drilling muds are also of concern, in that they release sediments and heavy metals. Metals also are released by dumping, and municipal and industrial water discharges. Some invertebrates concentrate PCBs and heavy metals, including silver, copper, and nickel (Pesch et al. 1979), mercury (Klein and Goldberg 1970), cadmium (Vattuone et al. 1976), chromium (Mearns and Young 1977). At certain levels of concentration, heavy metals can be lethal or have adverse effects at lesser concentrations. Sublethal concentrations of copper produced substantial kidney and gonad damage in sea scallops, whereas cadmium induced hormonal changes such as early gonad maturation (Gold et al. 1985).

Measures to protect benthic habitat should be taken based on the concerns mentioned above. The dumping of dredge spoils, drilling muds, and municipal and industrial wastes should be minimized in areas of known scallop concentrations. Dispersal by water currents should also be taken into account when waste disposal and drilling sites are chosen.

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 for most marine species, and the Department of Interior 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*
Snake River fall chinook salmon	*Oncorhynchus tshawytscha*
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*
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. Candidate species are species that are being considered by the Secretary for listing as an endangered or threatened species, but not yet subject to a proposed rule. Candidate species need not be included in Section 7 consultations (50 CFR §402) under the ESA. Species that are not presently listed but that are categorized by the U.S. Fish and Wildlife Service as candidate species are as follows:

Steller's eider	*Polysticta stelleri* (Category 1)
Marbled murrelet	*Brachyramphus marmoratus* (Category 2)
Red-legged kittiwake	*Rissa brevirostris* (Category 2)
Kittlitz's murrelet	*Brachyramphus brevirostris* (Category 2)

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.

Ultimately, the ESA attempts to bring populations of listed species to healthy levels. To reach this status, in addition to prohibiting activities which may threaten listed species, the ESA requires federal agencies to use their authority to conserve threatened and endangered 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 (Fig. 11). 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"[1] 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.

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

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.

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[1] The term Take 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).

