Trends in Fisheries and Fishery Resources

Associated with the Monterey Bay National Marine Sanctuary from 1981 – 2000

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TRENDS IN FISHERIES and FISHERY RESOURCES

ASSOCIATED WITH THE MONTEREY BAY NATIONAL MARINE SANCTUARY FROM 1981–2000

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EXECUTIVE SUMMARY

Fisheries in Central California are part of this region's rich cultural and economic history. In the last decade, however, catches of many fishery resources have greatly declined, due both to decreases in fish populations and to new regulations enacted to conserve or rebuild fish stocks. In this book, we summarize the technical concepts and information that fishery scientists use to estimate the population sizes of harvested species. In addition to summarizing scientific information, we also provide a brief description of the types of fisheries operating in the region encompassed by the Monterey Bay National Marine Sanctuary (MBNMS), and a summary of fishery management operations.

Currently, more than 1,200 commercial vessels annually fish within the MBNMS boundaries. This represents a decline of about 40% in the number of commercial fishing vessels working in this region since the early 1980s. Although the number of vessels has declined, total catches have increased as the commercial fishing industry targeted abundant pelagic species such as Pacific sardine and squid. Catches in recreational fisheries in this region grew by more than 60% from the 1960s to the 1980s. Recreational fishing effort increased by 65% in that same time frame. Since the late 1980s, however, both recreational catch and effort have fluctuated, but slightly declined. Nevertheless, recreational harvest exceeds commercial harvest for many nearshore species.

Commercial landings of all species combined increased from 1981–2000. This trend is misleading, however, because it is due to the large increase in catches of small pelagic fishes and squid. The combined catch of all other species decreased by about 50% from the mid-1980s to the late 1990s. The decline in landings was directly related to reduced population sizes of many of the species inhabiting deep-water bottom habitats, caused by excessively high rates of fishing in the 1980s, when fishery scientists and resource managers overestimated the productivity of stocks of bottom fish. Catches of nonpelagic fishes increased for a short time in the 1990s as a result of increased fishing in nearshore habitats; however, by the end of the 1990s, abundances of nearshore species had also declined.

In the late 1990s, laws such as the federal Sustainable Fisheries Act, and California's Marine Life Management Act (MLMA) and Marine Life Protection Act (MLPA) were passed that mandated more conservative management of marine resources. In response, federal resource managers reduced harvest rates on heavily fished species living in deep-water habitats. State resource managers also began to limit harvests of nearshore species. The full implementation of these new laws will likely result in more restrictive regulations that are intended to minimize the chance of overfishing, limit bycatch, preserve essential fish habitat, and in some cases rebuild depleted stocks.

In the short-term, these new regulations will probably result in a continued decline in the landings of many marine species harvested from MBNMS waters. Because many species with low population sizes co-occur with more abundant species, quotas for some healthy stocks will need to remain lower than necessary to protect stocks at risk. Also, because many of the fish species at risk are long-lived, grow slowly, and take a long time to reach maturity, it may take 10–20 years or more to see the results of current management regulations. The physical environment in the Monterey Bay region is very dynamic, however, and can have a strong influence on the population size of resident fish populations. There is some evidence that oceanographic conditions are changing back to a cooler, more productive environment in this region. If that proves to be true, we may see more rapid rebuilding of cold-water stocks and a decline in the abundance of warmer water species.

Historically, commercial and recreational fisheries have been regulated on a species by species basis. New ecological concepts, however, have led to an increased interest in managing fisheries using an approach that accounts for the importance of habitat in maintaining fish stocks. For that reason, we summarized the status of fishery resources in five major habitat types: 1) nearshore rocky reef and kelp, 2) nearshore soft bottom, 3) rocky deep shelf and slope, 4) soft bottom deep shelf and slope, and 5) open water habitats.

Historically, nearshore rocky reef and kelp habitats were fished more heavily by recreational than commercial fisheries. Nearshore rocky areas became more important to commercial fisheries in the early 1980s, however, because of increased participation in the open-access hook-and-line fisheries, and later as a result of the more lucrative live-fish fishery. Rockfishes are the predominant component of catches in nearshore rocky reef and kelp habitats; about 15 rockfish species are commonly caught in these shallow areas. Annual commercial landings of fishes from shallow rocky habitats averaged about 730,000 lb/yr from 1991–98, almost twice that of the annual landings in the1980s. The high catches in nearshore reef and kelp habitats in the 1990s were probably not sustainable, and appeared to have reduced abundance of nearshore fishes in the MBNMS, as evidenced by declining catch rates. In the late 1990s, commercial landings declined in rocky nearshore habitats, due to a decrease in fish abundance and more restrictive fishery regulations. Commercial landings of some invertebrates also declined because of high harvest rates. Red abalone stocks were harvested to the point that the fishery was closed in 1997.

Nearshore soft bottom habitats are home to many fishes and invertebrates, however the long-time exclusion of trawlers in the nearshore zone, and more recent ban of gill nets, have led to a limited and highly regulated fishing effort in this environment. Landings from nearshore soft bottom habitats averaged 14.3 million lb/yr from 1981–2000. Market squid are the main component of catches in these habitats, comprising more than 97% of the total landings. Fluctuations in squid landings and populations can be attributed primarily to market conditions and oceanographic changes such as El Niño events. Small sharks, white seabass, white croaker, surfperch, halibut, and several flatfish are the primary fish species caught in commercial and recreational fisheries in nearshore soft bottom habitats. Population sizes of most of these fish species are unknown, but there are indications that many of these populations are healthy in the MBNMS.

Rockfishes are the principal component of commercial and recreational fisheries in rocky deep shelf and slope habitats in the MBNMS. Commercial landings from these habitats averaged 8.6 million lb/yr from 1981–2000. Semi-pelagic rockfish species such as bocaccio, chilipepper, widow rockfish, and yellowtail rockfish, comprised 98% of the total commercial catch from rocky deep shelf and slope habitats in the MBNMS. In the recreational fishery, almost 50% of the catch from 1959 to 1994 was taken from these habitats, and eight of the ten most numerous species taken in the Commercial Passenger Fishing Vessel (CPFV) fishery utilize deep rocky habitats. Consequently, fish populations in rocky deep shelf and slope habitats were the most heavily impacted by the high rates of fishing that occurred in the 1980s and early 1990s.

Scientific stock assessments exhibit a range of population trends for rockfishes within rocky deep shelf and slope habitats along the West Coast of the United States. Stock assessments indicate stable or increasing trends in abundance for chilipepper and shortbelly rockfish. Similarly, yellowtail rockfish populations seem to be healthy and productive. The biomass of

Photo credits: Greenspotted rockfish (cover); fishing boats and fishers; coastal scenes; yellowtail and yelloweye rockfishes (p. 41); rosy rockfishes (p. 53); baby squid (p. 68); and canary rockfishes (p. 74) by Richard M. Starr. Yellowtail rockfishes (p. 31) courtesy of Cordell Bank Expeditions, NOAA archives; Monterey Fishing Company (p. 116) by Georgia Ratcliffe.

bank rockfish has declined, but it is not known if a problem exists with this heavily fished species. Bocaccio, canary, cowcod, and widow rockfish have been declared to be overfished and are now managed under stock rebuilding plans. Stocks of lingcod, another important groundfish species, have also been overfished and are managed with a stock-rebuilding plan.

Low stock sizes of rockfish species have been attributed to poor recruitment and excessively high rates of fishing, caused by overly optimistic estimates of allowable catch in the 1980s and the introduction of new fishing gear and techniques that enabled trawl vessels to fish in rocky areas. Most of these deep-water rockfishes are slow growing, long-lived, and have experienced high exploitation rates. Managers are concerned about the capability of some of these species to recover from high harvest rates, especially because some are prone to long periods of poor recruitment. Recent evidence of successful recruitment of several heavily fished species, however, provides an indication that some species may recover more quickly.

Concern about the health of rockfish populations led to more restrictive regulations in both commercial and recreational fisheries. The regulations resulted in a consistent decline in rockfish catches starting in 1991, with landings greatly dropping in the mid-1990s. Though rockfish quotas are generally decreasing, bycatch issues are still a major concern. Rockfishes are captured at high levels in some fisheries, and mortality of deep-dwelling rockfishes is essentially 100% when fish are brought to the surface. Historically, the Pacific Fishery Management Council (PFMC) has used a dynamic model to estimate bycatch. The Council plans to use fishery observers in the near future, however, to provide a better estimate of bycatch. It is expected that gear restrictions and new gear and techniques will then be used to reduce bycatch.

More than 30 species are routinely harvested from soft bottom deep shelf and slope habitats, and annual commercial landings from these habitats averaged 12 million lb/yr from 1981–2000. Species groups caught in these habitats include shrimp, prawns, rockfishes, thornyheads, sablefish, and flatfishes. Commercial catches in soft bottom deep shelf and slope habitats in the MBNMS remained high between 1985 and 1996, with an average estimated take of 13.5 million lb/yr, but dropped to only 5.7 million lb in the year 2000, due primarily to regulation changes. Coastwide, many species in these habitats, such as thornyheads, sablefish, Dover sole, and other flatfishes, are considered to be fully exploited, but not overfished. Some of the rockfishes inhabiting soft bottom habitats show signs of depletion in Northern California, Oregon, and Washington waters, but the population status of most of the rockfishes in soft bottom deep shelf and slope habitats in the MBNMS is not well known.

Commercial landings from open water habitats averaged 20.6 million lb/yr from 1981–2000. Population abundances of most species in these habitats are greatly determined by large-scale environmental phenomena that affect the success of spawning and recruitment. Landings of species from open water habitats have increased since the 1980s, especially for the group of fishes termed small coastal pelagics. The population of one of these species, the Pacific sardine, has been extensively managed for 30 years, and has dramatically increased in the last 20 years. In 1999, Pacific sardine biomass in United States waters was estimated to be about 3.8 billion lb, and total Pacific sardine landings for the directed fisheries off California and Baja California reached more than 253 million lb. These landings are the highest level in recent history, but still much smaller than annual Pacific sardine landings from 1930–50.

Another pelagic species, the Chinook salmon, is one the most important species in both commercial and recreational fisheries in the MBNMS. It has been intensively managed for more than 30 years. Resource management issues related to salmon abundance revolve primarily around the need to increase river flows and improve habitat conditions in watersheds. In the last 20 years, commercial and recreational catches of salmon have fluctuated in response to population trends, and regulatory seasons and quotas. Of concern to fishers and resource managers is a growing sea lion/angler interaction problem. In some years, sea lions can take a relatively large number of salmon from recreational and commercial fishing gear.

Catches of fishes known as pelagic migrants (tunas, swordfish, and large sharks) have declined since the 1980s. These species spend much of their life cycle in the open ocean and are known to make extensive migrations across the open ocean, occasionally entering the coastal zone. The recent decline in landings in the MBNMS is related to new regulations intended to reduce catches on depleted species, and changes in market distribution of these species, causing fishing for pelagic migrants to occur far from Central California ports.

In summary, the number of people and vessels fishing in MBNMS waters has decreased in the last twenty years. Catches of pelagic species have increased, but landings of all other species combined have greatly decreased. More restrictive regulations have led to shorter seasons and lower quotas for many species, thus reducing the flexibility and economic viability of many fishing businesses. New laws require more conservative approaches to fishery management, thus landings in the MBNMS will probably remain at or below current levels in the near future. The population status of a great many species harvested in the MBNMS is unknown. Available data, however, indicate that populations in shallow rocky habitats declined in the 1990s. In shallow soft bottom habitats in the MBNMS, the types of legal fishing gear are greatly limited, and populations of many species appear to be strong. Deep rocky habitats in the MBNMS harbor a large number of rockfishes and other species that have been heavily fished for decades. Population sizes of most of these species greatly declined in the 1980s, resulting in severe catch limitations in the 1990s. Because many of the fishes inhabiting deep rocky habitats are long-lived, slow growing, and have sporadic recruitment, it may take 10–20 years or more before we learn if current harvest levels are appropriate. In the meantime, the people involved in fishery management are trying to determine how to maintain economically and socially viable fisheries while conserving or rebuilding stocks. Deep soft bottom habitats have been intensively fished for decades, reducing population levels of many species; however, the species in these habitats that have been assessed seem to be at sustainable levels. Recently, there has been evidence of successful recruitment for several heavily fished species in deep-water habitats, providing hope for improved stock abundances. Open water habitats contain many short-lived, pelagic species that are greatly influenced by environmental conditions. Abundances of several of these species in the MBNMS are rapidly increasing.

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Fish populations, fisheries, and fishery management are typically characterized by constant change. The dynamic ocean and political environments often make trends difficult to identify and interpret. Many people helped to provide the information we presented. We would first like to thank the fishers and scientists who regularly spend many hours at sea and on the docks collecting these data. The Monterey Bay National Marine Sanctuary, the University of California Sea Grant College Program, Moss Landing Marine Laboratories, and the California Department of Fish and Game all provided support for this project.

The data presented in this report came from many sources. Will Daspit, Jason Sawicki, and Wade Van Buskirk of the Pacific States Marine Fisheries Commission (PSMFC) provided most of the fishery data from the PacFIN and RecFIN databases. Mike Dalton of California State University Monterey Bay and Cindy Thomson of the National Marine Fisheries Service gave us economic information about Central California fisheries. Karin Forney of the National Marine Fisheries Service and Scott Benson of Moss Landing Marine Labs gave us information about sea birds and marine mammals. Jana Robertson of the California Department of Fish and Game provided information about the live-fish fishery, and Lisa Wertz gave us information about nearshore fishery regulations.

Many people reviewed the early drafts of this report. Paul Reilly and Deb Wilson-Vandenberg of the California Department of Fish and Game, Bill Leet of the UC Sea Grant Extension Program, and Richard Parrish and Steve Ralston of the National Marine Fisheries Service all provided helpful information about fishery data. Fishers from the major ports also helped us with fishery information. Dempsey Bosworth, Vicki Crow, Kathy Fosmark, Bill James, Duncan Maclean, Tom McCray, and Mike Ricketts were especially helpful. Kaitlin Gaffney of the Ocean Conservancy also provided an extremely helpful review. Erica Burton of the Monterey Bay National Marine Sanctuary gave us exceptionally thorough comments, as did Andrew DeVogelaere, Bill Douros, Holly Price, and other Sanctuary staff. Gregor Cailliet of Moss Landing Marine Laboratories reviewed the document and helped provide information about the life history of fishes.

The final document is much improved thanks to the editing of Beverly Haney. The layout design and production was by Joann Furse, and the photographs coordinated by Georgia Ratcliffe, both of the California Sea Grant College Program. Nancy Wright of the California Department of Fish and Game provided support for Jamie Kum to prepare the GIS maps. Graphics of fishing vessels and gear were provided by Ginny Goblirsch of the Oregon State University Sea Grant Extension Program and Lynn McMasters of Moss Landing Marine Laboratories.

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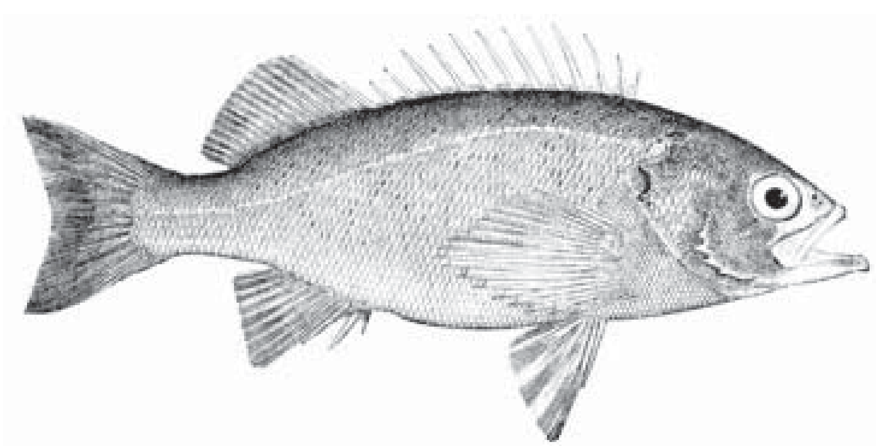


INTRODUCTION

As world population grows, technology advances, and fishing power increases, more and more pressure is placed on populations of harvested species. In many parts of the world, increased fishing has led to dramatic declines of fish stocks, changes in ecological relationships, and subsequent collapses of fisheries. These fishery collapses have caused widespread social and economic problems in coastal communities. In the United States, fishers, resource managers, members of conservation organizations, and other interested parties have been trying to develop strategies to maintain valuable fisheries while ensuring that marine species are not overfished.

A challenge of maintaining sustainable resources is to evaluate the status of harvested species and subsequently set appropriate fishing rates. Unfortunately, determining the status of a particular fish population is difficult, and the information needed to assess a localized fishery is often not readily available. Often, fishery managers have little or no direct research-based information with which to assess the numbers of fish in a specific region and, therefore, rely upon information derived from the fishery to estimate population sizes.

Data collected from commercial and recreational fisheries enable scientists to develop indices of population sizes or trends in fish abundance. Fishery data used for an index may include the amount of fish caught and sold at the dock (termed landed catch or landings), the rate of catch of a species (expressed as catch per unit effort [CPUE]; e.g., number of fish caught per hour), the average weight of fish landed, the average length of fish caught, or other biological information such as the sex ratio or mean length of mature fish. In addition to single indices, fishery managers develop and use population models to infer the status of fish stocks.

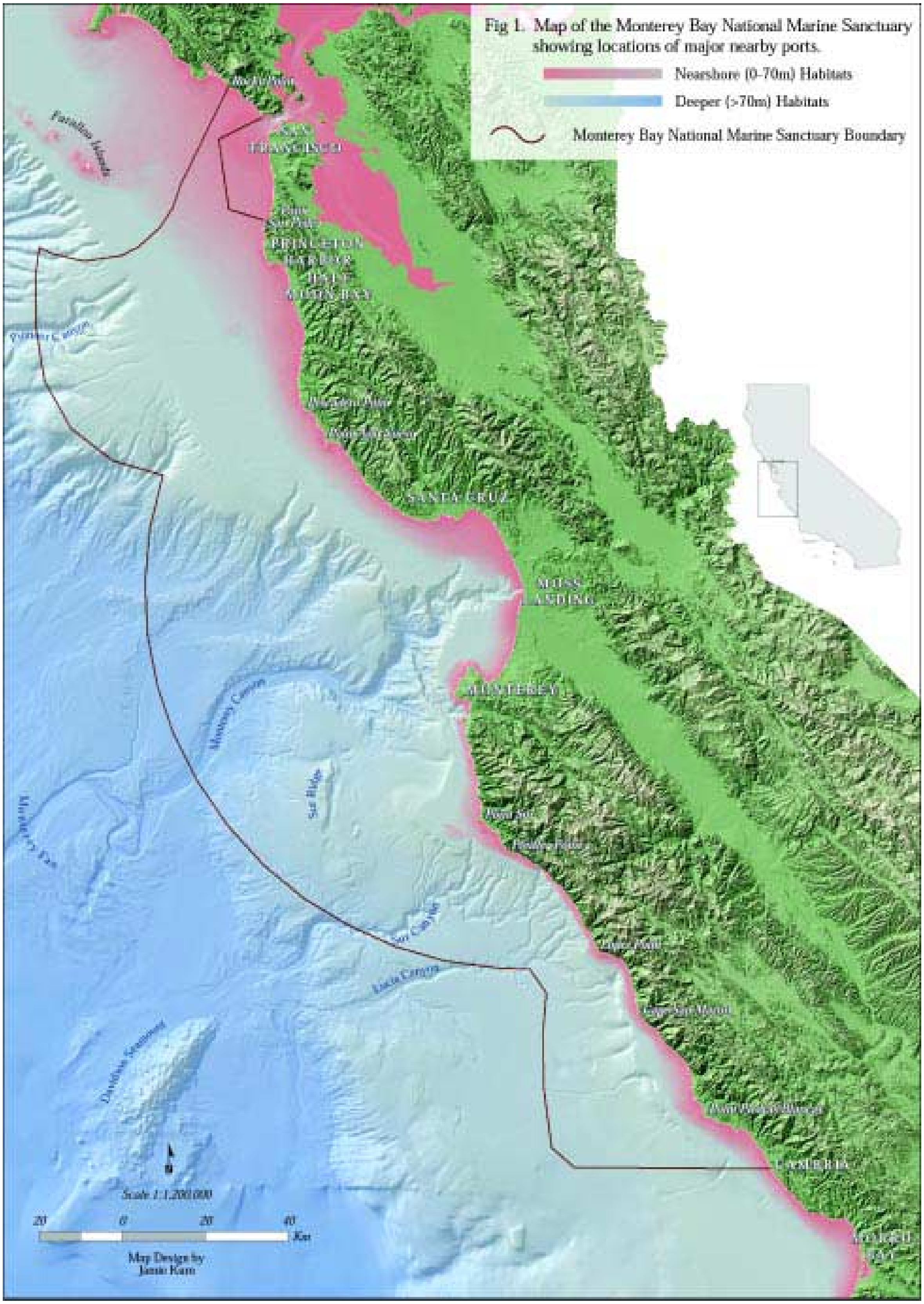


Fig 1. Map of the Monterey Bay National Marine Sanctuary showing locations of major nearby ports.

Biological information, such as length at age by sex, is used with fishery catch data in mathematical models to estimate the number of fish caught by age category. The models are then used to develop scenarios for appropriate harvest rates for future years.

A large number of scientific documents, articles, and books have been written about the many variables that influence indices of stock abundance and population models. It is not our intention to fully describe or discuss the methods employed by fishery scientists to estimate the sizes of fish populations. Instead, we attempt to provide a summary of the population status of the primary fishery resources that are harvested in the MBNMS (Fig. 1). This book is an update of a 1998 publication, *Fishery Resources of the Monterey Bay National Marine Sanctuary*. Some of the text in this book is derived from our 1998 publication, but the last five years have seen many changes in California fisheries; ones that will have long lasting effects.

Commercial and recreational fisheries have historically been regulated on a species by species basis. New ecological concepts, however, have led to an increased interest in managing fisheries using a more ecologically meaningful approach: especially ones that account for the importance of habitat in maintaining fish stocks. For that reason, we chose to arrange the discussion of fisheries using habitat as an organizational construct. We selected five major habitat types within the MBNMS: 1) nearshore rocky reef and kelp, 2) nearshore soft bottom, 3) rocky deep shelf and slope, 4) soft bottom deep shelf and slope, and 5) open water habitats (Figs. 2–4).

We chose to gather and display only information from the ports near the MBNMS (Fig. 1) for this overview of fisheries in the Monterey Bay region. Most of the commercial fishery information presented in this report originated from California Department of Fish and Game (CDFG) official landing records, which were graciously provided to us by the Pacific States Marine Fisheries Commission (PSMFC) and the National Marine Fisheries Service (NMFS). We also obtained recreational catch information from the PSMFC and from specific CDFG fishery biologists. Other biological and fishery catch information was obtained from published books, journal articles, and unpublished reports.

The mobile nature of fish, fishers, and fishing vessels makes an understanding of the distribution and harvest of fishery resources elsewhere essential to understanding the fisheries and resources in this region. One of the most useful references for this purpose is *California's Living Marine Resources: A Status Report*, edited by Bill Leet et al. and published in 2001. The authors and editors of this newly released publication present a thorough description of marine resources in California. They describe fishery history, important biological characteristics of fishery resources, and the statewide status of many fish populations.

For this publication we focused on providing information for the years 1981–2000. This time period contains the most comprehensive and accurate fishery information, and coincides with the time that some major fisheries around the world collapsed. Although detailed information is available for the last 20 years, population trends determined from that data set alone may be misleading. A level trend in the population estimates for a species during the period from 1981–2000, for example, may mean that the population was robust and stable, or it may mean the fish stock was severely depressed before 1981. A severely depleted stock will remain at low levels if biological factors or fishing pressure prevent recovery. Also, a 20-year time period may not be long enough to adequately assess the population status of a species that is greatly affected by environmental variation. Nevertheless, the period from 1981–2000 contains the most complete data set available, and provides an indication of trends or the current status of fishery resources in this region.