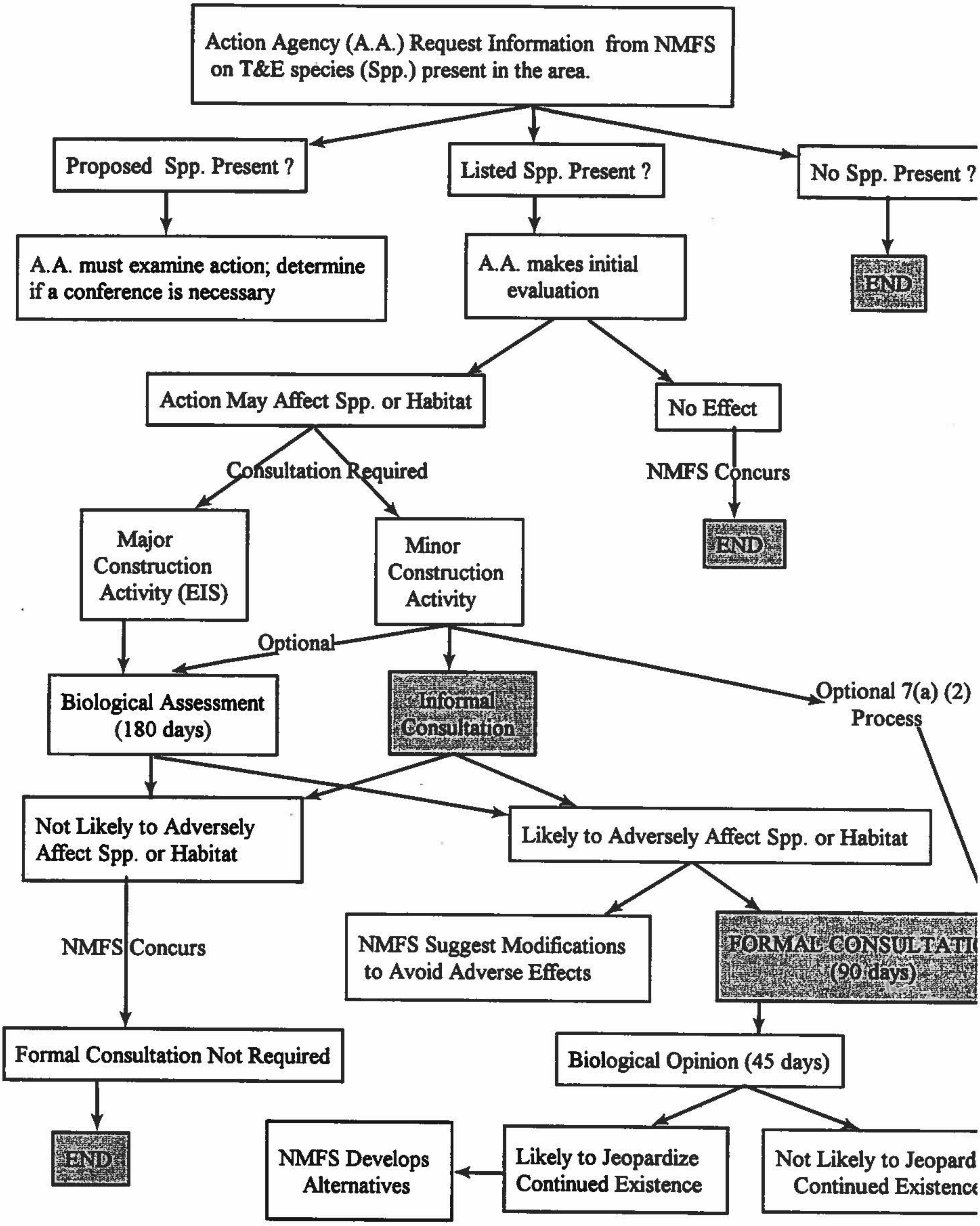


Figure 11
Section 7 Consultation Process
National Marine Fisheries Service

Based on current species status information and 1994 TAC specifications, a recent informal consultation with the USFWS concluded (February 14, 1994) that the allowable incidental take of two birds during harvest of the 1994 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 14, 1994 accommodates amendments affecting the allocation of the TAC specifications. Further consultation pursuant to Section 7 of the ESA is not necessary for the 1994 groundfish fishery in the BSAI or GOA unless any Category 1 or 2 candidate species within the range of the fishery is subsequently proposed for listing under the ESA.

Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) was amended on 30 April 1994. Several key provisions of the Act affecting commercial fisherman were changed. In particular, a new long-term regime for managing marine mammal takes in commercial fisheries replaced the Interim Exemption Program that had provided a general exemption on the MMPA take prohibition since 1988. The flow diagram in Fig. 12 illustrates the relationships between many of the key features.