As resource abundance, markets for seafood, and technology have changed, so have the participants and target species of fisheries. Although many changes have occurred, fisheries

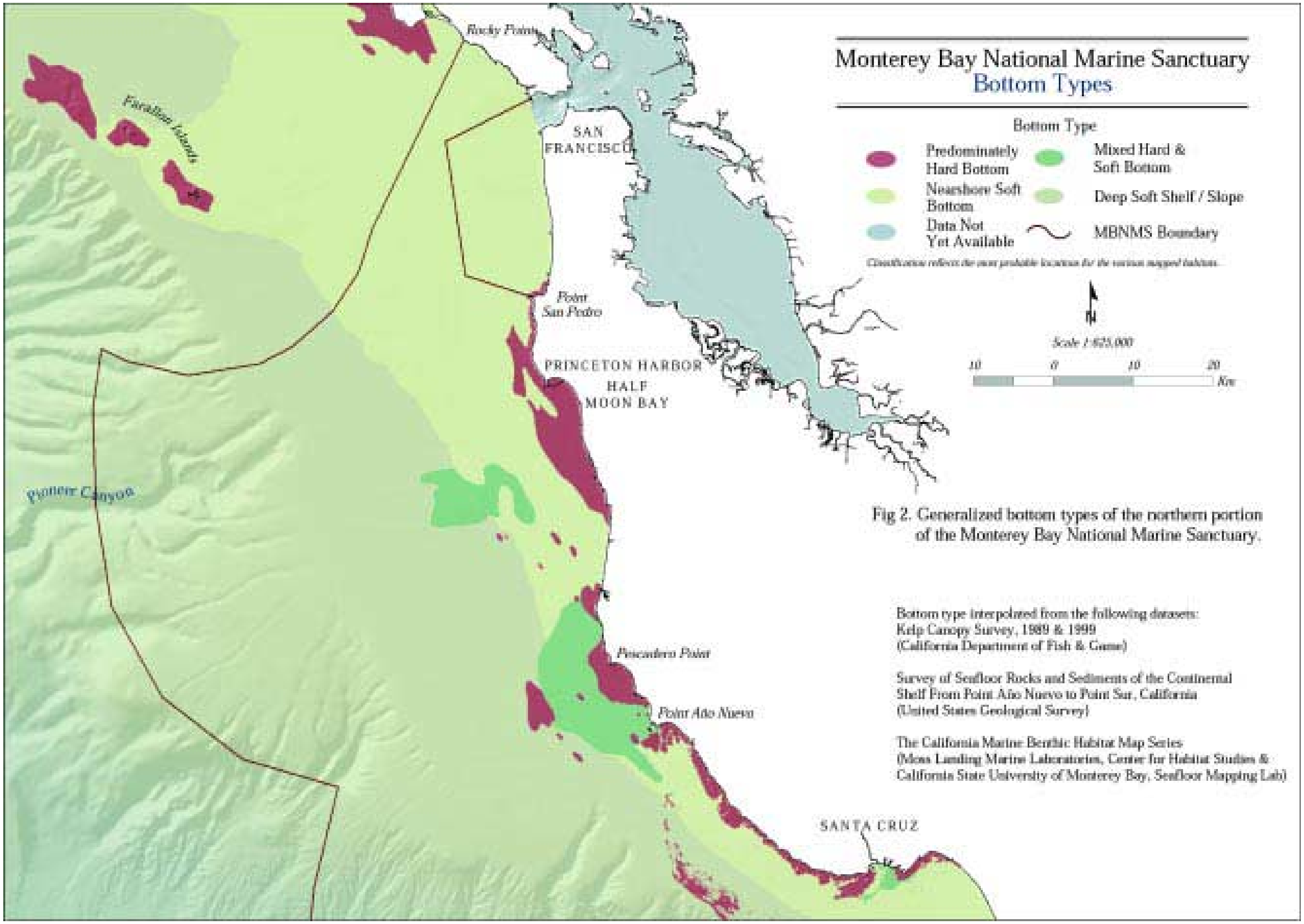


Fig 2. Generalized bottom types of the northern portion of the Monterey Bay National Marine Sanctuary.

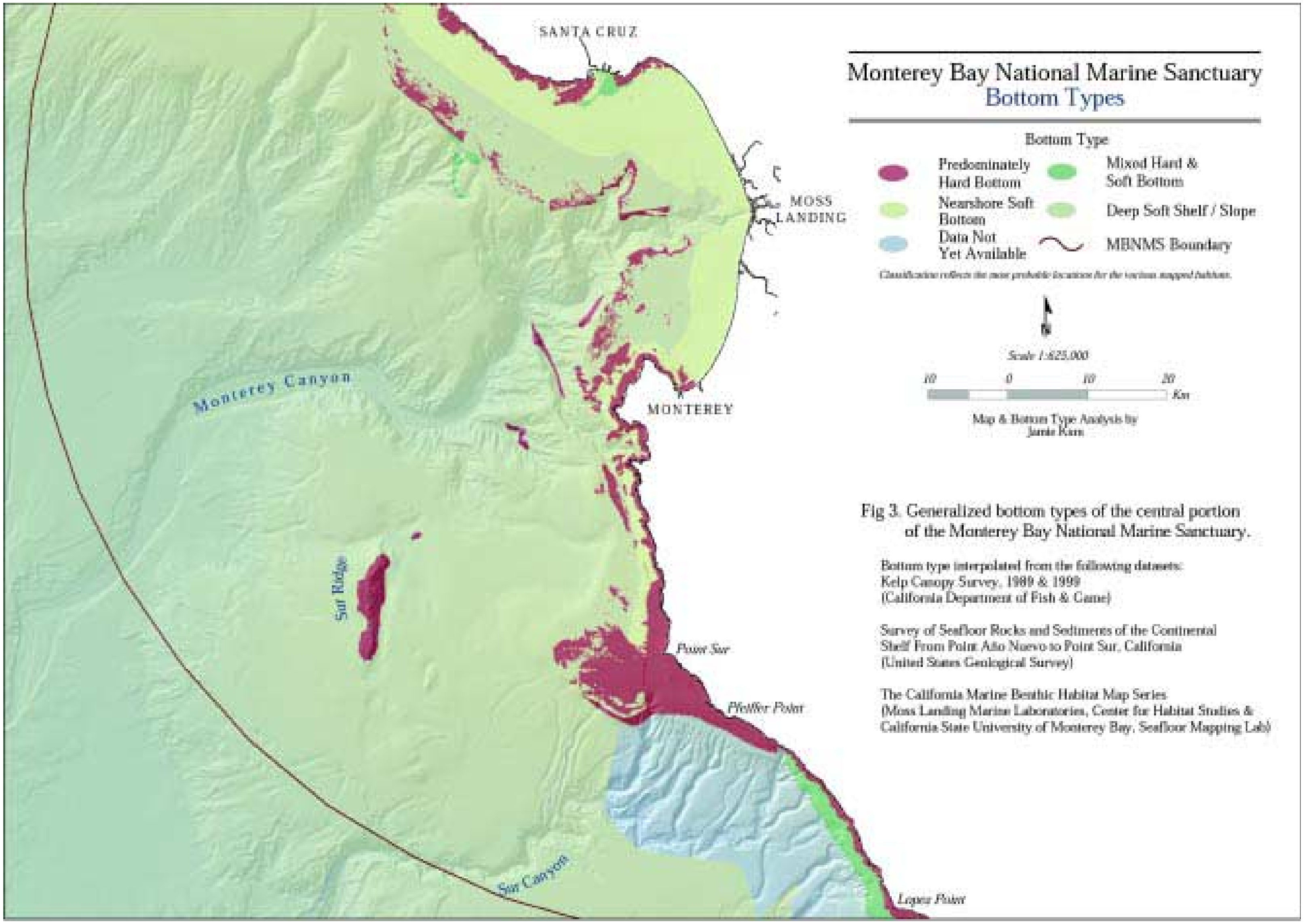


Fig 3. Generalized bottom types of the central portion of the Monterey Bay National Marine Sanctuary.

Bottom type interpolated from the following datasets:
Kelp Canopy Survey, 1989 & 1999
(California Department of Fish & Game)

Survey of Seafloor Rocks and Sediments of the Continental Shelf From Point Año Nuevo to Point Sur, California
(United States Geological Survey)

The California Marine Benthic Habitat Map Series
(Moss Landing Marine Laboratories, Center for Habitat Studies & California State University of Monterey Bay, Seafloor Mapping Lab)

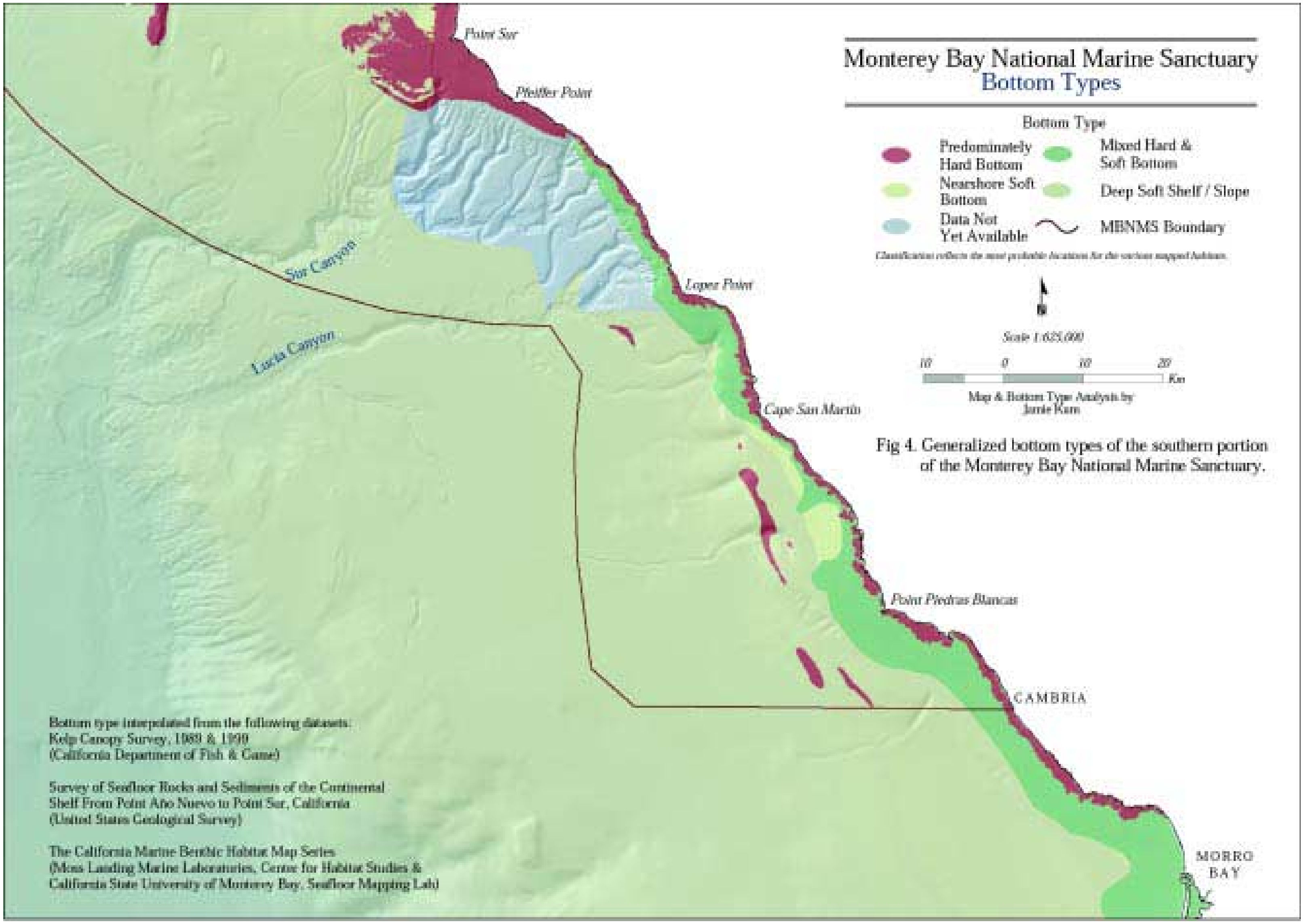


Fig 4. Generalized bottom types of the southern portion of the Monterey Bay National Marine Sanctuary.

remain a strong focus in our community today. In addition to providing a summary of the status of fished populations, we briefly describe the types of commercial and recreational fisheries, and their economic values. We do not discuss the research and educational harvest of animals, aquaculture ventures, or many nonconsumptive uses of marine resources. Research and educational harvests are minimal; and although aquaculture and nonconsumptive uses are important, our objective was to focus on the commercial and recreational harvest of wild fishery resources.

Historical Perspective

The fishing industry has played a large role in the cultural and economic development of much of the central coast of California. In Monterey Bay, humans have been harvesting marine resources for over 7,500 years. The Costanoan Indians fished year-round in Monterey Bay, both from shore and from small rafts, using seines, dipnets, weirs, harpoons, and basketry traps. From midden deposits, we know that they harvested numerous types of shellfish, nearshore fishes, and marine birds and mammals.

Beginning in the early 1800s, nonindigenous peoples visited this area to hunt for marine mammals. Russian vessels, often carrying Alaskan Aleut hunters, harvested sea otters for their fur. Intense hunting continued throughout the 1800s until the early 1900s when the otter population was nearly extirpated. The federal government gave sea otters protected status in 1911. The harvesting of whales also began in the early 1800s. Shore whaling in California was started at Monterey Bay in 1854 by Portuguese immigrants. Hunters targeted gray and humpback whales. Throughout this period, whaling stations were located along the entire coast of California, and several were within what is now designated as the Monterey Bay National Marine Sanctuary. By the 1920s, whale populations had declined and most shoreside processing facilities in this region had closed.

During the 1850s, local fisheries were established on the Monterey Peninsula. Chinese immigrants settled in Monterey and Pacific Grove and began harvesting large quantities of marine animals for drying and shipment back to China. Invertebrates, including abalone, urchins, and mussels were harvested from intertidal and nearshore habitats. Small skiffs were used to fish for sharks and marine fishes. The Chinese settlers were also responsible for the initiation of the squid fishery. They used torches and hand-held purse seines deployed from skiffs to attract and capture squid. These early small-scale fisheries represent the beginning of a rich, post-Native American tradition of commercial fishing in the Monterey Bay area.

Historically, the majority of fish caught in what is now the MBNMS were landed in Monterey. In the early 1870s, the lighthouse at Point Piños was built, and the Monterey and Salinas Valley Railroad were completed. Subsequently, warehouses and wharfs were built and Monterey became a major commercial fishing port. The port of Moss Landing was created in 1865 when Captain Moss built a wharf to house several sailing schooners. Development of the port, however, was slowed due to the unprotected coastline and limited land transportation. Early in this century, the Santa Cruz harbor was known as a favorite summer beach resort, as well as an important commercial fishing port. Morro Bay's port didn't develop until the early 1900s, when wharfs were built and catches could be trucked to the canneries of Monterey. Princeton, formerly known as Old Landing, and now commonly called Half Moon Bay or Pillar Point Harbor, was developed not with commercial fishing in mind, but as a port for farmers to ship produce to San Francisco.

During the early 1900s, fishing gained economic importance in the Monterey Bay region. Italian fishers came to Monterey Bay bringing their double-boat bottom seines, and later, large lampara nets. These new fishing techniques allowed for huge increases in squid landings and enabled new fisheries for northern anchovy and Pacific sardine. By 1918, the canneries that occupied the shoreline of Monterey, now referred to as Cannery Row, were producing 1.4 million cases of canned sardine per year. During the late 1930s, over 100 vessels, 19 canneries, and 20 reduction plants participating in the fishery provided hundreds of nautical and shoreside jobs. This economic boom continued until the 1940s and 1950s, when sardine and Pacific mackerel abundances began to decline. The decline is now attributed to a combination of environmental factors and excessive fishing pressure. By 1955, sardine and mackerel populations had crashed, the fishery in Monterey Bay had totally collapsed, and many of the canneries were closed.

During the 1950s and 1960s, fisheries for squid, salmon, albacore, anchovy, and Dungeness crab gained in importance. Fishers who could no longer survive on sardine catches used their lampara nets and purse seines to harvest squid and anchovy. Monterey landings dominated the California squid fishery up until the early 1960s when Southern California vessels entered the fishery. Salmon troll fishing originated in the 1880s and grew rapidly through the 1960s and 1970s. In 1980, a moratorium was placed on the issuance of permits to new participants in the fishery.

Recreational fishing also increased in the 1960s and 1970s. Commercial Passenger Fishing Vessels (CPFVs) have taken people on chartered fishing trips since the turn of the century, but the charter fleet grew steadily during the 1960s and 1970s. About 33 charter vessels operate in the MBNMS today. Private boats also became increasingly popular during this period as small boats and motors became more affordable to the general public. Between the time periods 1958–61 and 1980–86, recreational fishing effort increased by 60%, due primarily to increases in the CPFV and private boat use.

Trawl fishing began in California in 1876 with the introduction of the paranzella, a net towed by two vessels. Throughout the early 1900s, most of the trawl fishing within the state occurred in Central California. In 1946, the paranzella began to be replaced by the single vessel otter trawl, making trawling much more efficient and profitable. Increased demand for fish products during World War II initiated the widespread harvest of Dover and petrale sole, causing an expansion of the trawl fishery.

In the 1970s, trawl fisheries became a major component of local fisheries with the enactment of the Fisheries Conservation and Management Act of 1976 (FCMA or Magnuson Act). This legislation established a national fishery conservation zone (Exclusive Economic Zone or EEZ) extending from 3 to 200 nautical miles off the coast of the United States. The primary goals of the FCMA were to define domestic waters, limit foreign catch within domestic waters, prevent overfishing by increased regulation of both United States and foreign fleets, and encourage the expansion of American fisheries. As a result, a system of regional committees was developed to manage domestic fisheries and foreign fishing was limited to species not otherwise utilized by American vessels.

After passage of the FCMA, the United States government began providing financial and technical assistance for the domestic fishing fleet, so that United States vessels could take advantage of all fish stocks in the United States EEZ. Easily acquired loans and tax deferments were made available to fishers who wished to expand or upgrade their fishing operations. These programs resulted in fishing fleets with larger and more efficient vessels that were capable of landing more fishes in a shorter amount of time. Coincidental to the passage of the FCMA, better technology enabled vessels to fish farther from port, remain at sea for longer periods, and locate and capture fishes more efficiently. Similar processes were seen in other countries as the world fishing fleet more than doubled in number between 1970 and 1990.

With this sudden expansion of fleet size and catching capability, United States fisheries shifted to deeper waters, thus increasing effort on groundfish species groups such as rockfishes and flatfishes. During this growth period, rockfish landings from the Pacific coast of the United States increased from 42–70% of total landings. Flatfish landings also increased, and sablefish landings doubled. Similar trends were seen in the Monterey Bay area during this time. Traditional species such as squid and salmon remained important, but increasingly larger vessels began targeting other species as well. The period after the enactment of the FCMA represents the start of the modern fishery and increased fishery regulations. Now, United States vessels have a high degree of fishing capability, most stocks are fully utilized, and fishery management is complex and intense.

STATUS OF FISHERIES

Commercial Fisheries

Ports and Vessels

Today, most fish caught within the MBNMS are landed at one of five main ports: Princeton/Half Moon Bay, Santa Cruz, Moss Landing, Monterey Bay, or Morro Bay. More than 1,200 commercial vessels fish within the MBNMS annually, but not all vessels fish year-round. Many vessels switch gear types and target various species during different seasons or years, depending on abundance and demand for a given species. A large number of vessels also fish in other parts of the state or nation, and enter MBNMS waters to land and sell fish to local ports. In 1999, of the more than 1,200 vessels that landed fishery resources in Central California, approximately 89% landed their catch only in Central California, and the remaining 11% made landings in Central California and Northern or Southern California ports. The number of nonresident vessels fishing in MBNMS waters depends on species abundance, market price, and fish abundances in other locations. From 1981–2000, all five ports near the MBNMS experienced a downward trend in the average number of individual vessels fishing at each port (Fig. 5). This represents an overall decline of 40% in the last twenty years for all ports near the MBNMS. Such decreases in average number of fishing vessels may reflect increased restrictions on catches, limited entry programs, and various market changes. This trend is similar to the overall trend for the entire state of California.

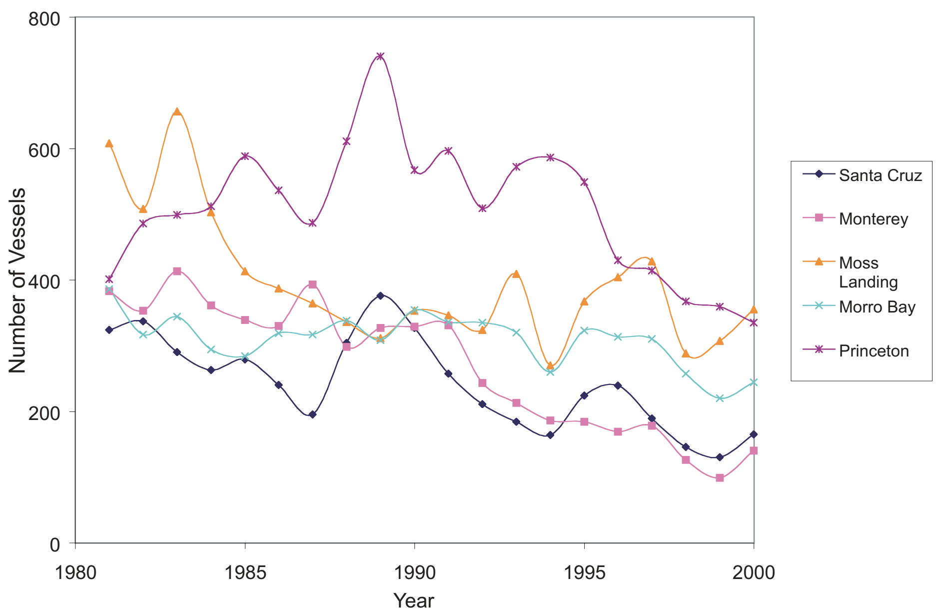


Figure 5. Number of individual vessels landing marine species at ports associated with the MBNMS from 1981–2000.

Table 1. Average total landings (million lb), average economic value (million USD, adjusted for inflation to year 2000 values), and principal species landed at ports associated with the MBNMS from 1981–2000.

Fishing Port	Average Total Landings (million lb) 1981–2000	Average Economic Value (million $)	Principal Species Landed
Princeton-Half Moon Bay	5.1	4.1	Rockfishes Chinook Salmon Market Squid Dungeness Crab Dover Sole
Santa Cruz	1.1	1.3	Chinook Salmon Market Squid Rockfishes Northern Anchovy Dungeness Crab
Moss Landing	18.7	4.7	Pacific Sardine Market Squid Rockfishes Albacore Dover Sole
Monterey	19.5	3.6	Market Squid Pacific Sardine Northern Anchovy Rockfishes Pacific Mackerel
Morro Bay	7.5	4.6	Dover Sole Rockfishes Thornyheads Albacore Sablefish

Fishers have changed gear types periodically to match fish abundance and availability, and regulation changes. For example, the number of vessels fishing troll gear in the MBNMS sharply declined from 1985 to 1993 as salmon abundance declined. During that time, there was a corresponding increase in the number of vessels fishing for other species with hook-and-line gear (Fig. 6). The increase in hook-and-line gear is a result of fishers switching from troll gear, limited entry in the trawl fishery (which resulted in an increase in the open access hook-and-line fishery), and also corresponds with the start of the live-fish fishery. Since 1993, however, the number of vessels fishing with hook-and-line gear declined, with a matching increase in troll gear, as salmon abundance increased and rockfish abundance decreased (Fig. 6).

There has been an overall decrease in vessels fishing with net gear in the MBNMS since 1985. This decrease in fishing of net gear is primarily related to increased restrictions on the use of gill and trammel nets in nearshore areas since 1980, culminating in a complete ban of gill and trammel net fishing in waters less than 30 fathoms deep in a large portion of the MBNMS after 1990. The number of vessels fishing with pot, trap, or longline gear has increased since the early 1980s, probably related to the emergence of the live-fish fishery, the displacement of net gear from the nearshore environment, and the increased abundance of crab and prawn populations. An increasing trend in the number of vessels using longline gear was evident in the 1980s and early 1990s, followed by a marked decrease since 1996. The recent decrease in use of longline gear may be the result of 1996 regulations imposed on the number of hooks allowed per vessel and general decreases in quotas. The composition of seine and trawl gear types remained relatively steady from 1981–2000 (Fig. 6).

The ports of Santa Cruz and Princeton/Half Moon Bay experienced relatively stable total landings from 1981–2000, whereas Morro Bay landings have generally declined over the past 15 years (Fig. 7). The ports of Monterey Bay and Moss Landing, however, had highly variable total landings over the past twenty years, caused primarily by fluctuations in squid, northern anchovy, and Pacific sardine landings. More than 70% of the commercial fish landings at these five harbors are comprised of market squid, Pacific sardines, rockfishes, Dover sole, northern anchovy, Chinook salmon, mackerel, albacore, and sablefish (Table 1). Landings at Monterey and Moss Landing are significantly higher than other ports associated with the MBNMS, primarily because of the large volume fisheries of market squid, northern anchovy, and in recent years, Pacific sardine, which predominate at these ports (Table 1). The port of Monterey has the highest landings within the MBNMS of market squid, northern anchovy, Pacific mackerel, jack mackerel, and is second in volume of Pacific sardine landings. Some vessels from local ports fish outside the MBNMS and then return home with their catches. This is especially common for Princeton/Half Moon Bay fishers who travel to fishing grounds north of the MBNMS boundary. High value species landed at ports near the MBNMS but which are caught outside sanctuary boundaries include salmon, sea urchin, albacore, and swordfish.

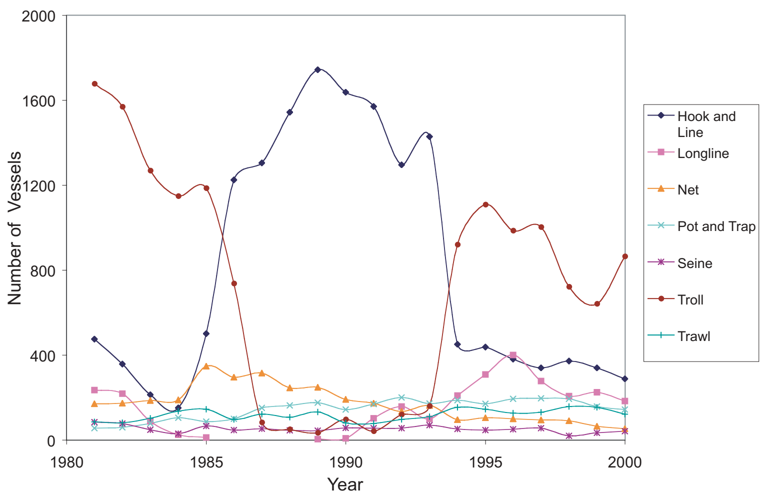


Figure 6. Number of vessels landing marine species at five major ports associated with the MBNMS by different gear types used in the commercial fishery from 1981-2000. Note that one vessel may use several gear types.

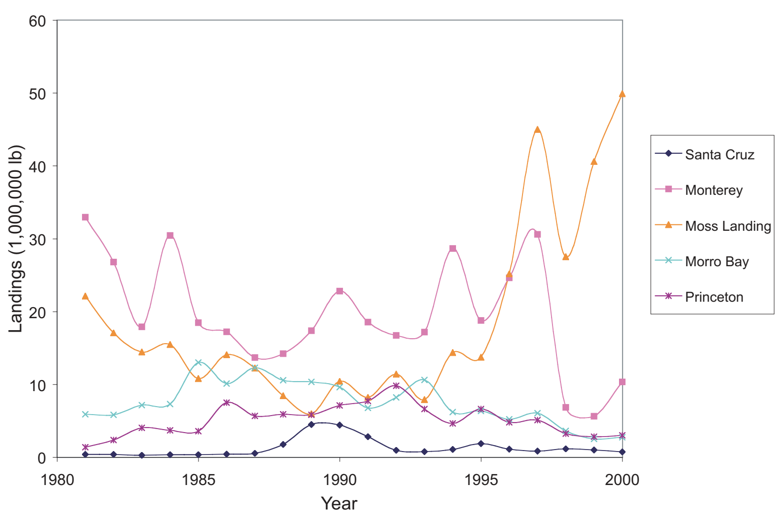


Figure 7. Total landings at each of the five major ports associated with the MBNMS from 1981–2000.

The low economic value of landings at Monterey reflects high catches of low value fish species (Table 1). Moss Landing has the highest landings of Pacific sardine, rockfishes and albacore within the MBNMS and is second highest in landings of market squid, Dover sole and northern anchovy. At Morro Bay, fishery landings are approximately half that of Moss Landing; however, the economic value of the ports are nearly equal. This high economic value can be attributed to the high volume of relatively high value species landed there, such as rockfishes, thornyheads, albacore, and swordfish. Similarly, the port of Princeton does not receive as high a volume of fish as Moss Landing and Monterey, but has higher landings of more valuable species such as rockfish, Chinook salmon, and Dungeness crab. Princeton has the highest landings of Chinook salmon and Dungeness crab of the ports associated with the MBNMS. Landings at Santa Cruz harbor constitute the smallest percentage of total landings in the MBNMS; however, the dominance of Chinook salmon and rockfishes give it a relatively high economic value. The fact that economic benefits come from either high volume or high value catches makes it difficult to predict the effects of fishery management measures on local communities, and indicates that more economic studies are needed to evaluate secondary impacts of fisheries.

Commercial landings of all species increased from 1981–2000. This trend is misleading, however, because it is due to large increases in abundances and catches of pelagic fishes and squid. The population sizes of most of the pelagic species are greatly influenced by environmental conditions and the productivity of coastal waters. In the past 20 years, oceanographic conditions appear to have been favorable for many of these species, as their abundances have greatly increased. These species are most frequently caught in seine fisheries, thus the ports of Moss Landing and Monterey, which have facilities for the seine fleet, have seen an increase in overall landings.

Although the catch of pelagic species increased from 1981–2000, the combined catch of all other species decreased by about 50% from the mid-1980s to the late 1990s (Fig. 8). Catches of nonpelagic fishes increased for a short time in the 1990s as a result of increased fishing in nearshore habitats. By the end of the 1990s, however, abundances of nearshore species had also declined. The decline in landings of nonpelagic species was directly related to reduced population sizes of many of the species inhabiting deep-water bottom habitats (e.g. groundfish species), most likely caused by excessively high rates of fishing in the 1980s. In the early 1980s, fishery models indicated that a spawning biomass of 25–35% of the unfished biomass would be sufficient to maintain groundfish populations, and fishery managers set allowable catch levels that were appropriate for those models. Now, fishery scientists and resource managers understand that fishing rates were too high and that those early models overestimated the productivity of groundfish stocks. We now know that many of those species are long-lived, slow growing, and have sporadic recruitment, all factors that indicate that a spawning biomass of 40% or more of unfished levels may be necessary to maintain healthy stocks. Currently, many stocks are at or below that level.

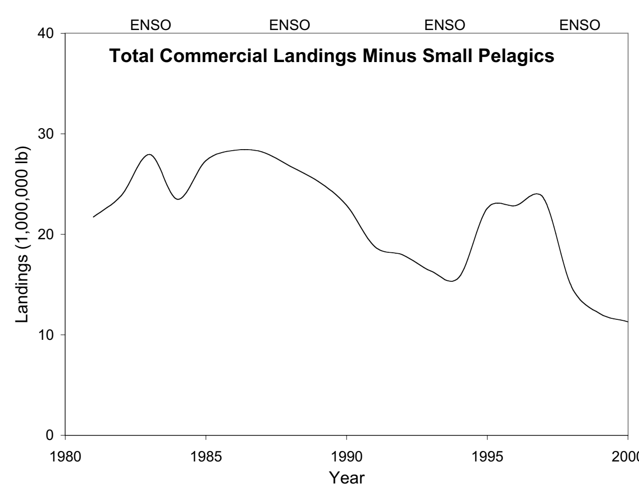


Figure 8. Total commercial landings, not including small pelagic species, from 1981–2000 at all ports associated with the MBNMS. Small pelagics include sardine, anchovy, jack and Pacific mackerel, and market squid.

Gear Types

Commercial fisheries can be grouped according to type of gear used and species caught. There are five primary types of gear used in the commercial fisheries that currently operate in the MBNMS; each type of gear most effectively catches a specific species group. The primary gear types used include pots or traps, trawl nets, hook-and-line gear, purse seines, and gill or set nets.

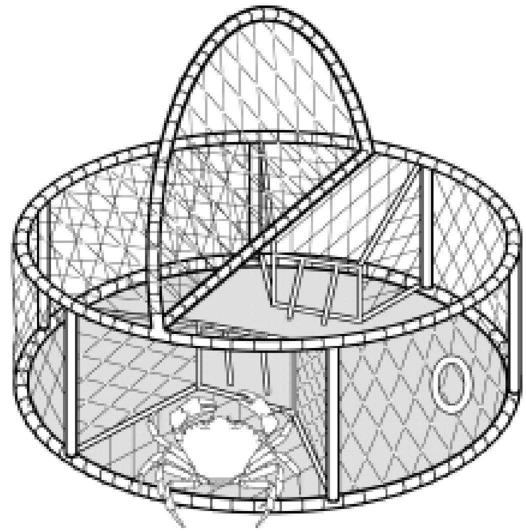


Figure 9. Commercial crab pot.

Pots or traps are fished in two ways. The most common method is to place a single pot at the end of a line that reaches to a surface buoy. Dungeness crab are captured with this method. Typical vessels in this fishery range from 10–20 meters in length, carry a crew of three people, and are rigged with a large, hydraulic winch. The fishers string a baited container in a 1.5-meter wide pot and leave it to soak for 1–3 days on soft bottoms that contain appropriate crab habitat (Fig. 9). At the end of the soak period, a vessel pulls the pot to the surface with the aid of the hydraulic winch. Legal animals are kept on board, nonlegal animals are returned to the water, and the pot is rebaited and sent back to the bottom. Vessels may fish several hundred pots at a time.

A second method of fishing pots is to attach a series of baited traps to a long ground line which is attached to a pair of buoys (Fig. 10). This method of fishing pots is used to catch spot prawn, sablefish, octopus, hagfish, and is a common method of capture in the live fish fishery. In the sablefish fishery, baited pots that are 2 meters long by 1 meter wide are either set out individually, or tied together in strings via a long ground line. They are also soaked for 1–3 days, and then retrieved. These vessels are typically 15–25 meters in length and equipped with

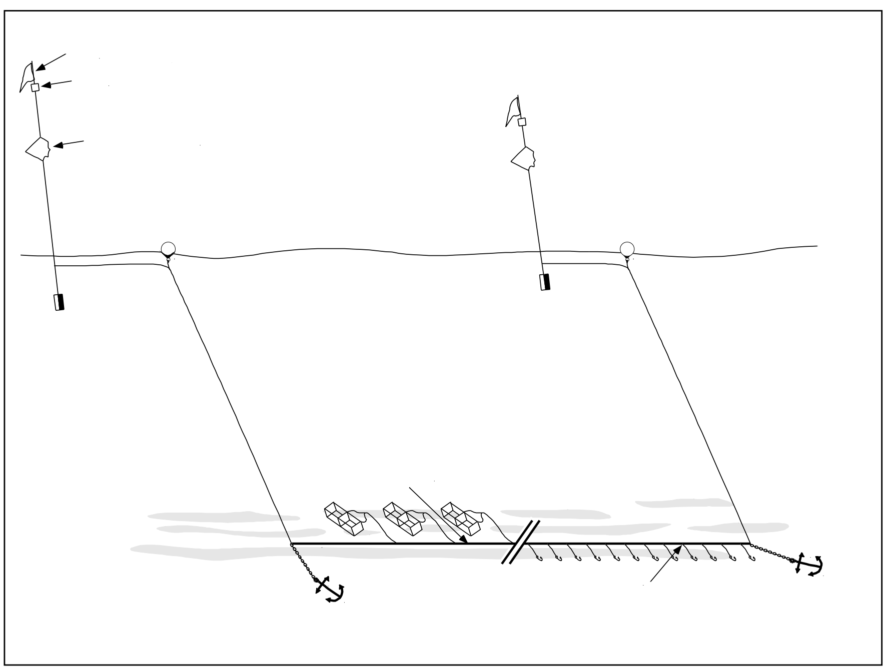


Figure 10. Longline gear used in sablefish trap and hook-and-line fishing operations.

a hydraulic winch and overhead hoist for carrying and lifting the large pots. In the last 20 years, an average of 145 vessels per year fished with pots or traps from ports associated with the MBNMS (Fig. 6). The number of vessels fishing with pots or traps more than doubled from the early 1980s (average 65 vessels) to the mid-1990s (average of 180 vessels). This increase was due to an increase in Dungeness crab populations and the emergence of the live fish fishery.

From 1981–2000, an average of 118 vessels per year fished with trawls from ports within the MBNMS. Trawl gear consists of many different styles of nets that fall into two general categories: bottom trawls and midwater trawls. Each targets a different group within the complex of groundfishes. The most common trawl net used in the Monterey Bay groundfish fishery is a bottom trawl net, also termed an otter trawl. Vessels in the bottom trawl fishery typically range from 20–30 meters in length, have a crew of 3–5 people, and tow trawls as large as 20 meters across at the opening. These nets are towed by a thick wire cable that is stored on large hydraulic winches on the back of the boat (Fig. 11). A bridle and set of wood or steel panels (termed doors) are placed at the terminus of the towing cable to force the mouth of the net open. The mouth of the net is bounded on the bottom by a heavy metal cable or weighted line (leadline) and on the top by a line with floats (headrope). As the net is dragged along the bottom, fish in its path are herded into the opening of the net and pushed to the back of the net (the codend of the net). Within this broad category of bottom trawls, different set-ups are used depending on the species being targeted and the preference of the vessel's skipper. For example, when targeting rockfishes or spot prawn over low relief rocky areas, rollers are added along the footrope to facilitate movement over rough terrain. Rollers may be several inches to several feet in diameter. Bottom trawls targeting flatfishes, such as sanddab and sole that typically lay on level sand or mud substrates, are often modified with a "tickler or sweep" chain. This chain drags along the soft sediments, chasing the fish off the bottom and into the net.

Midwater trawls are similar to bottom trawls, but are designed to fish within the water column and target such schooling fishes as widow rockfish and Pacific hake. Many of the midwater target species are fast swimmers that react quickly to disturbances. Thus, midwater nets are often much longer than bottom trawl nets, with a more tapered design, allowing them to be towed at higher speeds while producing low turbulence and drag. Midwater trawls also typically have a much larger mouth opening, both horizontally and vertically. This increases

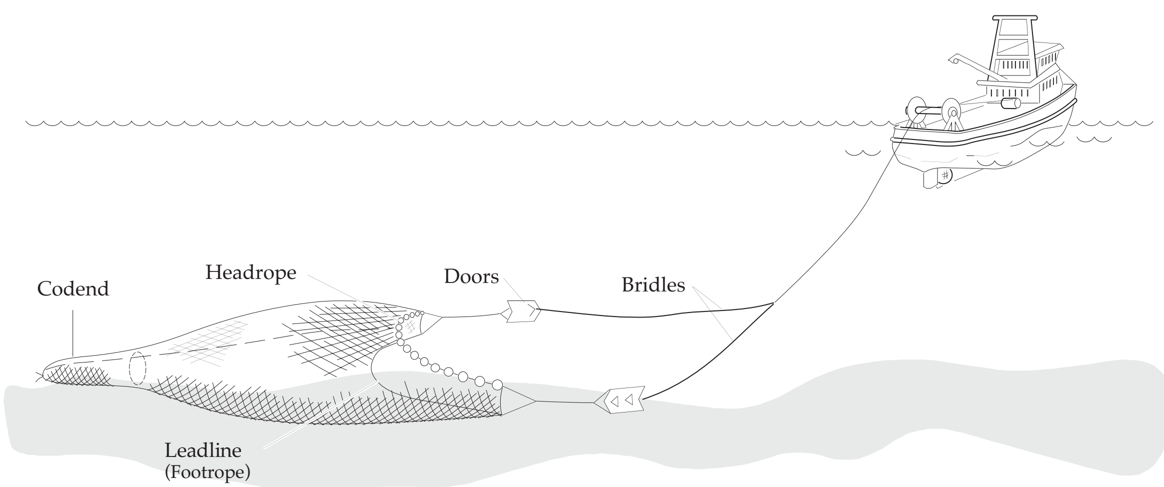


Figure 11. Example of trawl net configuration.

both the stability during operation and the area capable of trapping fish. Midwater trawl vessels are typically larger than bottom trawl vessels in order to handle the larger nets and higher towing speeds. They range from 25–35 meters in length.

Hook-and-line gear varies a great deal but generally consists of a series of baited hooks or lures that are either set and recovered at a later time or are actively fished. An average of 1,661 vessels per year fished with hook-and-line, troll, or longline gear from ports associated with the MBNMS from 1981–2000 (Fig. 6). These vessels range in size from 5 to 20 meters in length, and have crews of 1 to 3 people. Smaller boats fish only on day trips, while the larger vessels can stay out for days at a time.

Four major types of hook-and-line gear are used in the Monterey Bay. The first of these, the longline or setline gear, is placed on the bottom. This gear consists of a line anchored at two ends with each end attached to a buoy at the surface (Fig. 10). A line with baited hooks or lures lies along the bottom between the anchors. Sablefish, rockfishes, and halibut are often caught with bottom longline gear. In the 1990s, a new type of setline fishing began in the nearshore areas for the live-fish market. In this fishery, termed tree or pipe fishing, a small boat is used to set numerous 2-meter long plastic pipes along the bottom in shallow water. Each pipe is outfitted with 4–5 baited hooks and commonly soaked for shorter time periods than traditional hook-and-line methods.

A second type of longline gear is the vertical set or drift line, sometimes termed Portuguese longline. This gear type consists of a fishing line weighted at one end with the other end attached either to the vessel or to a buoy. Baited hooks are arranged vertically in the water column. This gear is often not anchored to the bottom and is used in a drift or slow cruising mode. Often, this gear is used to fish for rockfishes that may be distributed vertically around pinnacles or over irregular rocky bottoms. A variation of this method is to tow a series of hooks on a horizontal line near the bottom.

A third type of line fishing, trolling, is designed to catch fast-swimming fishes such as albacore and salmon. Usually, flashy lures and bait are used in this type of fishery and are trolled behind the moving vessel on heavily weighted fishing lines. The lines are mounted on outrigger poles to ensure separation, and are controlled by small electric or hydraulic winches or gurdies (Fig. 12). Trolling vessels fish at variable speeds and depths depending on target species.

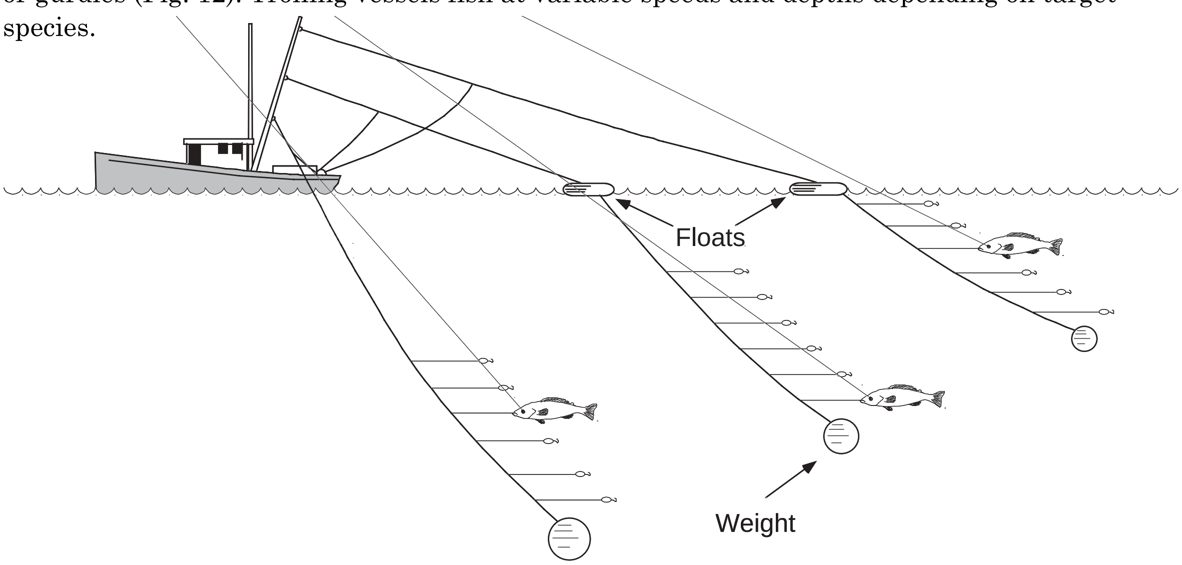


Figure 12. Example of troll fishing gear configuration.

A fourth type of line gear, the traditional set-up of a rod, reel, line, and hook or lure, is used by small commercial fishing vessels in nearshore waters. Although commercial fishers will catch nearshore rockfishes with hook-and-line gear because it is effective in kelp beds and rocky reef areas, it is far more prevalent in the sport fishery.

An average of 51 vessels per year fished with encircling nets such as purse seines and lampara nets from ports near the MBNMS between 1981 and 2000. The typical seine vessel averages 15–25 meters in length and has a hold capacity of 40,000–80,000 lb. Crew sizes for these boats may be 5–7 people or more. Purse seines are the most commonly used encircling nets in this region. They are used in highly targeted fisheries such as those for anchovy, sardine, mackerel, and market squid. When a school of fish or squid is located, one end of the net is drawn away from the vessel by a skiff, while the main vessel steams in a wide circle. The size of the circle is dependent upon the size of the seine net, which is typically 200–400 meters long and less than 50 meters deep (Fig. 13). Once the end of the net is back on the main vessel, the weighted bottom edge of the seine is pulled (pursed) underneath the schooling fish, and most of the net is hauled aboard. The portion of the net known as the bag is strapped next to the boat and emptied using hydraulic pumps or large dip nets, termed brails. In the squid fishery, a second vessel that uses high intensity lights to attract the animals to the surface at night typically assists the vessel deploying the purse seine. In some seine fisheries, small airplanes are used to spot fish schools from the air.

Gill nets consist of a single wall of webbing, usually made of monofilament line, bound at the top by a float line and at the bottom by a weighted line, and used for entangling fish by their gills. Gill nets can range up to 450 meters long and are deployed from smaller vessels (7–15 meters in length) using either bow or stern-mounted rollers (Fig. 14). Various sizes of net webbing are used for different target species. This fishery began in the 1970s, mostly targeting nearshore rockfishes. In the past 20 years, the primary species caught with gill nets and landed at ports near the MBNMS have been deepwater rockfishes and swordfish. Regulation of the gill net fishery began in the 1980s with a series of depth restrictions limiting the use of gill nets in nearshore. Since the early 1980s, numbers of vessels fishing with gillnets have steadily declined because of increased restrictions in this fishery.

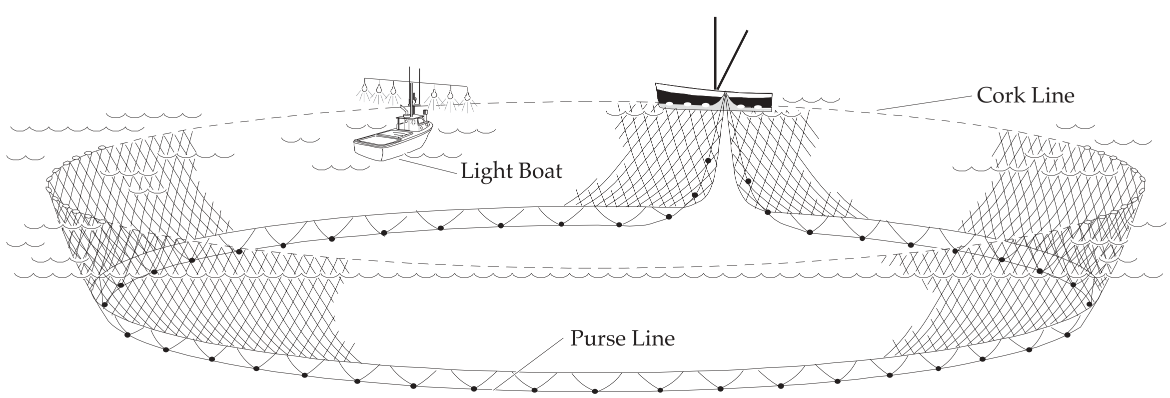


Figure 13. Example of purse seine fishing operations.

Target Species and Landings

More than 200 species of invertebrates and fishes were recorded in the commercial and recreational catches in this region from 1981–2000 (Appendix A). This species list was derived from a combination of the reported commercial landings, commercial live-fish fishery landings, and reported catches from recreational fishing vessels and angler interviews. Appendix A may include some species that were landed, but not caught in regional waters. It also only includes the larger invertebrate species that are commonly harvested in the recreational fishery. Undoubtedly, many more intertidal invertebrates are harvested in small numbers.

Commercial landing information is available for those species that were routinely caught and sold in this region from 1981–2000 (Appendix B). These data are derived primarily from records provided to CDFG by fish buyers, who often lump more than one species in the poundage reported for a group of fishes. This lumping of landed catch into broad groups or market categories can pose a problem for the evaluation of trends in species abundance. State and federal fishery biologists resolve the problem by routinely collecting biological information on market categories to the reported commercial landings to obtain estimates of the number and the species sold at the docks. Biologists obtain estimates of species composition of the landed catch by market categories. They then apply the ratios of species composition in the sampled weight of individual species caught. Appendix C is an example of the results of this procedure: it provides estimates of the commercial landings of individual rockfish species from 1978–2000. Note that estimates of total rockfish landings from Appendix C do not match the totals from Appendix B because the expansion procedures used by NMFS include rockfish landed and sampled in San Francisco as well as in other ports near the MBNMS.

Linear regression analysis was used to evaluate the trends in catch for species commercially landed in the ports associated with the MBNMS for the years 1981–2000. By fitting a best-fit straight line through the plot of landings over time, one can generally assess whether catch trends have statistically changed, and how they have changed (i.e. increased or decreased) over that time period. More than 90 species are frequently caught (more than 1,000 pounds/year or more than 1000 fish/year) in fisheries occurring in the MBNMS. Of these 90

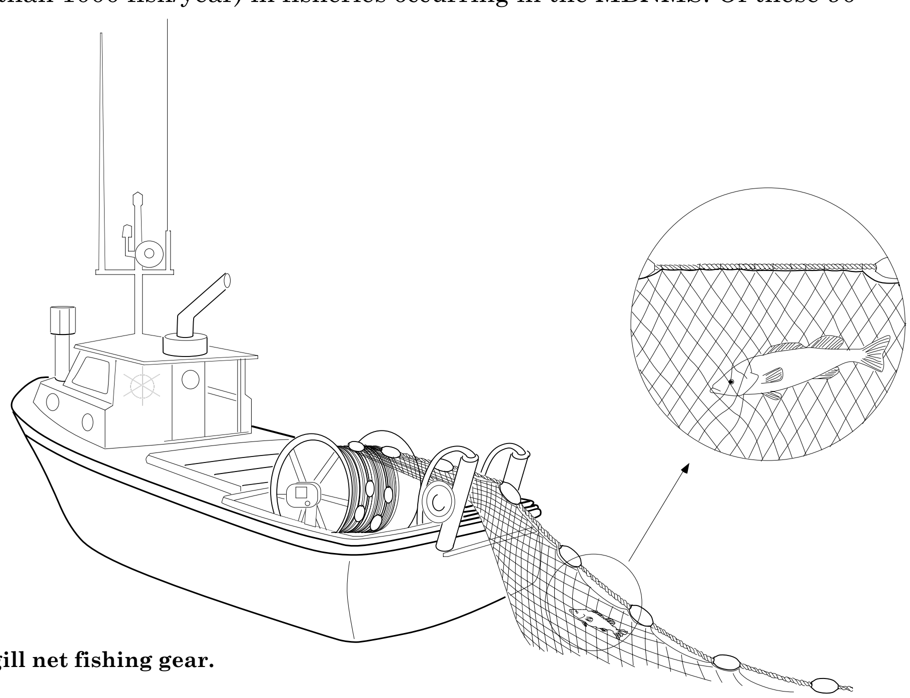


Figure 14. Example of gill net fishing gear.

species, reported catches of 23 species and 2 species groups (total rockfishes and shelf rockfishes) exhibited significantly decreasing trends from 1981–2000 (Table 2). The decline in landings of some species may be due to depressed stocks or poor annual recruitment, and therefore indicate declines in stock abundance (e.g. bocaccio, lingcod). In other instances, landings are declining because of poor market conditions or because reduced quotas for one species indirectly affects the catches of a second species because the two species are caught together (e.g., chilipepper rockfish). Catches of some other species may also be decreasing in the MBNMS because of environmental effects on larval recruitment and survival (e.g., Pacific Ocean shrimp). In addition, several nearshore and pelagic shark species show declining trends in landings, probably due to heavy fishing of stocks in the past and the recent increases in commercial gear regulations.