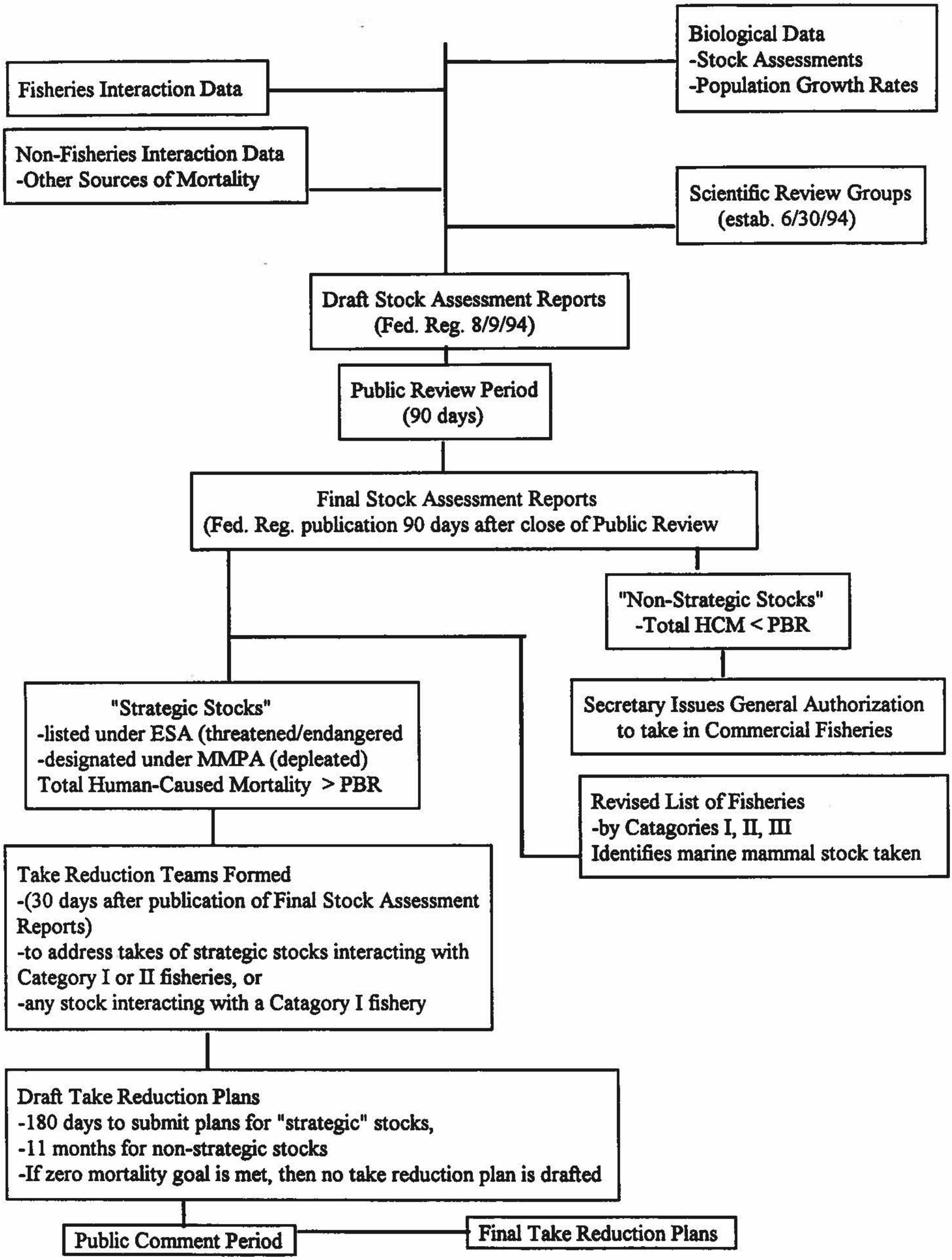
The central feature of the new regime is the development of Stock Assessment Reports for every marine mammal stock in U.S. waters. These reports will include calculation of the Potential Biological Removal (PBR), defined as the product of a minimum population estimate, a fraction of the maximum net productivity rate (0.02 for cetaceans and 0.08 for pinnipeds) and a safety factor (ranging from 0.1 to 1.0). The PBRs will form the basis for prioritizing management of marine mammal/fisheries interactions (see Table 2 for examples specific to Alaskan waters). Regional Scientific Review Groups (SRGs) have been established to provide recommendations and guidance on the contents of the assessment reports.

Stocks for which total human-caused mortality exceeds the PBR, or which are listed as threatened, endangered (under the Endangered Species Act) or depleted (under MMPA) are said to be "strategic". Management attention will focus on reducing strategic stock take levels, while takes of "non-strategic" stocks will be permitted in the course of commercial fishing operations under general authorization issued by the federal government.

The MMPA goal of reducing incidental takes in commercial fisheries to levels approaching zero is maintained. Take Reduction Teams will be formed to draft Take Reduction Plans in cases where commercial fisheries takes are high. The Plan objectives will be to reduce the take level below the PBR in 6 months, and to meet the zero mortality *goal* by approaching the zero mortality *rate* in 7 years. In cases where commercial fisheries are not the primary source of mortality, then the take level should be reduced "to the maximum extent practicable" in 6 months.

Some features of the Interim Exemption Plan remain, including the categorization of all domestic fisheries on the basis of incidental take level, vessel registration, mandatory reporting of

Marine Mammal Protection Act Amended



incidental takes, and provisions for observer programs. Vessels in Categories I and II (once designated under new criteria still begin developed) will again be required to register, but marine mammal exemption program logbooks will be replaced with postcard data forms to be sent to NMFS after completion of trips where marine mammal takes occurred. Mandatory observer coverage by category has been dropped, but observers may be placed in any fishery where up-to-date take data is needed.

The 1994 amendments also place a prohibition on the intentional taking of any marine mammal in commercial fishing operations except for the protection of life and limb. Such intentional takes have occurred commonly in some fisheries that regularly interact with harbor seals. The provision becomes effective upon publication of deference regulations later this year or in early 1995.

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