Thirteen species exhibited significantly increasing trends in landings from 1981–2000 (Table 2). Of these species, sardine and Dungeness crab populations are thought to be increasing because of favorable environmental conditions, and catches of some races of Chinook salmon are increasing because of favorable environmental conditions and improved management activities. Sanddab, spot prawn, cabezon, kelp greenling, and grass rockfish landings are increasing due primarily to fishing effort associated with increased market demand for those species. Increased landings of cabezon, kelp greenling, and grass rockfish can be attributed to the increase in the live-fish fishery; prior to the late 1980s there was little effort to catch these species. Since 1998, however, landings of cabezon and grass rockfish have declined because of new regulations imposed on nearshore fishes, reflecting the concern of state resource managers that populations of these stocks have also declined, and may not be able to withstand current harvest levels. The increase in white seabass landings may be attributed to high catches during warmer water conditions associated with El Niño events. In the last two years, fishers suggest that the white seabass population in this area is higher than it has been in recent history.

The remaining species or species groups show no significant trends in reported catch according to linear regression analysis, but such simplistic analyses may obscure useful information about species landings. For some of the species, landings have decreased just in the past five years (Table 2). For example, most of the nearshore rockfishes and thornyheads, all targets of the live-fish fishery, demonstrated sharp decreasing trends after the mid-1990s, because of reduced abundances, increased regulations, and market limitations. In other cases, such as Pacific mackerel, northern anchovy, and market squid, high variation in landings over the years resulted in overall nonsignificant regression trends. This variation is attributable to the influence of environmental conditions on recruitment in these species. Some species, such as jack mackerel and the Pacific bonito, with a coefficient of variation over 200%, were designated as having highly variable landings. This high variation is attributable to the profound effect of environmental conditions on these populations.

Trends in landings can be misleading because they do not incorporate a concomitant change in the effort of fishers through time in a given area. Thus, in addition to analyzing trends of reported landings, we applied linear regression analyses to catch per trip data, to see if catch rates exhibited similar trends as landings. We divided the total annual landings by the number of trips made by all vessels per year to generate a catch per trip value. These values were then analyzed in the same manner as the landing trends. In general, CPUE trends were similar to trends as described by the landing regressions, indicating that a decline in landings for a species usually is an indicator that population size of that species has declined (Table 2).

One caveat to this approach is that using number of trips as a measure of effort does not specify what species is targeted per trip. Changes in targeted species, therefore, may artificially increase or decrease a species' yearly CPUE value. For this reason, we included an analy-

Table 2. Categorical trends of species commercially landed from 1981 to 2000 at ports associated with the MBNMS. Categories include increasing, decreasing, or highly variable landings (^=estimated landings). Effort for the CPUE regression/trends analysis was measured by total yearly trips within the MBNMS. Rockfish CPUE trends reflect trends from 1981–1995. NS represents no significant trend. Bold values indicate CPUE trends that differ from landing trends. Trend comments indicate regressions that hide a more recent opposing trend. See text for further explanation.

Species	Average landing (1,000 lb)	CPUE/trend	Rockfish CPUE trends pre-1996	Comments
Decreased Landings				
Total Rockfishes^	10176	down	down	
Shelf Rockfishes^	9862	down	down	
Chilipepper^	2933	down	NS	
Boccacio^	2555	down	down	
Sablefish	1601	down		
Yellowtail Rockfish^	507	down	NS	
Lingcod	379	down		
White Croaker	325	down		
Common Thresher Shark	169	down		
Sand Sole	42	down		
Speckled Rockfish^	33	down	NS	
Pacific Angel Shark	24	down		
Soupfin Shark	23	down		
Leopard Shark	8	down		
Widow Rockfish^	1268	down	down	
Bank Rockfish^	956	down	down	
English Sole	487	down		
Bluefin Tuna	33	down		
Bigeye Thresher Shark	18	down		
Monkeyface Prickleback	<1	down		
Jack Mackerel	1183	**NS**		
Pink Shrimp	431	**NS**		
Copper Rockfish^	24	down	up	
Smelt	11	down		
Pacific Hake	2	**NS**		

sis of all rockfish species and species groups in the period before heavy regulations on most rockfishes were implemented (Table 2). Many of the trends are similar to the ones seen for years 1981–2000, but there are some discrepancies. Most notable is the chilipepper, a species whose population seems stable according to stock assessments, but whose recent decline in landings reflects its close association with the strictly regulated catch of bocaccio.

Species	Average landing (1,000 lb)	CPUE/trend	Rockfish CPUE trends pre-1996	Comments
Increased Landings				
Pacific Sardine	9527	up		
Cabezon^	66118	up		decrease after 1998
Sanddabs	670	up		
Spot Prawn	96	up		
Grass Rockfish^	28	up	up	decrease after 1998
Kelp Greenling	3	up		
Chinook Salmon	2210	up		
Albacore	1528	up		
Dungeness Crab	454	up		
White Seabass	5	up		
Sheephead	2	up		
Treefish^	1	up	up	
Wolf Eel	<1	**NS**		
No significant landing trend				
Market Squid	13960	NS		
Northern Anchovy	4298	NS		
Dover Sole	3631	NS		decrease after late 1980s
Chub Mackerel	2143	NS		
Thornyheads^	1762	NS		decrease after 1995
Swordfish	741	NS		
Splitnose Rockfish^	636	NS	NS	
Petrale Sole	429	NS		decrease after 1996
Pacific Grenadier	416	NS		decrease after 1996
Rex Sole	357	NS		decrease after 1995
Nearshore Rockfishes^	314	**down**	down	decrease after 1993
Blackgill Rockfish^	308	NS	NS	decrease after 1992
California Halibut	221	NS		
Pacific Herring	221	**down**		
Rock Crab	182	NS		decrease after 1993
Vermilion Rockfish^	140	NS	up	decrease after 1993
Brown Rockfish^	106	NS	NS	decrease after 1998
Canary rockfish^	102	NS	NS	decrease after 1996
Red Sea Urchin	97	NS		decrease after 1989
Darkblotched Rockfish^	93	NS	NS	decrease after 1997
Aurora Rockfish^	88	NS	up	decrease after 1993
Red Abalone	80	NS		decrease after 1992
Greenspotted Rockfish^	74	NS	up	decrease after 1997
Blue Rockfish^	68	NS	NS	decrease since 1994
Yelloweye Rockfish^	46	NS	NS	decrease after 1991
Pacific Bonito	40	NS		

Species	Average landing (1,000 lb)	CPUE/trend	Rockfish CPUE trends pre-1996	Comments
Cowcod^	37	NS	up	decrease after 1997
Mako Shark	36	NS		decrease after 1990
Surfperch	26	NS		decrease after 1998
Starry Flounder	26	NS		decrease after 1988
Gopher Rockfish^	24	NS	NS	decrease after 1992
Black-and-Yellow Rockfish^	24	NS	NS	decrease after 1998
Olive Rockfish^	21	NS	NS	decrease after 1996
Starry Rockfish^	20	NS	up	decrease after 1991
China Rockfish^	20	NS	NS	decrease after 1997
Black Rockfish^	19	NS	NS	decrease after 1998
Greenstriped Rockfish^	17	NS	NS	decrease after 1997
Redbanded rockfish^	13	NS	NS	
Rosy Rockfish^	11	NS	up	decrease after 1994
Stripetail Rockfish^	11	NS	NS	
Shortbelly Rockfish^	10	NS	NS	
Quillback Rockfish^	10	**down**	up	decrease after 1997
Greenblotched Rockfish^	9	**down**	up	decrease after 1998
Tiger Rockfish^	7	NS	NS	
Sharpchin Rockfish^	6	NS	NS	
Rock Sole	6	NS		
Kelp rockfish^	5	NS	up	decrease after 1993
Flag rockfish^	4	NS	NS	decrease after 1994
Octopi	4	NS		
Rougheye Rockfish^	3	NS	NS	
Bronzespotted Rockfish^	3	NS	NS	
Skipjack	3	NS		
Yellowfin Tuna	3	NS		
Rosethorn Rockfish^	2	NS	NS	
Chameleon Rockfish^	2	NS	up	
Pink Rockfish^	2	NS	NS	
Pacific Ocean Perch^	1	NS	NS	
Mexican Rockfish^	1	NS	NS	
Barracuda	1	NS		
California scorpionfish^	<1	NS		
Squarespot Rockfish^	<1	NS	NS	
Highly Variable				
Jack Mackerel	1183			
Pacific Bonito	40			
Grenadier	416			
Quillback Rockfish^	10			
Tiger Rockfish^	7			
Yellowfin Tuna	3			

Economic Value

Commercial fishing contributes both to the local and statewide economies. Although landings declined from 1981–2000, the average ex-vessel revenue per boat increased over the last 20 years (Fig 15). In 1999, commercial fishing in California accounted for $146.6 million in revenue (value corrected for inflation to 2000 dollars) to fishers (i.e., the dockside price paid to fishers, termed ex-vessel value). Ports within the MBNMS accounted for $15.7 million of that total (Fig. 15). Due to lack of complete economic data for the fishing industry, the ex-vessel value is the most commonly used measure of economic value for commercial fisheries. Ex-vessel value is an underestimate of the economic value for the commercial fishery, however, because it does not take into account income generated from businesses associated with operating and maintaining a fishing vessel and its crew. For example, fishers spend money for equipment, gasoline, gear maintenance, and crew members. These expenditures benefit a number of additional businesses including boat repair shops, marine supply stores, marinas, and the fuel industry. In an evaluation of the economic benefit to the community of the commercial fishing industry it was calculated that for every one dollar earned by the fishing industry approximately $1.30 to $1.90 is generated in the local economy. Average revenue per boat in Central California increased from $20,800 to $30,100 over the period of 1981–85 versus 1994–99.

Commercial fishing also benefits local economies by contributing to the success of other industries in the area. For example, commercial fishing provides a large benefit to exporting businesses. In 1995, seafood was ranked fifth in value of leading exports from California. In 1999, California was ranked fifth in the United States in seafood production, producing approximately 472 million lb in 1999. Exports of edible fish and shellfish from California in 2000 totaled nearly 186 million lb and were valued at over $276 million. Commercial fishing also creates cultural and economic benefits by creating a venue to which vacationers are attracted. The nautical atmosphere around harbors and marinas adds to local tourism, as do fish markets and restaurants featuring fresh, locally caught seafood.

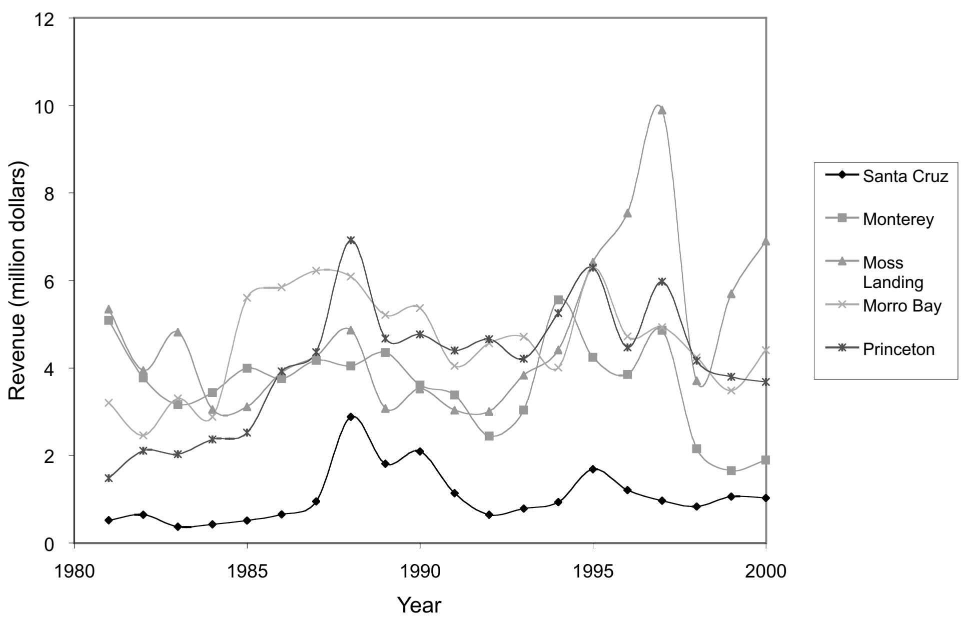


Figure 15. Adjusted ex-vessel value generated for the five major ports associated with the MBNMS from 1981–2000. Economic values are adjusted for inflation-year 2000 values.

Although commercial fishing is economically valuable, it accounts for only a small portion of the total economy, both statewide and locally. Much larger contributors include the agriculture and tourism industries. Agriculture, primarily in the Salinas and Pajaro valleys, is one of the largest industries in the Monterey Bay area. In 2000, agriculture was worth almost $3 billion to Monterey County (the third highest among California counties), $490 million in San Luis Obispo County, and $340 million to Santa Cruz County. These values represent wholesale prices alone, and can be expanded by a factor of 3–5 times when indirect expenses and personal income are incorporated.

Tourism is another big industry along the central coast. In Monterey County alone, tourism accounted for almost $3 billion in combined direct and indirect impacts in 1999, ranking Monterey County tenth in California for tourist spending. In 1999, the Monterey County Convention and Visitors Bureau estimated 18,400 jobs and $291 million in personal income are generated by tourism in Monterey County. In Santa Cruz County, tourism provided over 5,000 jobs, and $600 million in visitor spending and personal income. Included in the values for tourism, however, are the expenditures made by people who visit the area to recreationally fish, tour the harbors to see fishing boats, eat at seafood restaurants, or otherwise enjoy the cultural heritage provided by the fishing industry.

Recreational Fisheries

The recreational fishery includes a variety of fishing methods that are classified into six major modes: commercial passenger fishing vessel/charter (CPFV), private/rental boat (skiff), beach and bank, jetty and breakwater, pier and dock, and spear fishing. These modes reflect the variety of habitats used by species caught in the recreational fishery (Appendix D, E). Because of the spatially and temporally diffuse nature of these various fishing modes, the recreational fishery has traditionally been difficult to monitor and thus accurately assess its contribution to California's fisheries. The most comprehensive method used to collect recreational fishery data is through the Marine Recreational Fisheries Statistics Survey (MRFSS) conducted by the Pacific States Marine Fisheries Commission (PSMFC). The annual surveys include phone interviews and dockside surveys that collect data on recreational fishing catch, effort, and economic information. Telephone interviews are conducted within coastal counties to interview fishers at home to estimate angler trips, while intercept surveys of anglers at fishing sites estimate catch rates and species composition. These data have been collected since 1979, with the exception of 1990–92; a gap caused by lack of funding. Although this database covers a long time span, results from some years are highly variable and less reliable, making the information difficult to interpret. In addition, salmon catches, which are extremely important in the Monterey Bay area in some years, are not included in the survey. Another method of monitoring the recreational fishery comes from the California Department of Fish and Game CPFV logbooks that include information on number of anglers, location of fishing, and the type and number of fishes caught.

For major recreational species, Northern and Central California recreational catches make up almost half of the total recreational catch in California, comprising the majority of nearshore rockfishes, surfperches, greenlings and lingcod, flatfishes, salmonids, and sculpins caught in the state (Fig. 16). From the 1960s–80s, recreational fishing in Northern and Central California grew substantially; with annual average catch increasing from 3.9 million fish in 1958–61 to 6.5 million fish in 1981–86, and annual fishing effort increasing by 65%. Within the MBNMS, CPFV data reflect a decrease in fishing effort, along with a concomitant downward trend in catches since 1981 (Fig. 17).

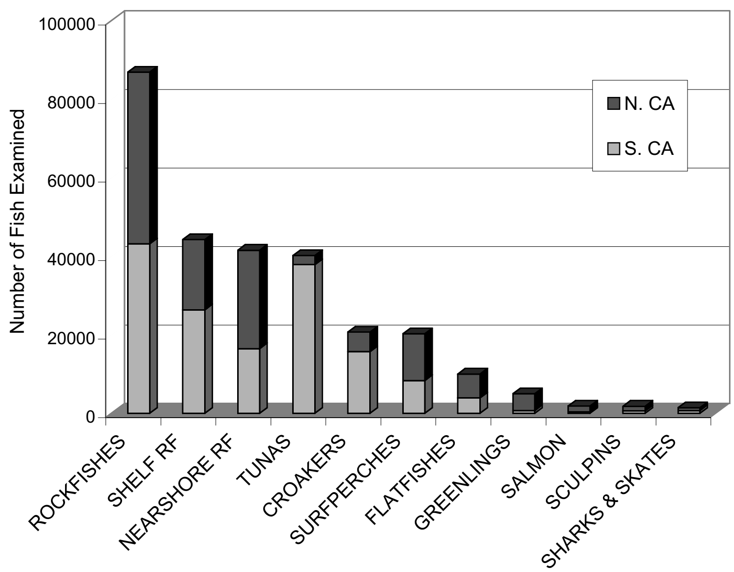


Figure 16. Total examined recreational catch of species in Northern and Southern California from 1980–2000. Rockfishes are abbreviated as "RF." "Tunas" category includes mackerel. "Greenling" category includes lingcod.

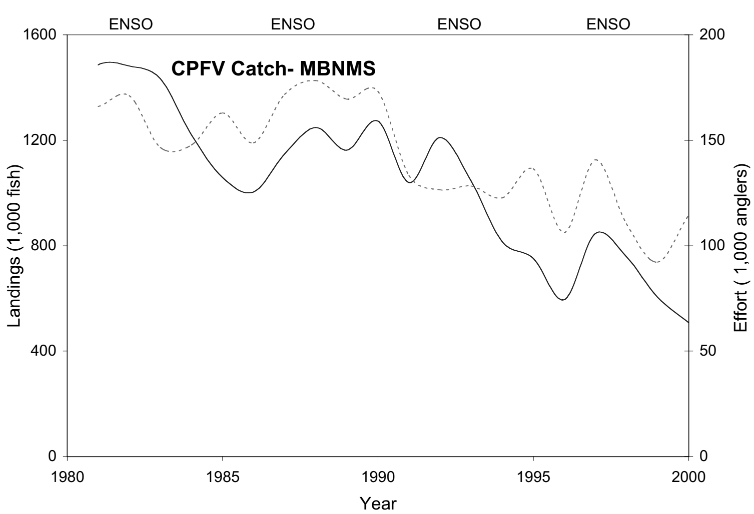


Figure 17. Total CPFV catch (solid line) and effort (dotted line) at five major ports associated with the MBNMS from 1981–2000.

Results from the MRFSS indicate that shore fishing is the most common form of sport fishing in Northern and Central California (Table 3). This is to be expected, as fishing from shore is the most accessible and least expensive form of fishing. Each of the three modes of shore fishing (beach/bank, jetty/breakwater, and pier/dock) are primarily hook-and-line fisheries, and combined accounted for at least 40% of the annual catch and over half of the recreational fishing effort from 1981–2000 (Table 3). Since 1981, shore catch has slowly declined, while the effort, despite a large, inexplicable increase in 1988, has remained comparatively steady (Fig. 18). The beach/bank mode comprised over one-half of the annual shore catch and fishing effort. Numerous species are caught in the shore fishery, but the most frequently occurring are smelts and silversides, surfperch, and croakers.

Table 3. Average annual total catch, average effort, and primary species caught in Northern California for each of the major sportfishing modes from 1981–2000.

Fishing Mode	Avg. Catch (No. of fish) 1980–2000	Avg. Effort (No. Trips) 1980–2000	Primary Species
Commercial Passenger Fishing Vessels (CPFV)	1.5 million	235,000	Rockfishes, lingcod, and mackerel
Private/Rental Boat (PRB)	2.0 million	944,000	Rockfishes, croaker, sanddabs, and lingcod
All Shore Fishing (Beach/Bank, Jetty/Breakwater, Pier/Dock)	2.9 million	1.3 million	Smelt, silversides, surfperch, croaker, and greenlings

*1990 –92 not available for all; 1990–95 not available for the CPFV fishery

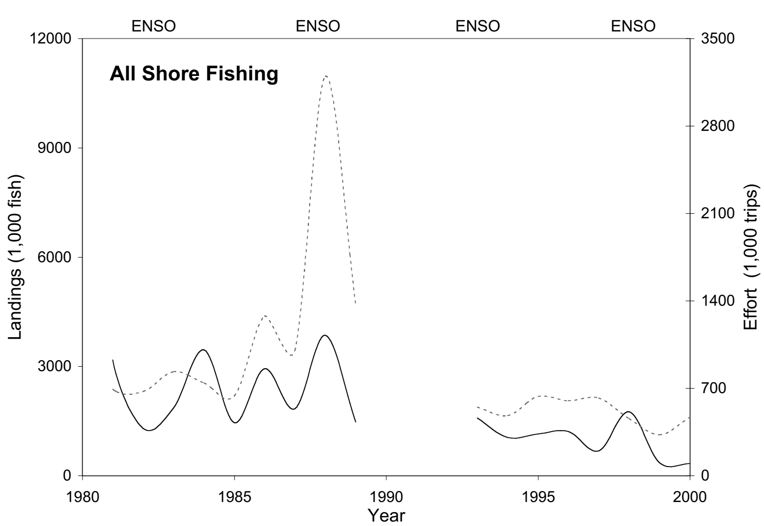


Figure 18. All shore fishing landings (solid line) and effort (dotted line) within Central and Northern California from 1981–2000.

Private/Rental boat fishing accounted for the highest average annual catch and effort for a single recreational fishing mode from 1981–2000 (Table 3). An estimated 50,000 boat launches/ yr are made from boat ramps at the five ports near the MBNMS. Many of these vessels are used in the recreational fishery. This fishing mode targets the same species as CPFVs, including salmon, rockfishes, halibut, lingcod, and albacore, but the private/rental boat average number of fishing trips is more than three times greater than that for the CPFV fishery (Fig. 19). The average annual catch, however, is only about twice as high, most likely a result of CPFV skippers being more knowledgeable and adept at finding good fishing grounds.

CPFVs constitute the most economically important category of recreational fishing, accounting for a multi-million dollar business and well over 1 million angler trips per year off the West Coast of the United States. Fishing from CPFVs in California has been popular since the 1920s, and landings from CPFVs have been sampled by the California Department of Fish and Game since the 1950s. Target species in Northern and Central California have traditionally been salmon, rockfishes, lingcod, and halibut, with albacore fishing also heavy in some years. In Northern/Central California and within the MBNMS, catch and fishing effort have declined in the CPFV fishery (Figs. 20 and 17). Declines in rockfishes and lingcod catches are particularly evident (Figs. 21 and 22), due both to declining abundances and reduced bag limits for these species. Another trend apparent in the recreational fishery around Monterey Bay is the decline in rockfish lengths since the 1950s. The mean length of all ten leading rockfish species caught in the recreational fishery has declined since the 1950s. In recent years, the average length of some rockfishes caught in the sport fishery has fallen below that of size at maturity. Catching fish below the size or age of maturity can negatively impact fish populations by lowering the population's reproductive potential. Because the same species are targeted in the recreational fishery as in the live/premium fish fishery (see Live/Premium Fish Section), additional pressures have been put on these populations.

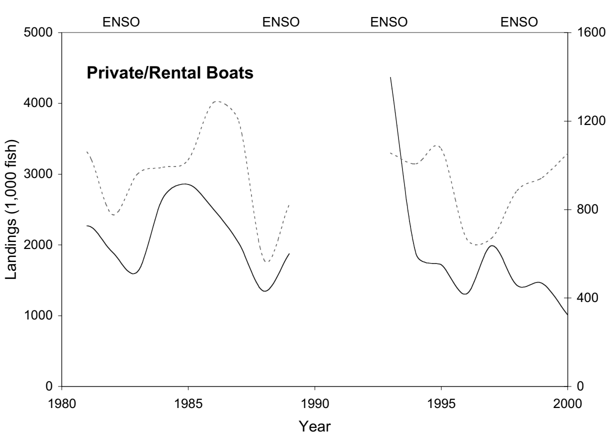


Figure 19. Private/Rental boat landings (solid line) and effort (dotted line) within Central and Northern California from 1981–2000. No RecFIN data are available for years 1990–1992.

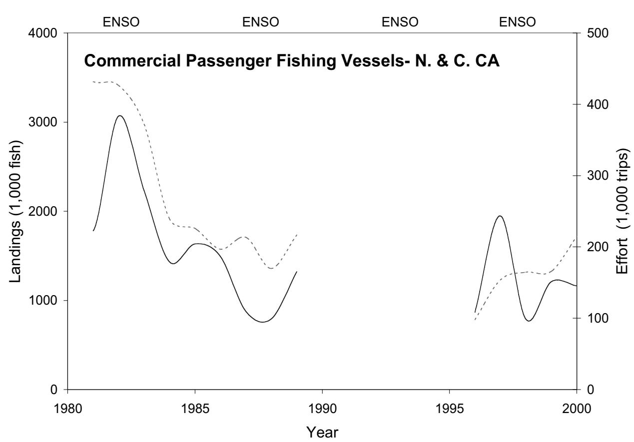


Figure 20. CPFV landings (solid line) and effort (dotted line) within Central and Northern California from 1981–2000. No RecFIN data are available for years 1990–1995.

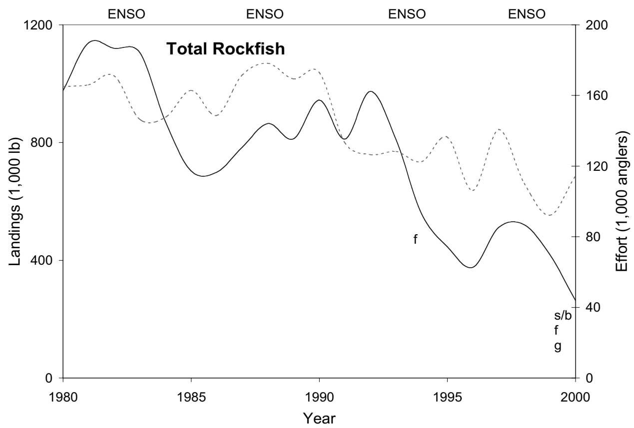


Figure 21. Total rockfish CPFV landings (solid line) and effort (dotted line) within the MBNMS. See Appendix G for specific yearly meanings of each regulatory symbol.

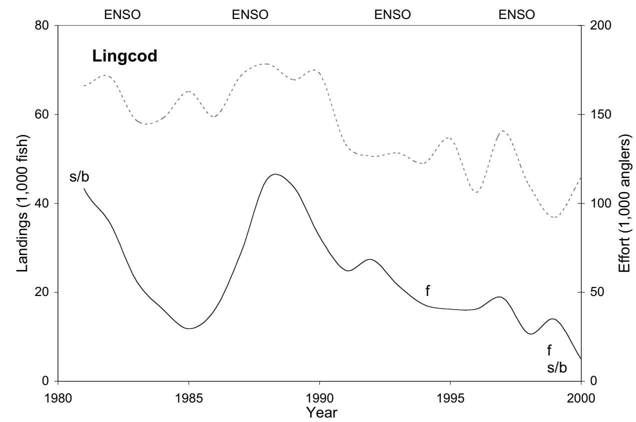


Figure 22. Total lingcod CPFV landings (solid line) and effort (dotted line) within the MBNMS. See Appendix G for specific yearly meanings of each regulatory symbol.

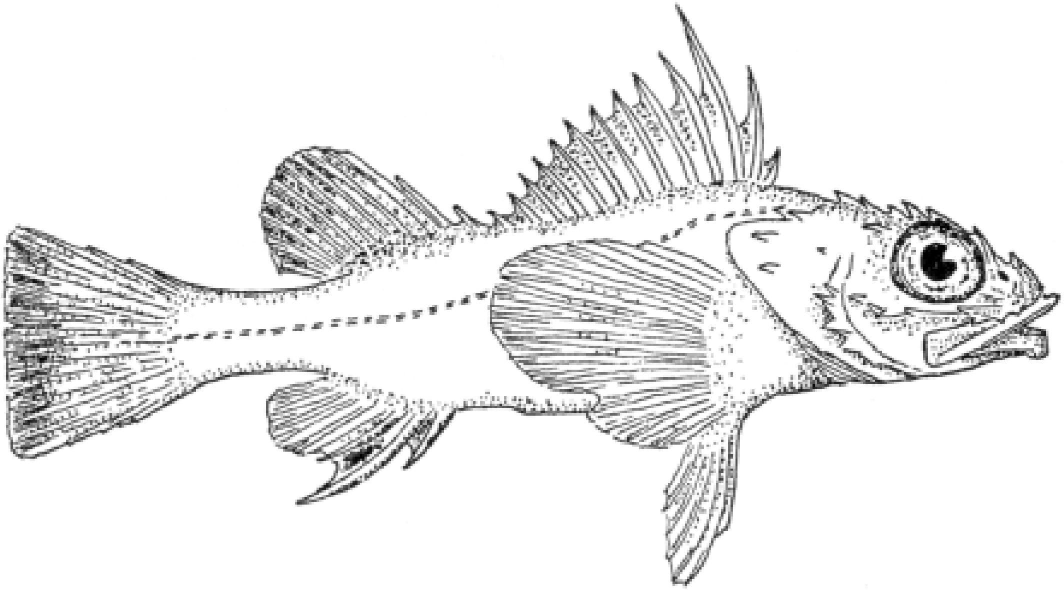
Primary Target Species

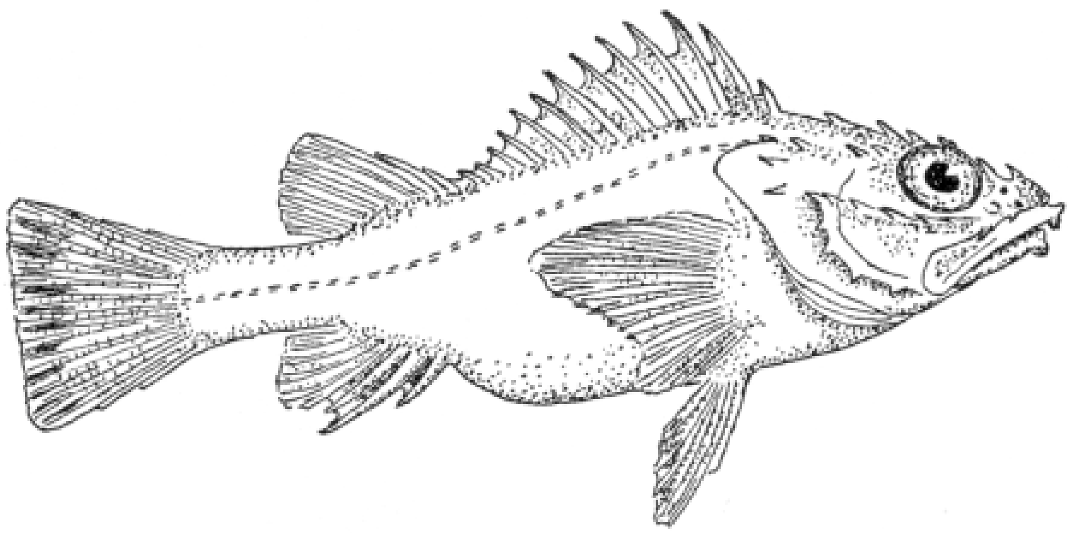
Generally, recreational fishers will catch what they can, but often attempt to catch highly prized species such as salmon, lingcod, halibut, large rockfishes, and surfperches. Rockfishes are the most abundant fishes in recreational catches and are targeted most frequently, though specific target species tend to change seasonally. They are fished year-round and comprise over 50% of the recreational catch in Central California. For some species of nearshore rockfishes, reported recreational catches exceed catches reported in the commercial fisheries. The average estimated sport fishing catch for rockfishes in the past twenty years has been 2.4 million fishes a year in Northern and Central California, but catch has also shown a steady decline over the same time period. Other notable components of the recreational fisheries are lingcod, albacore, striped bass, flatfishes, and cabezon. Recently, white seabass catches, particularly in Monterey Bay, have increased tremendously.

In the summer, a large amount of recreational fishing effort is aimed towards salmon, one of the most popular sport fishes in Central California. Recreational fishing for salmon has been an important component of marine sport fisheries since the late 1800s. In the Monterey Bay region, almost all salmon caught are Chinook salmon, many of which originated from the Sacramento River basin. Between 1981 and 2000, an average of 74,000 Chinook salmon were caught annually in the recreational fishery associated with ports near the MBNMS. The recreational salmon fishery is open during spring and summer months, typically between April and October. During these months CPFV and private boats leave harbors daily to target salmon. The most common and successful method of fishing for salmon is trolling.

Economic Value

Overall, the recreational fishery lands fewer fish, but has a larger impact on California's economy than does commercial fishing. From 1998–99, resident and visiting recreational fishers spent $107.9 million on trip-related costs to fish in Central/Northern California waters. Additional costs for gear, licenses, and other expenses related to fishing expeditions totaled $68.6 million, adding up to angler expenditures of $176.5 million in the Central/Northern California recreational fishery. In California, recreational fishing annually provides communities with approximately $5 billion in personal income and more than 150,000 jobs.





FISHERIES MANAGEMENT

Concepts

The goal of fisheries management is to maintain healthy fish populations while providing social and economic benefits from fisheries. Management strategies are thus based upon a complex array of social, economic, and ecological concerns which must be addressed when decisions affecting a fishery are made. An implicit assumption of fishery management is that fishes represent renewable resources that can maintain population levels when subjected to limited harvesting on a continual basis. This assumption relies on the concept that fish populations have a surplus production that is available to be harvested. In theory, in an unfished population, the biomass (total weight) of fish in a habitat will approach a theoretical carrying capacity (maximum number of individuals that can be accommodated) for that habitat. The older fish will dominate the habitat and their presence prevents all but a small percentage of the young fish produced each year from surviving to reproduce. Following this logic, if some larger, older fish are removed from the habitat, there will be room for a greater number of younger, faster growing fish to take their places. These new fish thus represent a harvestable portion of the fish stock because they represent a spawning biomass above and beyond that needed to maintain stock levels. Although this theory is logical, the processes affecting adult mortality, adult growth and reproductive output, and juvenile survival are highly variable, and make equilibrium population size a concept and not a static number.

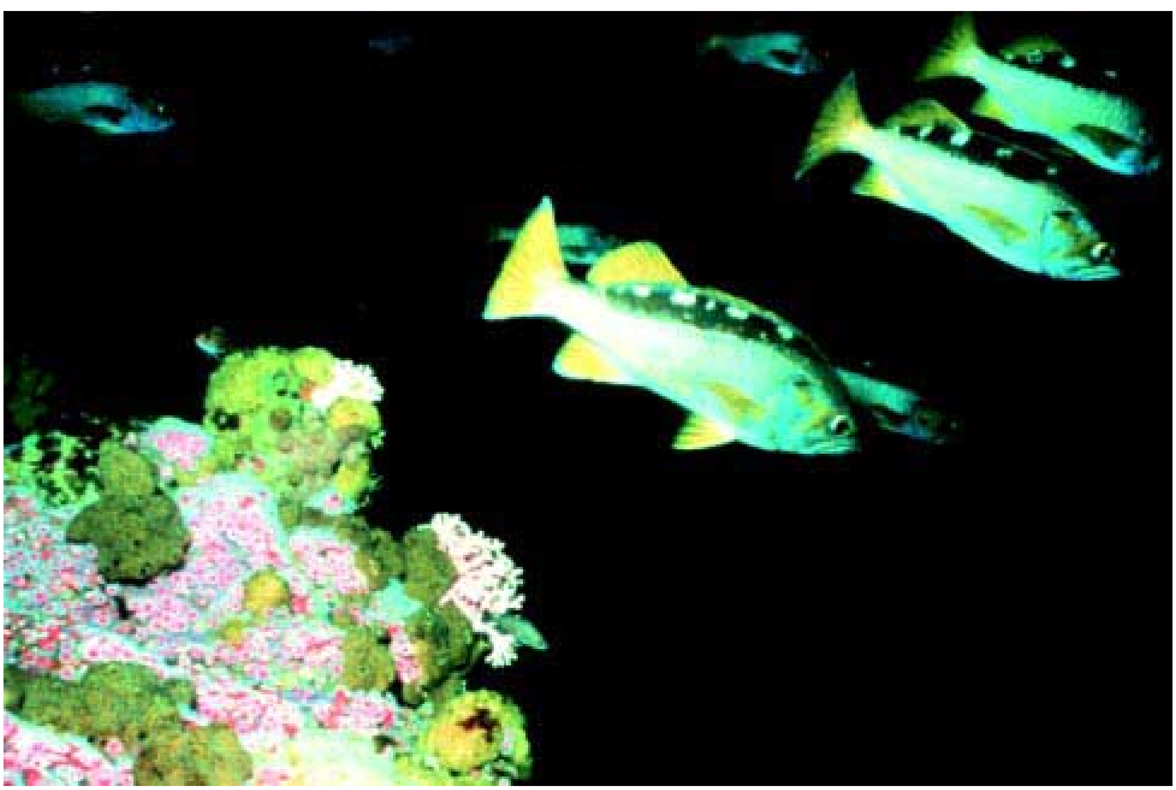


Table 4. Stock status of commercial species landed within the MBNMS.

Species	Last Assessed	Status of stock
Arrowtooth Flounder	1993	Stock increasing
Bank Rockfish	2000	No evidence of depletion
Blackgill Rockfish	1998	No evidence of depletion
Bocaccio Rockfish	1999	Overfished stock
Canary Rockfish	1999	Overfished stock
Chilipepper Rockfish	1998	No evidence of depletion
Cowcod	1999	Low abundance
Darkblotched Rockfish	2000	Stock status uncertain
Dover Sole	2001	No evidence of depletion
Lingcod	2000	Overfished stock
Petrale Sole	1999	Stock increasing
Pacific Whiting	2000	Stock at moderate abundance
Pacific Ocean Perch	2000	Stock at low abundance
Sablefish	2001	Stock status uncertain
Shortbelly Rockfish	1989	No evidence of depletion
Shortspine Thornyhead	2001	No evidence of depletion
Widow Rockfish	2000	Overfished stock
Yelloweye Rockfish	2001	Stock at low abundance
Yellowtail Rockfish	2000	Stock decreasing
Pacific Sardine	2001	Stock at high abundance
Pacific Mackerel	2001	Unfinished
Ocean Salmon	2001	Low abundance (California)

* stock status determined by Pacific Fishery Management Council

Stock Assessments

Fishery scientists determine the health of fish populations by conducting stock assessments. A current list (as of the end of 2001) of species with stock assessments is provided in Table 4. Stock assessments combine available biological data with information about fishing activities to assess trends in fish abundance. There are several approaches to gathering information for stock assessments. One of the primary methods involves examining annual records of catch and fishing effort and then standardizing them to a common measure. Fishery biologists divide the amount of fish caught and sold at the dock (landings) by the amount of fishing time expended in the fishing process. The resulting number is termed CPUE and is often used as an index of abundance.

As with all methods for assessing the status of a stock, reviewing catch records is not a perfect approach. A primary drawback to this approach is that it relies on indirect evidence of population size and is not a direct measurement of fish abundance. Catch records alone are insufficient to define the health of a stock because catches can fluctuate for a variety of social and economic reasons that are independent of fish abundance. A less obvious problem of using catch records is the difficulty and expense of gathering reliable data on fishing effort.

Fishery scientists also use biological information in stock assessments. The age structure of a stock provides a historical as well as contemporary view of the stock. It shows information about the current status of the stock and gives clues to events in the past that have led to the changes in that status. The shape of the age frequency distribution can also provide evidence that a stock has been overfished, for instance, when a reduction in the number of fish results in fewer older year classes. Some other pieces of information that can be obtained from catch curves are: age at first entry into the fishery (recruitment), estimates of longevity, year-class strength, and estimates of total mortality. Obtaining an estimate of total mortality from catch curves is a critical component of many fishery stock assessments. Total mortality is the combination of mortality due to natural causes and mortality caused by fishing efforts.

The age at first reproduction and the size and age structure of a population are two important biological indicators of the health of fish stocks. For example, if the average length of a given age of fish decreases over time, managers assume that growth overfishing is evident. Growth overfishing occurs when fisheries catch most of the older fish or larger, faster growing fish at a given age. The result is that younger and slower growing fish are left to reproduce. After several generations, only younger and slower growing fish remain in the population. The result is a lowered mean length and weight per given age of fish, and a reduced value of the fishery.

Recruitment overfishing is of greater concern to fishery managers. For example, if most of the fish in a stock spawn for the first time when they are 10 years old, and many of the fish caught are less than 10 years old, then the potential exists to catch a large proportion of the stock before a majority of animals can spawn. This is a form of recruitment overfishing, which means more fish are removed from the stock than can replace themselves. When this type of recruitment overfishing is evident, managers often move to protect the smaller fish by imposing minimum size limits or mesh-size restrictions in an effort to conserve the spawning stock. Unfortunately, protecting small fish does not necessarily prevent another type of recruitment overfishing. Recruitment overfishing also occurs when the fishery harvests too many large, old fish. This reduces the production of larval fish because smaller fish produce fewer eggs than larger fish.

Once the status of a stock is known, fishery managers employ a variety of techniques to maintain the health of the stock. These include use of one or more of the following management strategies:

- Fishing gear restrictions or prohibitions,
- Fleetwide quotas on total fish taken per season,
- Seasons and/or area closures (e.g., refuges),
- Individual quotas on total fish taken (e.g., commercial IFQs, recreational bag limits),
- Size, species, or sex limits, or
- Restricting or limiting access to a fishery.

Once these strategies have been enacted in the form of statutes or regulations and are enforced in the respective fisheries, fishery scientists have a variety of tools at their disposal to assess whether a fishery has met or exceeded allowable biological catch or is presently underutilized. Models are also available to evaluate the performance of a fishery relative to some estimate of optimum economic yield. Most of these methods and models involve some fairly sophisticated mathematical derivations based on mortality rates and age structure of the population. Unfortunately, even with the array of tools used by fisheries managers, many species have been overfished. There are many reasons for this, some of which are:

1. Difficulties in obtaining accurate landing information about species, especially for new or emerging fisheries. Most species sold at the dock are recorded as belonging to a market category. For instance, the “red” rockfish category recorded by fish buyers can contain species such as vermilion rockfish, starry rockfish, or canary rockfish, which have different life histories and stock sizes;
2. Difficulties in obtaining adequate biological data. Basic life history information, such as age and growth, mortality estimates, replacement rates are either lacking or difficult to estimate;
3. Absence of long-term data sets needed to effectively model or estimate the size of fish stocks. Unfortunately, few long-term data sets are available for fished populations. Much of what is known or suspected about Monterey Bay species is derived from relatively short-term data sets. In addition, many of those short-term data sets reside in a variety of locations and are not easily collected for analysis. Time lags between emergence of fisheries, the establishments of data sets, then formal evaluation of the data also limits effectiveness of models;
4. Difficulties in managing mixed fisheries, or fisheries in which more than one species is caught at the same time. In these cases, management options are more limited if the stock of one of the species caught is healthy while the other is depleted;
5. Spatial and temporal variation in fish abundance, leading to localized depletions;
6. Environmental changes that affect survival of year-classes;
7. Difficulties in estimating bycatch and discard of animals inadvertently caught while fishing for the target species;
8. Societal desire to maximize short-term economic gain to coastal communities;
9. Overcapitalization of the fleet (too much fishing power), causing the total allowable catch (TAC) to be exceeded before managers can close the fishery;
10. Enforcement problems, such as poaching.

Regulatory Process

In the United States, most fish stocks are a common property resource, meaning there is open access for utilization of the resource. Often in the case of common property resources, many harvesters tend to maximize their short-term benefits, without regard to long-term costs. When this occurs, each participant in the fishery has little incentive to conserve the resource. If they don't harvest their share or more, another fisher will simply harvest the resource. Historically, common property resources have thus been subject to inadvertent overexploitation, a phenomenon that has been called the "tragedy of the commons."

This situation, combined with the substantial social, economic, and ecological impact of fisheries, provides the rationale for fisheries management. Regulations pertaining to the commercial harvest of species are derived from a combination of federal statutes and state law. Fisheries for species that are migratory in nature, occur entirely in federal waters, or that have wide distributions are regulated by federal laws administered by the National Marine Fisheries Service. Commercial fisheries for many species taken within state waters are regulated by the California Fish and Game Commission, as mandated by the MLMA of 1999 (see Marine Life Management Act Section for more information). In cases where there is no state law or where state and federal laws overlap, federal statutes usually take precedence. In special cases, such as for some salmon species and for specific ecological reserves, local or tribal regulations provide guidance for fishery managers. An additional special regulatory process occurs when a stock of fish is harvested by more than one nation. In these cases, international fishery management councils may be established. Often, when just two countries are involved, fishery management will be determined through a treaty process. In some cases, the two nations do not agree on stock estimates or management strategies and the fishery is regulated by both (or neither) country.

Pacific Fishery Management Council

The Fishery Conservation and Management Act (FCMA) of 1976 created the Pacific Fishery Management Council (PFMC). The PFMC is one of eight regional fishery management councils that were created to advise NMFS on fisheries management issues; it has responsibility for federal fisheries management on the West Coast of the United States. The voting members of the council include a representative from each state fishery management agency on the West Coast (including Idaho), a mandatory appointee from each state, at-large appointees from the states in the region, and the regional director of NMFS. The councils produce fishery management plans (FMPs) with public input, which describe the nature and problems of a fishery along with regulatory recommendations to conserve it. After approval by the Secretary of Commerce, regulations that implement management measures in the fishery management plans become federal law and are enforced by NMFS and state agencies.

National Marine Fisheries Service

The National Marine Fisheries Service is part of the National Oceanographic and Atmospheric Administration (NOAA), an agency in the U.S. Department of Commerce. It is the federal agency with primary responsibility for implementing fisheries management strategies in the United States EEZ from 3 to 200 miles from shore. The National Marine Fisheries Service has a broad array of duties relating to marine resource management. A primary responsibility is to provide scientific information for use in fishery management plans. Researchers from NMFS conduct field surveys to gather basic biological data, publish scientific articles, and learn about the variables that influence survival at critical stages in the life history of a species. They collect information about critical habitats for a species as well. Additionally, NMFS scientists model population dynamics of species, using data from research cruises and fishery landings. The models are then used to develop stock assessments, which are delivered to the NMFS staff that supports the PFMC regulatory process. Once fishery management plans are enacted, and regulations promulgated, NMFS fishery enforcement officers work with the U.S. Coast Guard and coastal states to enforce regulations.

California Department of Fish and Game

The California Department of Fish and Game (CDFG) has primary management responsibility for species that occur entirely within the state's three-mile territorial sea, and also those that are not managed by the federal government. The California Department of Fish and Game has several important functions in the process of fishery management within the state. One of their primary duties is to regulate fishing activity through licensing of fishing vessels and fishers. The California Department of Fish and Game is responsible for the enforcement of existing statutes and regulations regarding fisheries within the state. The California Department of Fish and Game also collects a great deal of fishery data by monitoring regional fisheries, both aboard vessels and dockside. The data collected from these monitoring programs are used to make recommendations to the PFMC and State Fish and Game Commission, publish scientific articles, maintain long-running databases of catch statistics for all regions, and produce annual commercial and recreational fishing reports and provide information to the public.

Following preparation of a fishery management plan by PFMC and subsequent approval by the U.S. Secretary of Commerce, the director of CDFG for the state of California has several options to conform state law or regulations to the fishery management plan. These options center on the ability of the director to either suspend existing laws and regulations that conflict with the fishery management plan, modify existing laws and regulations to conform with the fishery management plan, or enact new laws for a limited period (up to one year) to comply with the fishery management plan. In rare cases, the state will choose to enact regulations that do not comply with fishery management plans.

Pacific States Marine Fisheries Commission

Authorized by Congress in 1947, the Pacific States Marine Fisheries Commission is one of three interstate commissions dedicated to resolving fishery issues. Representing California, Oregon, Washington, Idaho, and Alaska, the PSMFC does not have regulatory or management authority; rather it serves as a forum for discussion, and works for coastwide consensus on management strategies. PSMFC also addresses issues that fall outside state or regional management council jurisdiction. PSMFC's goal is to promote and support policies and actions directed at the conservation, development, and management of fishery resources of mutual concern to member states through a coordinated regional approach to research, monitoring, and utilization. It plays an important role on the West Coast by being the primary agency responsible for collecting, storing, and providing fishery data from each state for coastwide analysis.

Fishing Organizations

Fishing organizations play an important role in fishery management. In addition to the information generated from fishery logbooks, many fishers work closely with researchers and fishery managers to design studies and collect information necessary to craft effective fishery regulations. Often, fishing organizations help by encouraging their members to collect and provide additional information for managers.

In addition to numerical data, fishers provide information on the practical aspects of fisheries. Often, state and federal fishery plans and regulations can have several different designs that meet similar management objectives. Individual fishers and fishing organizations provide resource managers with ideas for regulations to maximize economic returns or to improve the flexibility of fishing options. In this manner, input from fishers often helps make management actions more practical and enforceable.

Public Involvement

The state legislature, CDFG, NMFS, environmental organizations, and the general public make recommendations to PFMC about FMPs affecting federally managed species. Public hearings are required by law to be held in the area of the fishery under consideration after recommendation of a fishery management plan by PFMC to the Secretary of Commerce. It is the responsibility of the director of the Fish and Game Commission to arrange times and places for the public hearings as well as provide adequate notice to the public and appropriate policy committees in the state legislature.

Key Fisheries Legislation

Magnuson-Stevens Fishery Conservation and Management Act/Sustainable Fisheries Act

The Fishery Conservation and Management Act (Public Law 94-265) was enacted by Congress in 1976. This law authorized the federal management of fishing from 3 to 200 miles offshore, an area denoted as the EEZ. The main objectives of this act were to provide sustainable fishery management, promote stock conservation, and eliminate foreign fishing activity within the EEZ. The FCMA set up eight regional fishery management councils to adopt and implement management plans in conjunction with NMFS. Each regional fishery management council consists of state, federal, and regional representatives with expertise in marine fisheries and the special concerns of the region. The interests of fishermen and the general public are also incorporated through individual participation in the regulatory process. The council is required to create a plan that aims to protect fish stocks and at the same time allocate fishery resources to maintain the sustainable harvest of a fishery by commercial and recreational fishing interests.

In 1996, Congress reauthorized and amended the FCMA by passing the Magnuson-Stevens FCMA, also known as the Sustainable Fisheries Act (SFA). The main changes made to the Magnuson-Stevens Act were in regards to issues of overfishing, rebuilding stocks, reduction of bycatch, and protection of fish habitat. The implementation of the SFA added additional national standards to guide fishery management plans and fishery regulations. The SFA set out ten national standards to guide the management of United States fisheries. These guidelines emphasized conservation, fair allocation, the use of best available scientific data, optimum yield (OY), and sustainability of resources.

The SFA has resulted in an increase in regulations that minimize the chances of overfishing, minimize bycatch, and preserve essential fish habitat. The SFA guides the federal management of fisheries in offshore waters and aims to protect the future of the nation's fisheries. Thus far, the regional councils have implemented 35 FMPs designed to protect those species or groups of species considered vulnerable to overfishing and in need of management. A good summary of the SFA is provided in Wallace and Fletcher's 2000 book: *Understanding Fisheries Management: A manual for understanding the federal fisheries management process, including analysis of the 1996 Sustainable Fisheries Act.*

Marine Life Management Act

On January 1, 1999, California's Marine Life Management Act (MLMA) was signed into law, redefining the State's marine living resource policy. The primary goal of the MLMA is to establish sustainable fisheries through the restoration and conservation of fisheries and ecosystems, including nontarget species and habitats, while also maintaining healthy, growing commercial and recreational fisheries. The MLMA is particularly notable for this emphasis on all marine wildlife that affect and are affected by fisheries, not just commercially and recreationally caught fish and invertebrates. The MLMA recognizes that California's living marine resources are important to many different groups on varying levels; the overriding objective is to therefore ensure that such resources are sustainable on a long-term basis, but also accessible and usable to the citizens of California.

The MLMA effects a notable change in state resource management responsibilities by delegating the authority over commercial fisheries from the State Legislature to the California Fish and Game Commission and the California Department of Fish and Game (CDFG). Under the guidelines and procedures of the MLMA, the Department and Commission may develop and adopt management plans for current recreational and commercial fisheries within California waters (within three miles of shore), as well as identify and manage emerging fisheries (i.e., fisheries not currently regulated). While the National Marine Fisheries Service will retain management of certain species (such as groundfishes, salmon, and coastal pelagics) out to the 200 mile Exclusive Economic Zone, the Commission has the authority to include additional regulations that build upon any current federal regulations. Additionally, for commercial fisheries not delegated by law to the Commission and Department, management plans may be prepared and adopted, but final implementation must be conducted through legislation.

All management decisions created under the MLMA will be based on the best scientific data available for each fishery, including life history information, fishery assessments, ecological requirements of the fishery, and conservation measures. External peer review panels, determined by nonadvocacy organizations, will evaluate all key documents for their scientific merit and determine if the documents are based on sound scientific knowledge and methods.

One objective of the MLMA is to create a more comprehensive approach towards marine resource management. To accomplish this task, FMPs will be developed for each fishery. The FMPs, developed by CDFG, are planning documents that amass all fishery information and

Table 5. Species included in the Nearshore Finfish Fishery Management Plan.

Common Name	Scientific Name
Black-and-Yellow Rockfish	*Sebastes chrysomelas*
Black Rockfish	*Sebastes melanops*
Blue Rockfish	*Sebastes mystinus*
Brown Rockfish	*Sebastes auriculatus*
Cabezon	*Scorpaenichthys marmoratus*
Calico Rockfish	*Sebastes dalli*
California Scorpionfish	*Scorpaena guttata*
California Sheephead	*Semicossyphus pulcher*
China Rockfish	*Sebastes nebulosus*
Copper Rockfish	*Sebastes caurinus*
Gopher Rockfish	*Sebastes carnatus*
Grass Rockfish	*Sebastes rastrelliger*
Kelp Greenling	*Hexagrammos decagrammus*
Kelp Rockfish	*Sebastes atrovirens*
Monkeyface Prickleback	*Cebidichthys violaceus*
Olive Rockfish	*Sebastes serranoides*
Quillback Rockfish	*Sebastes maliger*
Rock Greenling	*Hexagrammos lagocephalus*
Treefish	*Sebastes serriceps*

management alternatives. Specifically, FMPs are to include detailed descriptions of each fishery, both biologically and historically, habitat requirements of fishes, and information on bycatch and discards within the fishery. Prevention of overfishing and the rebuilding of depressed stocks are primary concerns of each FMP, so status of each fishery will also be classified, setting standards to determine when a fishery is considered depressed or overfished. For a good description of the MLMA, see Weber and Heneman's 2000 book: *Guide to California's Marine Life Management Act.*

Currently, FMPs are being developed for five fisheries (market squid, nearshore finfish, white seabass, abalone, and Pacific Ocean shrimp), but the Department has recognized the nearshore finfish (Table 5) and white seabass fisheries as most in need of FMPs. Whereas the state's major white seabass fishery is in Southern California, fifteen of the nineteen species listed as nearshore finfish show significant catches in the Monterey Bay National Marine Sanctuary. As a group, the nineteen species show a rise in catches in the MBNMS coincident with the rise of the Central California live-fish fishery that relies heavily upon nearshore fishes. Recreational catches, after a peak in 1997, have shown a decline within the Sanctuary (Fig. 17).

Marine Life Protection Act

The idea of setting aside specific areas of marine habitat for restricted purposes is long-standing, but the explicit use of marine protected areas (MPA) as an alternative management scheme for worldwide marine ecosystems has only been seriously considered since the late 1950s. California established its first MPA (the Point Lobos Marine Reserve) in 1960. In California, MPAs are considered a subset of Marine Managed Areas (MMAs) and are distinguished from the latter by the inclusion of regulations concerning the harvest of marine organisms that are more restrictive than the general CDFG regulations. Since the 1950s, a total of 104 state and federal MMAs have been established in Californian waters, of which 52 are considered MPAs.

In February of 1999, the MLPA was added to the California Fish and Game Code to explicitly deal with the use of MPAs to conserve marine resources in California. Similar to the MLMA, the MLPA recognizes the educational, recreational, scientific, socioeconomic, and environmental importance of California's living marine resources, and the need to protect them from potentially destructive entities such as pollution, coastal development, and other destructive human activities. Along with the modification of current MPAs, a process of abolishing or establishing new MPAs is also required by the MLPA. The following is a list of six primary goals of the MLPA to be used as guidelines to formulate MPAs:

1. To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
2. To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
3. To improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.
4. To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.
5. To ensure that California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines.
6. To ensure that the state's MPAs are designed and managed, to the extent possible, as a network.

The California Department of Fish and Game has begun a process to designate MPAs that fulfill the requirements of the MLPA. Constituent involvement and input is important in the plan preparation, with all final decisions and recommendations based on the best available scientific knowledge. The following components are to be included in the plan:

- Recommendations for the extent and type of habitat that should be included in MPAs.
- A list of species and groups of organisms that may benefit from MPAs—including their habitat and ecological requirements and dependent oceanographic conditions.
- An analysis of current MPAs, with recommendations on the adequate size, number, and siting of each MPA, and proposed alternatives to current networking of MPAs.
- Recommendations for monitoring and research within the proposed MPA network to assist in the adaptive management of the system.
- Recommendations for management and enforcement to ensure appropriate and effective protection of each area under designation.

Further information can be found by visiting the CDFG's website (www.dfg.ca.gov/mrd/mlpa).

Current Management Issues

Maintenance of Economically Viable Fisheries

Commercial and recreational fisheries have provided economic benefits and an important cultural heritage to the Monterey Bay region. A current concern is the need to ensure that fisheries maintain economic viability so they can continue to provide social and economic benefits to this region. Fishery products are now shipped all over the globe. In most cases, fishery products purchased from a distant country cost less than comparable products from this region. Prices of fuel, insurance, and supplies needed to operate and maintain vessels have increased. These increased costs have caused some fishers to move or go out of business, and most fishers are attempting to harvest as much as they can to increase their revenues. Aquaculture has grown substantially in recent years, competing directly with the fishing industry by offering consumers an alternate source of seafood. Additionally, the fishing industry has seen a decline in subsidies, such as federal funding for dredging of ports, funding for weather buoys at sea, or low-interest loans for vessel construction and maintenance. One way to help maintain the economic viability of fisheries is for coastal communities to recognize the special needs of fishery and fish processing businesses. Future land use and fishery management decisions should account for the need for local fishers and processors to operate more effectively so they can compete in world markets. Increased harvest of underutilized species is another way that fisheries may adapt and maintain economic viability. Fishers can also increase or add value to existing target species through strategies such as export marketing, or selling live fish to local fish markets and restaurants. The fishing industry, coastal communities, and consumers will all benefit by long-term sustainable fisheries.

Overcapitalization

In the last 30 years, the rapid increase in electronic fish finding and catching technology, combined with an increased number and size of fishing vessels, has led to greater harvesting capability than fish populations are capable of supporting. The increase in global trading of fishery resources has exacerbated this problem. Most fishery scientists agree that the excess of fishing capacity is the primary cause for overfishing in the world, and that fleet overcapacity is the single most important factor threatening the long-term viability of harvested fish populations. Fishing capacity needs to be brought into line with harvest capability in most marine fisheries. In addition to biological problems, excess fishing capacity can pose social problems as well, such as conflicts for fishing space. The Monterey squid fishery is an example of social conflicts caused by a large number of boats fishing in a small area with no set catch quota.

On a global scale, fishery managers have been addressing the problem of overcapitalization by using a variety of management tools such as limited entry programs, harvest rotations, gear limitations, vessel buy-back strategies, and individual quota systems. The global experience to date indicates that one technique alone (e.g., limited entry) is not sufficient to limit overcapitalization.

Catch Allocation

When the harvest of a stock is restricted, fishers often find themselves competing for fish. In these cases, fishery managers attempt to protect fishery resources while equitably allocating the allowable catch. To do so, fishery biologists first determine the TAC for a stock based on the best available scientific information. Resource managers then allocate harvest to different sectors of the fishing industry in an attempt to maximize economic benefit to local communities while reducing the risk of overfishing. In an attempt to be fair, catch allocations are often partitioned on the basis of historical catch records. Ideally, the entire allocation for a fishery will not exceed the scientific estimate of total allowable catch. Unfortunately, this is not always the case because of political, social, and economic considerations.

One of the innovations regarding allocation that has achieved some success around the world is the implementation of individual fishery quotas or shares (IFQs or IFSs). Individual fishery quotas are similar to the ancient practice of "catch rights" in which a fisher is entitled to a certain proportion of the TAC. Some countries have found that the IFQ system improves economic performance, while reducing social conflicts and the potential for excess harvest associated with overcapitalized fisheries. Catch IFQs are usually implemented along with a limited entry system that places a cap on the number of vessels allowed in a fishery. After the initial allocation set up by the IFQ system, market demand guides actual fishing effort and economic return of participating fishers. Although IFQs have proven to be effective in some situations, they have received limited acceptance in the United States because many fishers believe IFQs concentrate fishing (and thus market) power in the hands of a few people.

Multispecies Fisheries

Many fishes and invertebrates occur together in time and space, and thus are often harvested together. In many multispecies fisheries, vessels harvest both abundant and depleted populations of fishes. In the groundfish fishery, for example, rockfishes, flatfishes, and roundfishes (e.g., lingcod, sablefish, or Pacific hake) are often caught together in a single trawl tow. The species in these groups each have different life history strategies and population abundances. Some of the species caught in multispecies trawl fisheries are long-lived, have low reproduction rates, and currently have low population sizes. Others are fast growing, highly productive, and are currently abundant. Managing trawl fisheries on a species-specific basis can thus result in excessive waste of abundant fishes or overharvest of depleted species.

The issue that resource managers face is how to maximize catches of abundant species while minimizing catches of species with low population sizes. In response to this issue, PFMC managers have enacted limited entry programs and set trip limits on species complexes, or co-occurring species groups. Many rockfish species, for example, are managed as part of the *Sebastes* complex with catches regulated by limited entry, trip limits, and cumulative catch limits by month. A problem with this management strategy is that it limits catches of abundant species; and limits the options of individual fishers. Many fishers have the capability to change gear type or target species in order to increase landings of species with high abundances or values, often reducing fishing pressure on low abundance species. With the limited entry system, a fisher may be prohibited from changing gear type to participate in a fishery for which an entry license is unavailable. Thus, fishers are sometimes forced to remain within a given fishery, even if fish abundances and landings are low.

Bycatch of Nontarget Species

The inadvertent catch (bycatch) of unwanted fish or invertebrates that are captured together with target species is a problem in some fisheries, especially those using bottom trawl gear. This potential waste or inefficient use of marine species may have large economic and ecological consequences. For example, the removal of an important food item (prey species) through bycatch may adversely affect another species, which eats that prey. In addition to the unknown ecological consequences of harvesting nontarget species, bycatch can be a problem when undersized commercial or sport fish species are collected. These small fishes may be of the same species for which the fisher is targeting, but have no economic value, or may be below the minimum size limit imposed by management agencies and therefore be illegal to catch. The bycatch of undersized species may increase fishing mortality estimates and thus decrease the amount of larger fish available for harvest.

Bycatch occurs in almost all fisheries. To minimize mortality caused by bycatch, managers implement tools such as minimum mesh size restrictions, season or area restrictions, and other management methods. A management method that has been suggested by some scientists is to implement individual bycatch quotas, whereby a vessel stops fishing after a level of bycatch is reached. Placing a limit on the bycatch of each vessel encourages skippers to fish in areas in which their catch is “cleaner” (has less bycatch). Some insightful fishers are also experimenting with new net configurations, inserts, or designs to reduce bycatch in trawl fisheries. Managers are also exploring new ways to gain insight into actual bycatch rates by issuing experimental fishery permits (EFP). These permits allow fishing under relaxed regulations in order to provide on-board observers opportunities to measure the actual amount of bycatch and discard (see below) occurring within a fishery.

One particularly notable example of high bycatch within the MBNMS is the commercial set gill net fishery. Set gill nets are an effective way to catch California halibut, but they have also contributed to mortality of sea birds, harbor porpoise, and sea otters. Karin Forney of the NMFS estimated that from 1991 to 2000, 16,000 common murres and 450 harbor porpoise accidentally died in the set gill net fishery. Evidence of continued high bycatch of birds prompted the CDFG in late 2000 to enact a series of emergency closures to move the set gill net fishery to waters deeper than sixty fathoms in Central California. There is a new regulation being proposed for permanent adoption that will restrict gill or trammel nets to ocean waters which are sixty fathoms or greater in depth at mean lower low water from Point Reyes to Point Arguello, essentially closing down the Central California halibut set gill net fishery in this area.

Discard

Discard is a specific type of bycatch, as denoted by the California Fish and Game Code as fish taken but not retained in a fishery. In almost all fisheries, some fish are discarded at sea. The numbers, types, and sizes of the species that are discarded are influenced by management regulations and market conditions. For example, some fishers discard undersized or lower-valued fish or invertebrates to meet size or sex regulations, remain within quotas, or make space for economically more valuable species. This occurs in all fisheries. For some species, mortality associated with discard is low and thus is not considered to be a problem. For other species such as rockfishes, however, mortality related to discard is very high. When unreported, these discards make fishing mortality more difficult to estimate, making stock assessments more uncertain and management decisions more challenging. Unreported discard is of special concern for highly regulated or protected species.

Many management techniques are used to lessen the problem of discard. One of the most common methods of lowering discards is the use of selective gear, such as traps or nets with larger mesh size. This method is most effective with stationary nets. As nets are pulled through the water, the net fills and effective mesh size decreases, thus lowering the selectivity of the net. Area or seasonal closures are successfully used for some species, but may simply redirect the mortality to different areas or fishes. In a few cases, managers have crafted regulations to favor fisheries that are more selective and result in fewer discards.

A more drastic measure is the total prohibition of discards, or enforcement of full use of catch. This technique is not currently in use because it would be difficult to enforce and greatly reduces profitability of fisheries. If fishers were prohibited from discarding any of their catch, average total value of landings would be reduced, trip lengths would be shortened, and additional equipment and production costs would be required to process the additional sizes and species that are not offset by the added value of the products. One of the most successful techniques for reducing fish discard is employed by experienced fishers who reduce discard by knowing when, where, and how to fish for target species.

Enforcement

Fishery management agencies have several ways to monitor fishing practices, quotas, and regulation compliance. One of the principal methods is the use of fishery logbooks, which are voluntary in some fisheries, and required in others. In fisheries with mandatory logbook programs, fishers are required to keep a log with information on when and where they fished, how long they fished, the gear they used, and the estimated catch by species during a given fishing trip. These data are then collected and used with landing data to evaluate trends in catch. Occasionally, management agencies institute observer programs to collect additional information at sea on abundance, size, and species composition of catches and discards.

All fish buyers are required to provide CDFG with records of the type and amount of product they purchase from fishers. These records are termed landing receipts or "pink tickets"; they are collected and summarized by CDFG, then collated on a coastwide basis by the Pacific States Marine Fisheries Commission. This record keeping system is the primary method by which management agencies determine if catch quotas are met or exceeded. This method is obviously contingent on fishers and buyers providing accurate information. State and federal fisheries enforcement officers and auditors periodically visit docks and processing plant offices to monitor catches and watch for violations of regulations. Fishery biologists also get some feeling for regulation compliance as they collect biological information at the dock.

The California Department of Fish and Game, NMFS, and U.S. Coast Guard enforcement officers work together to patrol fishing grounds, board fishing vessels, and check for violations at sea. In the past, these efforts have been under funded, however, resulting in an irregular and infrequent enforcement schedule at sea. There have been increased efforts in recent years to secure more boats and personnel for fisheries enforcement. Also, some resource managers have discussed ways to increase the efficiency of at-sea fishery monitoring by requiring fishing vessels to install electronic transmitters. The transmitters would enable enforcement officers to use satellite technology to track fishing vessel traffic in closed areas or during closed seasons. Many fishers have felt this is a violation of their privacy and constitutional rights, however.

Given the complexity of fishery regulations and the difficulties enforcing regulations, the effectiveness of fisheries management policy is currently determined as much by the level of voluntary compliance as by enforcement activities. Compliance is influenced by a number of factors such as whether fishers or their peers agree with regulations, think they or others can violate rules without being caught, or believe the magnitude of the punishment (e.g., fine) is small compared to potential economic gains. Probably the most effective method of enforcement is getting fishers to agree that management rules are necessary and good, so they voluntarily choose to comply.

Need for More Scientific Information

More scientific information is needed to achieve sustainable fisheries for many populations. Information is not only needed on population abundance and critical life history stages, but also on the interactions between species, the effect of harvest activities on marine habitats, and the effect of environmental change on marine fishes.

Accuracy of stock assessments has improved with an improving information base regarding marine fisheries. Nevertheless, fishers and managing agencies agree that more research cruises and fishery information are needed to improve current stock assessments. Currently, stock assessments are not available for the majority of species harvested in the MBNMS. Attempts to increase funding and to obtain more reliable and accurate data from research cruises and from the fishers are ongoing. In the last few years, managers and fishers have been working more closely to expand upon and improve the use of fishery data in stock assessments. Still lacking, however, is a method for using the vast body of knowledge embedded in the minds of fishers. People who spend most of their lives on the oceans have a great storehouse of knowledge that unfortunately is not always in a form accessible to stock assessments. More efforts need to be made to devise ways that fishers and resource managers can combine this knowledge.

Cost Recovery

Government moneys from taxes and fees are used to support fisheries research and management programs, and there is a growing concern about the amount of money spent relative to economic gain. As fish populations decline, the total value of the landings usually shows a corresponding decline, and the cost of research and management increases relative to economic benefits. In extreme cases in which harvest of a depleted species is prohibited, the cost of research and management exceeds the ex-vessel value of the fishery. Although public funds for endangered species are available, securing public funds for industries with low cost/benefit ratios can be difficult. The economic cost/benefit of fisheries management is impossible to address without considering the full range of social benefits provided by fisheries. Sustained availability of high protein food resources, the creation of jobs, and the retention of cultural identity associated with fishing communities all increase the benefits of fisheries above that of strictly ex-vessel value.

The question of who should pay for research and management programs becomes more complicated for limited access fisheries. Limited entry and IFQ management techniques restrict access to fish resources to a set number of people. By limiting access, managers hope to improve resource conservation and increase economic viability of a fishery. Certainly, permitted fishers have a greater incentive to conserve and manage the resource for their future use, and may have a better chance of reaping a profit. But should general fees and taxes be used to manage a fishery that is no longer a common property resource? Fishers without access submit that their tax money is being used to manage fisheries from which they are restricted. Funding for limited access fisheries in the future may thus be based on fees generated by those with vested interests; the revised FCMA allows for increased use of fees in the limited access and IFQ programs.

Alternative Management Strategies

Some people believe that the current method of allocating catch in open access fisheries is destined to create fishery collapse. This argument is based on the assumption that people setting management strategies will always err on the side of maximizing catches (food) for people. When catches are always maximized, the risk or potential for population instability increases, and environmental change can make fish stocks crash. Proponents of this argument suggest that alternative management strategies are needed to protect fish stocks.

Fishery managers are beginning to consider a variety of alternative resource management strategies. For example, area management, and rotating open and closed fishing zones have proven to be successful techniques for some shellfish fisheries. Those management tools work well for sedentary animals that are highly productive with short life spans. IFQs, individual fishing effort quotas, and gear certificates that limit the amount and type of gear used have worked in some parts of the world. Occasionally, the effort or catch allocations are sold in a bidding process. Community quotas, in which the allowable catch is distributed by a local political group to a community, are being implemented in parts of the world as a new implementation of an old concept.

One alternative strategy that has recently received a great deal of interest is the use of marine reserves (or "harvest refugia") as a means to help protect declining fish stocks (see Marine Life Protection Act section for more details). There is some evidence to suggest that excluding fisheries and other extractive activities from reserves may be an effective method to help replenish depleted stocks. There is clear evidence that refugia show increased numbers of animals and increased diversity relative to surrounding exploited areas. Proof that these newly

Table 6. Live-fish fishery landings, value, and price per pound (adjusted for inflation to year 2000 values) for landings within the MBNMS from 1993–2000.

Year	Landings (lb)	Value	Price per lb
1993	25,429	$47,233	$2.02
1994	361,046	$760,149	$2.24
1995	356,119	$868,162	$2.31
1996	384,018	$1,000,081	$2.14
1997	488,988	$1,546,566	$2.33
1998	923,584	$2,652,648	$2.68
1999	561,236	$2,170,536	$3.37
2000	340,983	$1,495,411	$4.18
Total	3,441,404	$10,540,785	$2.66 (avg.)

regenerated and highly localized populations will significantly increase abundances in the exploited areas is slowly emerging. Several small harvest refugia are located along the shoreline in the MBNMS. Although they may be beneficial for some nearshore invertebrates and fishes, they are currently neither sufficiently large nor sufficiently diverse to protect most species that are commercially fished.

Emerging Fisheries

Historically, the early developments of new fisheries occur in the absence of fisheries information. Several years of fishery data are needed before a management agency can adequately regulate harvest. In some cases, fisheries have started, then failed because of a lack of a suitable market, or problems with product quality. In other cases, however, new fisheries have decimated populations before managers were able to enact reasonable management strategies. For these reasons, emerging fisheries are challenging for fisheries managers and often require inventive and innovative approaches to fisheries management.

Over the years, the Monterey Bay region has experienced several short-lived fisheries. Often the new fisheries exhibited patterns of boom and bust, with an initial period of rapid expansion followed by a rapid decline in landings. A large hagfish fishery, for example, was established in San Francisco and Monterey areas in 1988. This fishery increased steadily through 1990, but declined in 1991 and 1992 because of a decrease in market price.

Often, however, new fisheries collapsed because harvest exceeded the biological capability of the population. Sharks, for example, take a long time to reach maturity and have a relatively low reproductive output, making them susceptible to overfishing. Sixgill and sevengill sharks are early examples of short-lived fisheries. These sharks were the most common species taken in the shark fisheries in the 1930s and 1940s, until the populations collapsed in the early 1950s. The highly migratory basking shark was the target of small, localized harpoon fisheries off California for more than 80 years. Basking and soupfin shark landings peaked in the 1940s and 1950s due to high demand for the oil-rich liver. This fishery quickly collapsed because of declines in stocks and the availability of alternate sources of oil. A commercial fishery for thresher shark was established in 1977, but lasted only 10 years until overfishing necessitated strict regulations. Short-lived fisheries have also existed for species other than sharks. More examples of important commercial fisheries that have grown, then quickly declined can be found in Leet et al. *California's Living Marine Resources: A Status Report* (2001).

Live/Premium Fish Fishery

Arguably the most rapidly developing fishery to emerge in recent years is the nearshore live/premium fish fishery. In this fishery, small boats and skiffs, kayaks and even surfboards are used to set baited hooks or traps in water less than 30 meters deep. Captured fish are held in aerated containers and transported live or are killed, iced and shipped (as "premium fresh") directly to seafood markets and restaurants locally and globally. The high demand for live fish has created a worldwide market with prices per pound well above that of traditional commercial fisheries (Table 6), thus increasing the value of catches and attracting more fishers to the fishery.

The fishery emerged in the mid-1980s when commercial fishers, displaced by reduced salmon and groundfish catches, increased regulation of gill net fisheries, and the implementation of limited entry programs, started to feed the demands of local restaurants for live fishes. The fishery began in Southern California as a trap fishery primarily for sheephead, but quickly spread up the California coast. In the early 1990s, the fishery expanded to Central California, and in 1995 the region recorded the highest catches in California, with the majority of catches caught using the various hook-and-line and trap methods. The number of vessels in the live-fish fishery increased ten-fold from 1989 to 1999: from 76 to 819 vessels. Within the MBNMS, catches and catch values steadily rose to a peak in 1998 (Table 6). In California for the year 1999, 46% of all reported live-fish catches were taken in the area from San Luis Obispo to San Francisco, with Morro Bay the leading port for live-fish landings in California.

The fishery also moved from a limited target fishery to one that included almost 100 species. As regulations on specific species increased, the number of new target species harvested also increased. Initially, sheephead, cabezon, lingcod, greenlings, and nearshore rockfishes were the most desired fishes to catch, however fishers began to target thornyheads as landing limits on nearshore rockfishes decreased. Unfortunately, the life histories of many species caught in the live-fish fishery are poorly understood. For the few species with dependable life history information available, their sedentary nature, slow growth, and late ages of maturity make them vulnerable to overfishing by the live-fish fishery. Preliminary studies have shown an overall decline in the average size, weights, and catch rates of cabezon and rockfishes in the sport fishery since the late 1980s. These characteristics are indicative of stressed populations that may be unable to withstand increased fishing pressure. In the last decade, however, fishing pressure on nearshore populations did increase because of the overlap of the live-fish fishery with traditional nearshore recreational fisheries.

Biologists were concerned about the indicators of stressed nearshore populations by the mid-1990s, but management of the nearshore live-fish fishery was slow to occur because of the nontraditional nature of the fishery. Most fish were caught from very small boats and quickly shipped to restaurants and markets without documentation of the catch. When catches were reported, often fish were misidentified or lumped into broad categories that masked actual catch composition. Regulations to solve these problems were implemented in the late 1990s (the Nearshore Fishery Management Act, enacted concurrent with the MLMA). In 1999, the state required limited entry permits of fishers in the previously open live-fish fishery. Also in 1999, size limits for ten species were implemented in the live-fish fishery. Complicated regulations that close certain days of the week to fishing have also been implemented to protect the stocks of those fish targeted in the live-fish fishery. Currently, various monthly closures and catch limits have greatly reduced allowable catches, and further management action is expected with the formulation of a Nearshore Fisheries Management Plan (see Marine Life Management Act section for further information).

Protected Species

The federal and state governments have enacted legislation to provide specific protection for all marine mammals and some fish species. In most cases, the resulting regulations have successfully conserved or enhanced the population of protected species. These regulations, however, have also affected fishery operations for those species for which there is a direct competition between humans and the protected species. Two obvious instances of competition for fishery resources in the MBNMS involve sea lions/salmon fishers and sea otters/abalone fishers. Many sea lions have learned to follow vessels fishing for salmon and attack the hooked salmon before they can be brought aboard the fishing vessel. As sea lion populations have grown, conflicts with fishers have increased. In some years, fishers relate that sea lions take a large proportion of the salmon they have hooked. This is especially true when salmon populations are high. Mike Weise reported in his thesis (Moss Landing Marine Laboratories) that sea lion predation on salmon hooked in the CPFV fishery has increased since 1983 (5.2% in 1983, 10.5% in 1995, 13.7% in 1997, and 26.3% in 1998). The take of legal-sized hooked salmon can be even higher in the Monterey Bay skiff fishery, with 31% taken by sea lions in 1998. This was also a large increase compared to 1983 (1.4% taken that year). The result is an increased mortality of salmon and a decreased yield to the fishery. Increased take of hooked salmon by sea lions in both of these fisheries in 1998 may likely be a result of the 1997–98 El Niño, which caused major declines in the availability of common sea lion prey, such as squid, hake, and herring, in the Monterey Bay. Loss to commercial fisheries has also been estimated. Annual loss of revenue in Monterey Bay from sea lion/angler interaction in the commercial salmon fishery ranges from $4,300 to $10,800 per fisher, depending on the number of people fishing in Monterey Bay. Combining the other ports within the MBNMS, total annual losses may reach $2 million or more. Similarly, there is a direct competition between sea otters and abalone fishers. In some locations, the combined harvest by sea otters and humans has severely depleted abalone populations.

Habitat Loss

Increased habitat loss from human activities is a problem of utmost concern to fishery managers and members of the fishing community. Of primary importance is the loss of essential fish habitat that is critical for certain life history stages of species, such as spawning or rearing. In order for fish stocks to remain healthy, they must have adequate spawning, rearing, and feeding habitat. Prey species also need adequate habitats and resources in which to complete their life cycles.

Habitats most threatened by human activities include estuaries and coastal wetlands, eelgrass and kelp beds, and rocky banks. Coastal wetlands and estuarine waters are among the most sensitive, most accessible, and therefore most altered of coastal habitats. They also contain valuable nursery areas for early life stages of many marine species. These important habitats are easily degraded by urban and agricultural development and runoff, and water diversion projects, all of which not only alter habitat, but also drastically reduce the water quality in these environments. Efforts are underway at many levels to reduce the amount of destruction and to restore valuable habitat resources off our coast, thereby enhancing our fisheries.

Fishing activity can negatively impact habitat complexity and in turn affect the species composition and diversity of an area. Fishing activity such as bottom trawling alters structural habitat, important to some species for the completion of their life cycles, and disturbs the benthic community. Since the advent of roller gear in the late 1970s, fishers have been able to drag nets over rougher terrain than before. Trawl nets towed over rocky bottoms alter both species composition and the physical structure of habitats through the direct removal of benthic fauna and structure making habitat more homogenous and less productive. There is compelling evidence that trawling over hard or complex bottom habitats is detrimental. There is less information about the effects of trawling over soft bottom habitats. Generally, trawling is now prohibited in California state waters (within 3 miles).

ENVIRONMENTAL FACTORS AFFECTING FISH POPULATIONS

From both a biological and economic viewpoint, a current description of local fisheries is only a snapshot in time of a larger picture. The physical environment in the Monterey Bay region is very dynamic and greatly influences the population sizes of resident fishes, as indicated by the fact that fish populations have fluctuated for centuries, long before fishing became a factor in stock abundance. For several marine species, population trends in the last 200 years are highly correlated with environmental factors. The dominant oceanographic feature in this area, the California Current, has fluctuated in strength and productivity every 10 years or so for the last 100 years. Zooplankton abundance in the California Current, for example, declined by more than 70% from 1950–91. Paleontological records suggest that larger scale environmental fluctuations have occurred at approximately 55 to 60 year intervals. As the environment has fluctuated, the dominant species inhabiting marine waters off MBNMS, and resulting ecological relationships have also changed. Correspondingly, in the last 100 years, the primary species or species groups, harvested by commercial fisheries have changed several times, as did the composition and character of the vessels used, and people participating in commercial fisheries.

The results of decadal, or longer, oceanographic shifts are evident in fish populations beyond the time of actual environmental change, producing long-term cycles of highs and lows in abundance. One such regime shift in the North Pacific is determined by the mean position and intensity of a seasonal low-pressure area known as the Aleutian Low. In the North Pacific, a clockwise-flowing Central Pacific gyre and a counterclockwise-flowing Alaskan gyre drive water masses. The boundary between these two circulation systems is called the Subarctic Current (or West Wind Drift) and is located at 45–50° N latitude. The Subarctic Current divides into two branches as it nears the coast of North America. One branch, the California Current, flows south, the other, the Alaska Current, flows north.

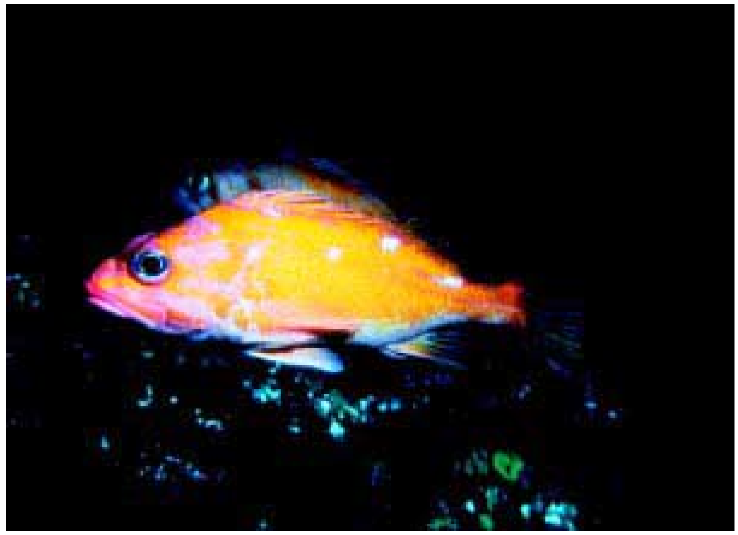
During years that the Aleutian Low intensifies, the location of the boundary between the Central Pacific gyre and the Alaskan gyre moves southward. In those years, the cooler, productive subarctic waters travel shoreward and northward with the Alaska Current. High primary production in the Alaska Current leads to increased zooplankton abundance, and consequently, increased fish production off Alaska and British Columbia. One such event began in the late 1970s and persisted into the late 1980s. During this time Alaska salmon catches were close to historic highs, and strong year-classes of walleye pollock, Pacific cod, Pacific halibut, sablefish, and Atka mackerel were evident. During that time, California Current waters were less productive than in previous years. However, migratory California current species such as sardine, Pacific mackerel, and Pacific hake had major population increases.

Conversely, during years that the Aleutian Low weakens, the productive subarctic waters travel south into the California Current system. When this happens, fish stocks off Oregon and California benefit. In both scenarios, once these strong year-classes have passed through the fisheries, declines in fish production and landings are evident. This natural decline in fish abundance and biomass is difficult to separate from effects of fishing. The results of regime shifts are evident in fish populations beyond the time of actual environmental change, producing long-term cycles of highs and lows in abundance. In the last 100 years, regime shifts occurred in 1925, 1947, 1977, and 1989, and there is some evidence of a shift in 1997. The 1977–88 regime was favorable to groundfish recruitment, whereas the 1989–97 regime resulted in poor survival. Both fishers and biologists hope that a new regime shift will bring favorable conditions to this region.

On a shorter time scale, a global environmental condition termed El Niño has been known to affect many important fisheries. In California waters, an El Niño is expressed as increased water temperature, decreased salinity, onshore and poleward advection of water masses, and delayed annual phytoplankton blooms. For many species, these conditions cause year-class failures. This causes an additional decrease in stock biomass when the failed year-classes are unable to replace losses in the population due to natural and fishing mortality. El Niño conditions have resulted in dramatically reduced squid populations in California, and have had secondary effects on the many species of fish, birds, and mammals that feed on squid. Rockfish recruitment is also documented to be poor during El Niño conditions. Increased water temperatures and delayed production result in poor adult condition and a drop in larval survival. For some species, such as squid and California halibut, El Niño years result in low catches, but the populations rebound to higher levels in following years.

A physical oceanographic condition that acts on a seasonal basis is upwelling. Upwelling occurs off the West Coast of the United States during spring and summer months, when northerly winds drive surface waters offshore. These surface waters are replaced by deep, nutrient rich waters resulting in high levels of primary and secondary production in nearshore waters. The timing and magnitude of upwelling can have a pronounced effect on the survival of many important fish stocks. Excessive upwelling can result in eggs and larvae being dispersed too far offshore, preventing fishes from reaching essential nursery grounds. Too little upwelling leads to a reduction in spring and summer plankton blooms, thus lowering the abundance and quality of food available to fishes. Minimum upwelling also results in a lack of offshore transport, causing eggs and larvae, many of which are adapted for offshore waters, to remain in coastal waters where predation is high. Thus, the effects of seasonal upwelling affect a number of important fish species, both positively and negatively.

Fishery Status of Selected Species



More than 200 species are harvested from waters in the MBNMS. In an earlier chapter, we reported statistical trends for commercial landings of the most frequently caught species from 1981–2000. In this section, we describe the status of knowledge about fisheries and stocks for those species. We grouped species that are caught in similar habitats to provide an estimate of the ecological changes occurring in each habitat type for the period 1981–2000 (Tables 8–12). Five major habitat types were used: 1) nearshore rocky reef and kelp, 2) nearshore soft bottom, 3) deep rocky shelf and slope, 4) deep soft bottom shelf and slope, and 5) open water habitats. Nearshore habitats were defined to be in water depths less than 70 m (Fig. 1). Rocky habitats included mixed soft and hard bottoms.

We grouped species into habitat categories based on known habitat associations and known depth distributions of each species. Some fish utilize a variety of habitats and have a wide depth distribution. In those cases, we placed the reported catch of that species into the habitat category in which it is typically caught. In some cases (e.g., lingcod), the species was caught in a variety of habitats with a variety of gear types. In those cases, we evenly distributed the reported catch into each habitat category.

We sub-divided species in open water habitats into three ecological sub-groups (small coastal pelagics, coastal migrants, and pelagic migrants), based on the life history characteristics of fishes harvested in that habitat. For all habitats, we reported total catches of all species, and also separately reported catches of invertebrates, vertebrates, and selected other taxonomic guilds. For each species, we summarize the fishery trends, relevant life history information, and stock status (if known).

Graphs of reported catches and ex-vessel value are provided; each graph also contains indications of relevant management actions and periods of recorded El Niño-Southern Oscillation (ENSO) events. This information is included to help identify factors besides fishing that may contribute to the rise and fall of catches. Management actions are labeled on each graph. A “G” on a graph, for example, indicates the start of a new commercial gear regulation. A “P” represents introduction of a new commercial permit requirement, such as a limited entry permit system. A “Q” indicates a management action related to a commercial fishery quota, and is usually a reduction in quota. An “S” indicates the implementation of a commercial size limit. Likewise, for the recreational graphs, “f” represents a fishing regulation, “g” a gear regulation, and “s/b” size or bag limit implementation. Appendices F and G include further details about regulations that are highlighted on the graphs.

Nearshore Rocky Reef and Kelp Habitats

Nearshore rocky reef and kelp habitats are primarily located north and south of Monterey Bay, on the open coast in the MBNMS (Figures 2-4). These habitats usually contain nearly flat to high relief rock bottoms that are covered with kelp or other algae. Often, patches of sand, shell, or sandy mud surround the rocky areas. Nearshore rocky reef and kelp habitats are almost exclusively fished using hook-and-line gear, pots or traps, or spears, because trawling and gill netting are prohibited near the California coast. In 1992, commercial fishing with set lines, vertical fish lines, and troll lines within 1 nautical mile of shore (except for halibut and salmon) was also banned. These nearshore habitats therefore have not been as commercially productive as the deeper habitats, comprising less than 2% of the total commercial landings at ports near the MBNMS from 1981–2000 (Table 7). However, nearshore rocky areas became more important in the 1990s as fishing effort greatly increased in these habitats. Annual commercial landings of fishes from shallow rocky habitats averaged about 730,000 lb/yr from 1991–98, almost twice that of the annual landings in the1980s. The large peak in landings in 1989 (Fig. 23) is attributable to an intense spike in red sea urchin catch (Fig. 24). Vertebrate landings from these habitats increased in the early 1990s because of increased participation in the open access hook-and-line and live-fish fisheries (Fig. 25). Subsequent declines in landings later in the decade reflected the decrease in fishing effort caused by increased regulations on nearshore rockfishes, cabezon, greenlings, and other species included in the nearshore fishery management plan (see MLMA section for list). Rock crab, red abalone, red sea urchin, lingcod, cabezon, and rockfishes comprise the majority of landings from nearshore rocky reef and kelp habitats (Table 7). Most of these species were heavily fished in the 1990s, resulting in reduced species abundances. Now, fewer sea urchin are caught, red abalone fisheries are closed, and quotas of most nearshore fishes are low.

Table 7. Primary species landed in commercial fisheries in the MBNMS that were caught in nearshore rocky reef habitats, and the percentage that each species contributed to the landings from this habitat group and the total commercial landings in the MBNMS. Landings from nearshore rocky reef habitats period equaled 18.253 million pounds from 1981–2000. Total landings in all of the MBNMS equaled 1.14 billion pounds from 1981–2000.

Guild	Common Name	Scientific Name	% habitat	% total
Invertebrates				
Crustaceans	Rock crab	*Cancer* spp.	19.9	0.3
Mollusks	Abalone, red	*Haliotis rufescens*	7.5	0.1
	Octopus	*Octopus* spp.	0.5	< 0.1
Echinoderms	Urchin, red sea	*Strongylocentrotus franciscanus*	10.1	0.2
Vertebrates				
Hexagrammids	Kelp greenling	*Hexagrammos decagrammus*	0.2	< 0.1
	Lingcod	*Ophiodon elongatus*	13.8	0.2
Scorpaenids	Black rockfish	*Sebastes melanops*	2.1	< 0.1
	Black-and-yellow rockfish	*Sebastes chrysomelas*	1.5	< 0.1
	Blue rockfish	*Sebastes mystinus*	7.2	0.1
	Brown rockfish	*Sebastes auriculatus*	6.2	0.1
	China rockfish	*Sebastes nebulosus*	2.0	< 0.1
	Copper rockfish	*Sebastes caurinus* (*vexillaris*)	1.3	< 0.1
	Flag rockfish	*Sebastes rubrivinctus*	0.2	< 0.1
	Gopher rockfish	*Sebastes carnatus*	4.6	0.1
	Grass rockfish	*Sebastes rastrelliger*	2.3	< 0.1
	Kelp rockfish	*Sebastes atrovirens*	0.5	< 0.1
	Olive rockfish	*Sebastes serranoides*	2.3	< 0.1
	Quillback rockfish	*Sebastes maliger*	0.3	< 0.1
	Rosy rockfish	*Sebastes rosaceus*	0.9	< 0.1
	Vermilion rockfish	*Sebastes miniatus*	7.6	0.1
Cottids	Cabezon	*Scorpaenichthys marmoratus*	6.0	0.1
Labrids	California Sheephead	*Semicossyphus pulcher*	0.1	< 0.1
Other species	Surfperch spp.	Embiotocidae	2.9	< 0.1

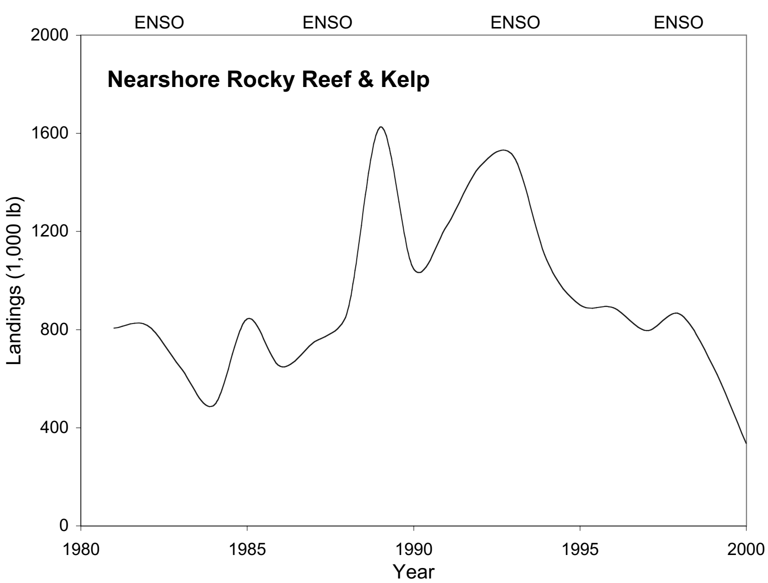


Figure 23. Reported commercial landings from 1981–2000 of all species within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS.

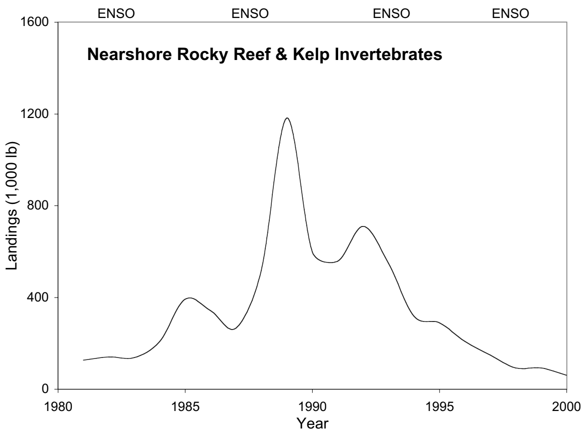


Figure 24. Reported commercial landings from 1981–2000 of invertebrates within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS.

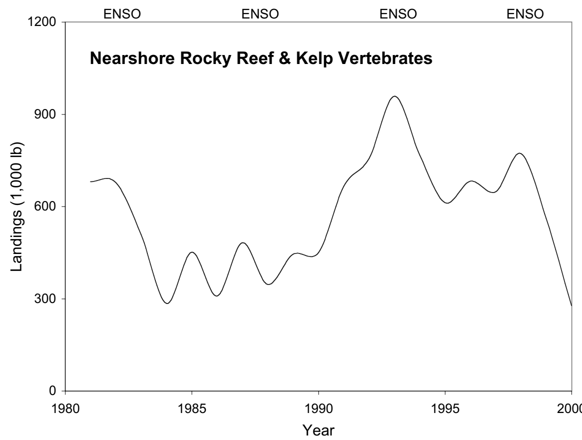


Figure 25. Reported commercial landings from 1981–2000 of fishes within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS.

Invertebrates

Rock Crab (*Cancer productus, C. antennarius, and C. anthonyi)*

Three species of rock crab (red, brown, and yellow) are harvested off California. These species are not separated in the landing statistics, so specific catches of individual rock crab species are difficult to distinguish. Rock crab is harvested using traps, and either landed alive for retail sale by fresh fish markets, or landed whole and sold as crab claws. The most common traps used in the rock crab commercial fishery are rectangular with 2 x 2 inch welded wire mesh. Traps are set and buoyed in 25–75 m of water in both open sandy areas and nearshore rocky habitats. Traps are usually retrieved 2–4 days after being set.

Rock crab landings have been reported since 1930, but landings were low until 1950. The rock crab fishery grew steadily through the 1960s, 1970s, and 1980s, with California landings peaking in 1986 at over 2.1 million lb. Historically, the majority of landings in the rock crab fishery have come from Southern California. In the 1980s, the fishery expanded into areas north of Point Conception. Today, however, Southern California catches still account for more than 90% of total landings in the state. Low rock crab catches north of Morro Bay result from the combination of lower fishing effort and preferential harvest of Dungeness crab, rather than low availability of the species. Rock crab landings from ports near the MBNMS increased from 1981–92, then steadily decreased until present. Over the past twenty years, rock crab landings have averaged more than 181,000 lb/yr (Fig. 26). Rock crab catches represent 20% of the landings from nearshore rocky reef and kelp habitats in the MBNMS from 1981–2000 (Table 7).

The commercial rock crab fishery is managed by the CDFG. A minimum harvest size for rock crab is set at a carapace width of 4.25 inches for all three rock crab species. The recreational fishery is regulated by a minimum size limit of 4.0 in and a bag limit of 35 per day. Rock crab traps are also required to have open rings with a diameter of 3.5 inches to allow for the escape of smaller individuals.

Little information is available on the population status of rock crab. Catch rates are known to have decreased in areas with extended high fishing pressure. Rock crab populations are probably more greatly affected, however, by variable larval survival and recruitment resulting from environmental factors.

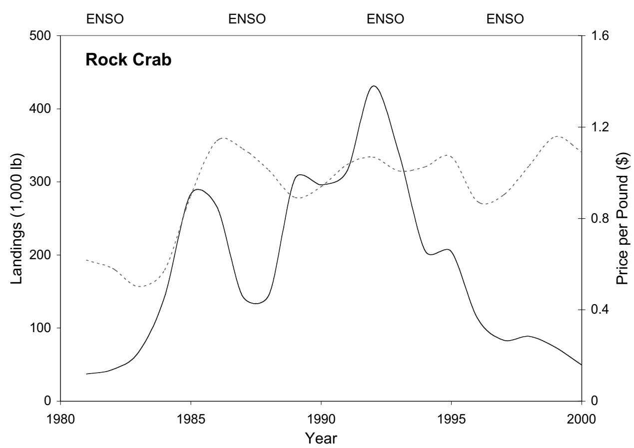


Figure 26. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of rock crab within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS.

Red Abalone *(Haliotis rufescens)*

Commercial diving for red abalone began in California in the late 1800s. During the 1940s, the coastline between Monterey and Point Conception produced commercial landings of about 720,000 red abalone annually. Historically, these Monterey area landings were the majority of the California commercial catch. In the 1950s, divers became more efficient at harvesting abalone with the advent of the "hookah" system. This system provides air to the diver through 90–150 m of hose connected to a full-face mask, and allows for longer dive times and a more thorough inspection of crevices. A large recreational fishery for abalone also developed throughout California in the 1950s. Between 1965 and 1985, the number of recreational divers, "shore pickers," and free divers targeting abalone increased four-fold.

After 1970, commercial landings of abalone declined drastically, largely as a result of reduced populations caused by increased fishing pressure and an expansion of sea otter populations. With the decline of red abalone stocks, California fishers began targeting other abalone species, such as pink, black, green, and white. By the early 1980s, catches of these other species from Southern California waters comprised over three-fourths of the California abalone catch.

Red abalone catches in the MBNMS averaged 80,000 lb/yr from 1981–97, with an increasing trend in landings from 1981–87 and a subsequent decrease in catch from 1987–97 (Fig. 27). The decreasing trend in landings indicated a decreased abundance of red abalone stocks, and contributed to the decision to close this fishery in 1997. Currently, all commercial take of red abalone is prohibited in California. The recreational fishery is restricted to the coastline north of a line drawn through the center of the mouth of San Francisco Bay; no take of red abalone is permitted south of this line. Red abalone stocks throughout Central and Southern California became over-utilized because of a combination of increased harvest efficiency

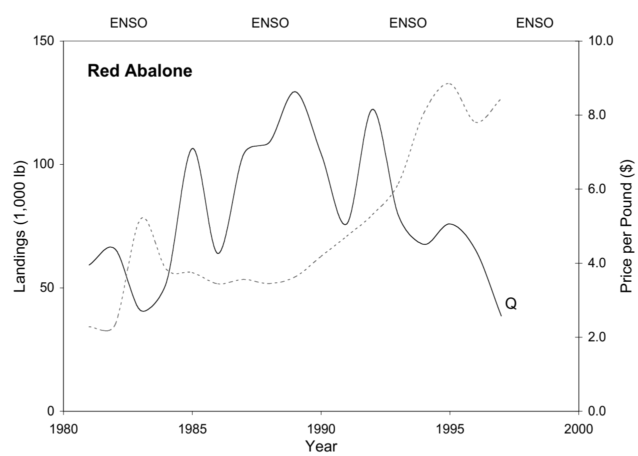


Figure 27. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of red abalone within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

and market demand in the commercial fishery, and continued fishing effort by the recreational fishery. In addition, oceanographic changes, such as warm waters associated with El Niño events, can stress the abalone population. Predation by sea otters also placed additional pressure on red abalone stocks in Central California. Finally, all abalone populations in the southern half of California have been stressed by a bacterium, causing "withering foot syndrome." The disease has been spreading northward and may pose a problem for abalone in the MBNMS.

Red Sea Urchin (*Strongylocentrotus franciscanus*)

Sea urchins, taken primarily for their gonads, are harvested using hookah gear similar to that used in the abalone fishery. The red sea urchin is the main urchin species currently harvested off the West Coast of North America. The fishery developed in Southern California in the early 1970s when sea urchin gonads were exported to Japan. Fishery managers also encouraged the fishery as a way to reduce fishing pressure on abalones and to reduce grazing by urchins on valuable kelp beds.

The sea urchin fishery grew steadily through the 1970s with landings reaching 40 million lb in 1987. By 1996, the sea urchin fishery was the most valuable fishery in California. Prior to 1985, the bulk of the landings came from the Northern Channel Islands and off the Southern California coast. Continued high fishing pressure, as well as El Niño conditions between 1982 and 1984, led to lowered catches in the southern half of the state. Total California landings were maintained during this time by the expansion of the sea urchin fishery into Northern California. From 1985 to 1988, Northern California landings increased from 1.9–30.4 million lb. Extremely high landings were evident in 1989; this peak in landings has been attributed to an increased export demand and high monetary exchange at the time. Commercial landings throughout California in 1999 totaled 14 million lb and were worth more than 13 million dollars, making this fishery third highest in overall earnings. Although the sea urchin fishery has remained productive and lucrative since the late 1980s, total landings and catch per unit effort (CPUE) have declined, especially in Central and Northern California. Red sea urchin landings at ports near the MBNMS averaged 97,000 lb/yr from 1981–2000; however since 1995, landings have been below 27,000 lb/yr (Fig. 28). Recent declines have been attributed to a reduction in permits issued, declines in kelp abundance as a result of El Niño warm water conditions, reported abundance of illegal size and low quality sea urchins, bad weather in Northern California; and some shift in fishing effort from California to Alaska.

In addition to fishing pressure, larval survival has a large impact on the status of sea urchin populations. Annual recruitment is greatly dependent on the density of adults and fate of larvae as ocean currents carry them either offshore or into suitable nearshore habitats for settlement. Ocean conditions in the Southern California Bight appear to be especially favorable for relatively consistent recruitment. Recruitment in North-

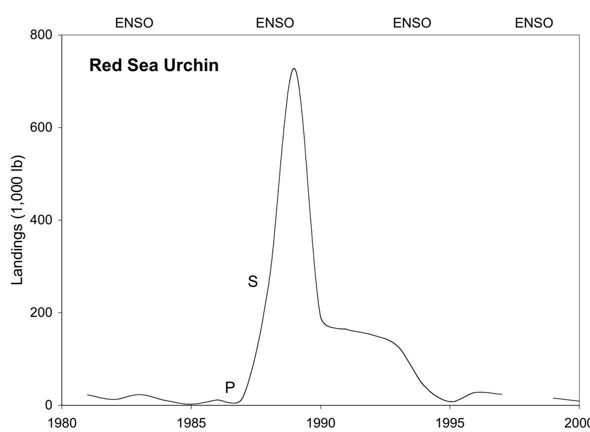


Figure 28. Reported commercial landings from 1981–2000 of sea urchin within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

ern California, however, is less predictable, and urchin populations tend to exhibit cyclical patterns of rapid increases followed by rapid declines. Predation by sea otters also placed additional pressure on red sea urchin stocks in Central California. Surveys by CDFG biologists indicate that in Northern California, red sea urchin are currently about one-third as abundant as they were prior to the onset of the commercial fishery.

The sea urchin fishery is managed by the CDFG through the use of a limited entry system, seasonal closures, and size limits. The sea urchin fishing season extends through most of the year, with certain days of the week closed during specific months. Urchins harvested in Southern and Northern California must have shell diameters larger than 3.25 and 3.5 in, respectively.

Vertebrates

Nearshore Rockfishes (*Sebastes* species)
Rockfishes are a dominant and ecologically important component of nearshore rocky reefs and kelp forests, with about 15 species commonly taken in the nearshore habitats of the MBNMS. They range from solitary, territorial, substrate-associated individuals to mid-water schooling species. Limited studies of their movements reach the general conclusion that many nearshore rockfishes do not migrate long distances and depend on their larval and pelagic juvenile stages for dispersal. This may limit these species' ability to repopulate depleted reefs. These traits, along with late ages of maturity and long lives (Appendix H), make rockfishes particularly susceptible to overfishing.

Subsistence fishing for nearshore rockfishes has existed for millennia in the Monterey Bay area, with records of rockfish otoliths prevalent in excavated middens around the bay. Recreational fishing for nearshore rockfishes has been recorded since 1875. Increased fishing pressure in the 1960s caused a shift from nearshore rockfishes to some of the deeper species, though pressure has recently shifted back to the nearshore with the decline of offshore species and the increase in the live-fish fishery. Commercial landings fluctuated at levels below 400,000 lb in the 1980s, then increased sharply in the early 1990s, when the live-fish fishery expanded to Central California (Fig. 29). Annual commercial landings of fishes from shallow rocky habitats averaged about

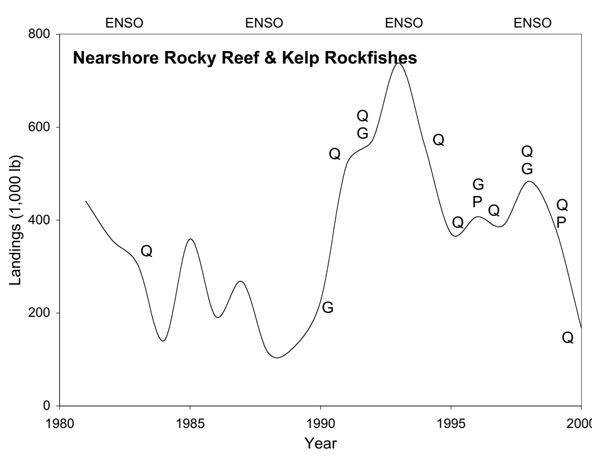


Figure 29. Reported commercial landings from 1981–2000 of rockfishes within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

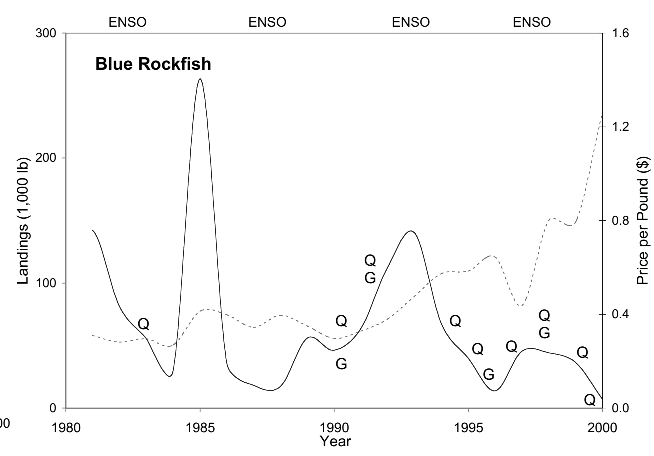


Figure 30. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of blue rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

730,000 lb/yr from 1991-98, almost twice that of the annual landings in the1980s. This increase in live-fish take is particularly noticeable in the high average price per pound values for individual species (Figs. 30–41). Some other notable trends in these graphs are also worth explaining. For instance, the enormous increase in olive rockfish landings in 1991 (Fig. 39) may be attributable to misidentification of yellowtail rockfish (see concomitant decrease in reported yellowtail rockfish landings in Fig. 77– p. 85. Also, general trends in decreased nearshore catches after 1998 are attributable to reduced fishing effort, caused by more restrictive regulations implemented because of concerns about possible overuse of these nearshore species (Figs. 25 and 29).

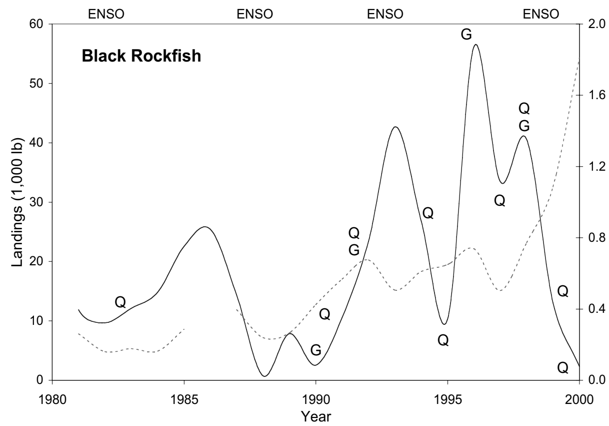


Figure 31. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of black rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

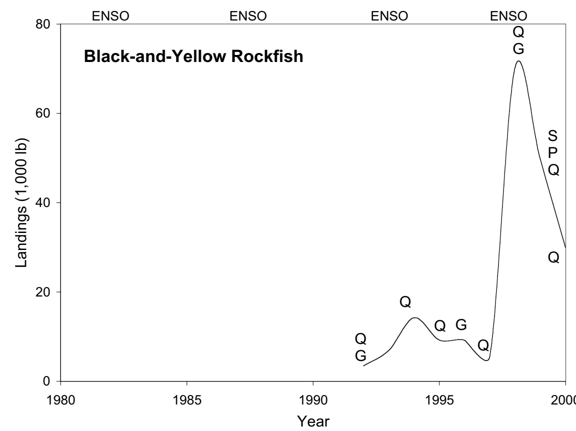


Figure 32. Reported commercial landings from 1981–2000 of black-and-yellow rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

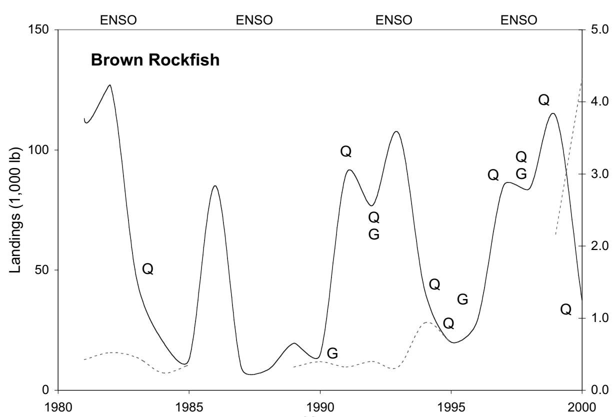


Figure 33. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of brown rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

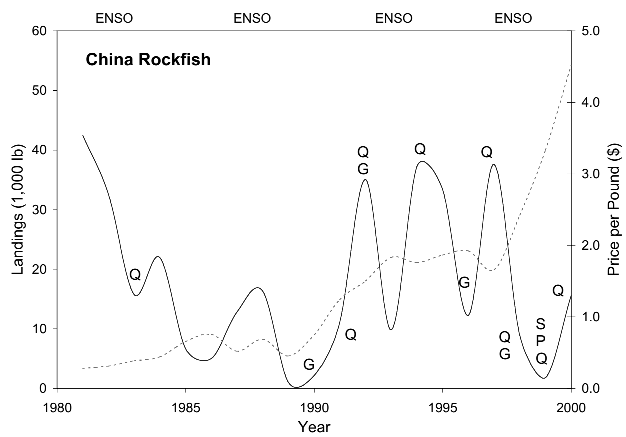


Figure 34. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of China rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

The nearshore fishery remained indirectly regulated until 1999, when a nearshore permit was required of all commercial fishers and size limits were implemented for ten species of nearshore fishes, including some rockfishes. In 2000, the Pacific Fisheries Management Council recognized nearshore rockfishes as a management category and issued regulations to limit catch of nearshore rockfishes to an average of below 1,000 lb per month. These regulations are reflected in the large drop in catches of nearshore rockfishes in 1999 and 2000. To date, the only nearshore rockfish stock to be assessed is the black rockfish, mostly because of its importance in Oregon fisheries. Copper, flag, quillback, and vermilion rockfishes are important components of nearshore rocky habitats; these species are

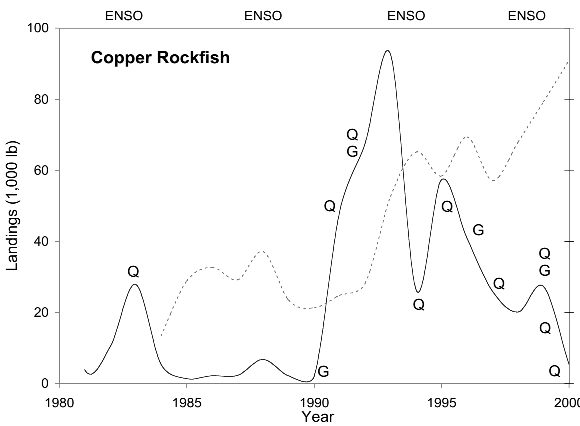


Figure 35. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of copper rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

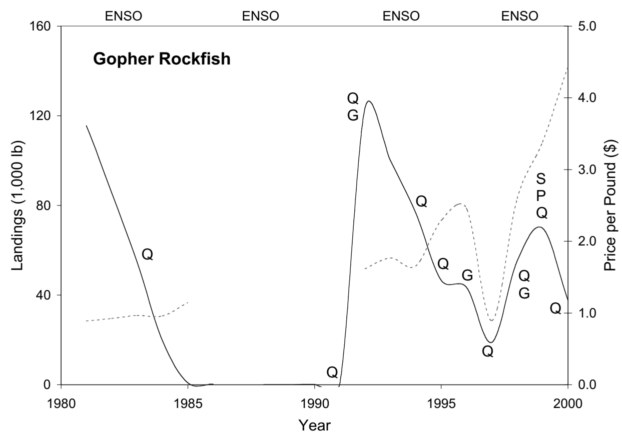


Figure 36. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of gopher within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

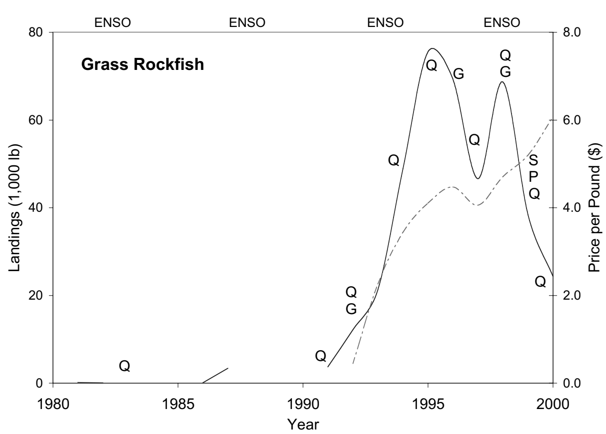


Figure 37. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of grass rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

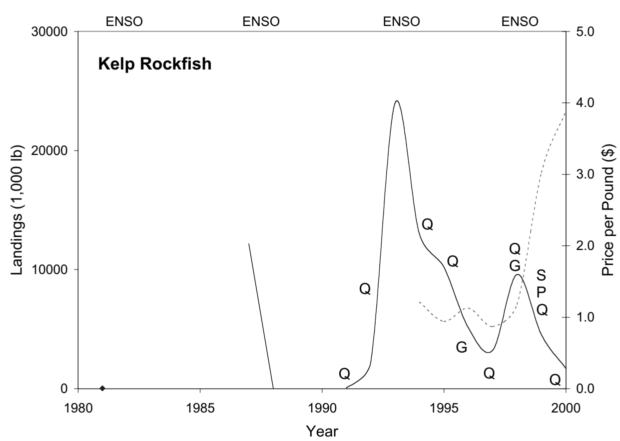


Figure 38. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of kelp rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

also landed commercially in rocky deep shelf and slope habitats.

Commercial fishery landings of nearshore rockfishes are generally less than landings from deeper habitats because offshore trawling allows for greater catch with less effort. Foul weather can also reduce the number of fishing days available to a nearshore fisher because small boats and skiffs are often used to get into the potentially treacherous shallow rocky reefs and surf zones. Though traditional commercial fishery pressure is relatively low in the nearshore, a combination of high recreational fishing and the intense growth of the live-fish fishery in the past decade may have put unsustainable fishing pressure on these species. As recognition of this concern and the importance of rockfish to the nearshore environment, 13 of the 19 designated vulnerable nearshore fishes included in the MLMA Nearshore Fishery Management Plan (FMP) are rockfishes.

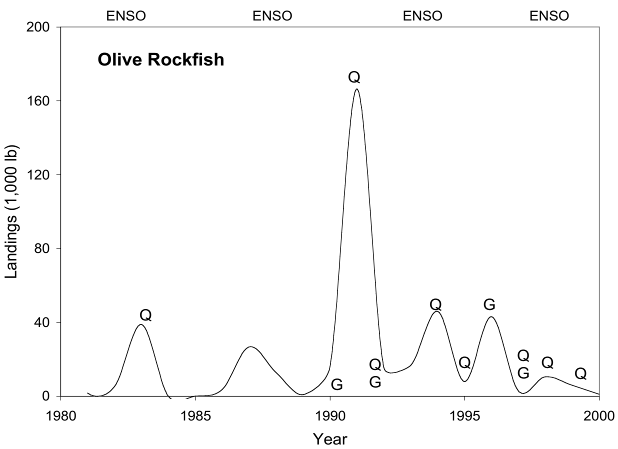


Figure 39. Reported commercial landings from 1981–2000 of olive rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

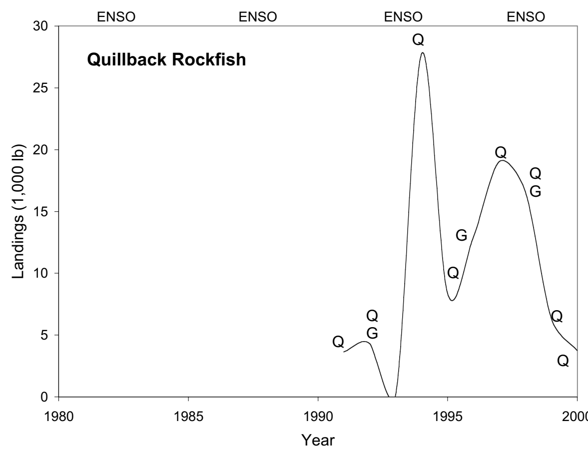


Figure 40. Reported commercial landings from 1981–2000 of quillback rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

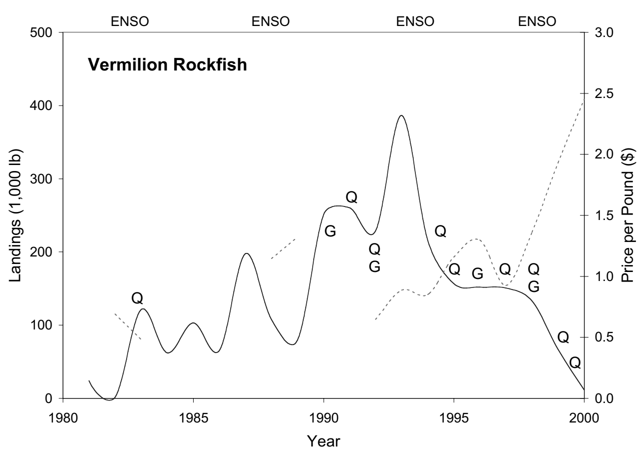


Figure 41. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of vermilion rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Recreational catches of nearshore rockfishes, as reflected in the CPFV landings (Fig. 21), declined during the 1990s, along with a slight but consistent drop in CPUE (Fig. 42). In 1999, size limits were imposed for most nearshore rockfishes, and in 2000, additional gear regulations and area closures brought both catch and effort down.

Blue rockfish are the most important fish in the Central California recreational fishery, comprising 27% of the CPFV catch from 1980 – 94. Although yearly catches and landings fluctuate (Fig. 43), the population size of blue

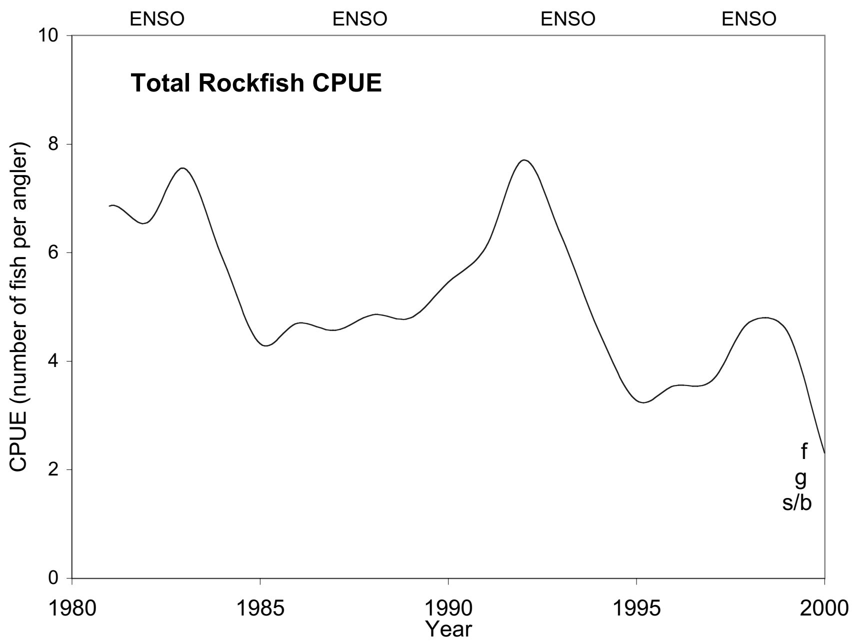


Figure 42. Recreational catch per unit effort from 1981–2000 of total rockfish within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix G for specific yearly meanings of each regulatory symbol.

rockfish in the MBNMS seems to be relatively stable, but potentially stressed. One notable trend is a decrease in average total length of blue rockfish. From 1960–94, blue rockfish lengths decreased nearly 7%. This decrease in mean size may be due to successful recruitment and a corresponding increase in the numbers of small fish available to anglers. The overall trend of decreasing lengths though, along with a decrease in average weight, is suspected for the other nearshore species as well (e.g., mean lengths of olive rockfish declined 9% in the same period). Future management of the nearshore rockfishes by the California Department of Fish and Game will address these recreational fishery trends, as well as the commercial trends, in an attempt to promote sustainable nearshore fisheries.

Kelp Greenling (*Hexagrammos decagrammus*)

Prior to 1988, there was very little commercial fishing effort for kelp greenling. The commercial fishery increased as the kelp greenling

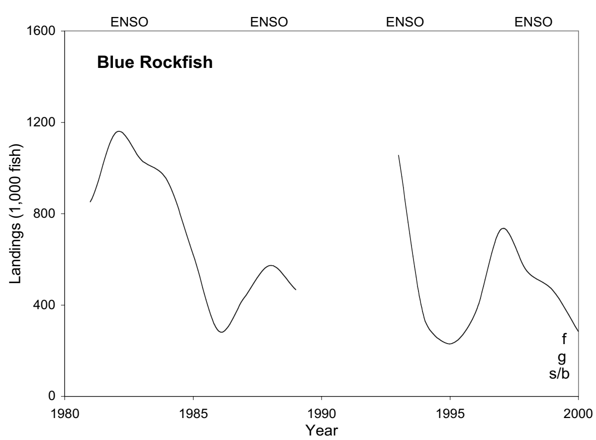


Figure 43. Reported recreational landings of blue rockfish in Central and Northern California from 1981–2000. No RecFIN data are available for years 1990–1992. See Appendix G for specific yearly meanings of each regulatory symbol.

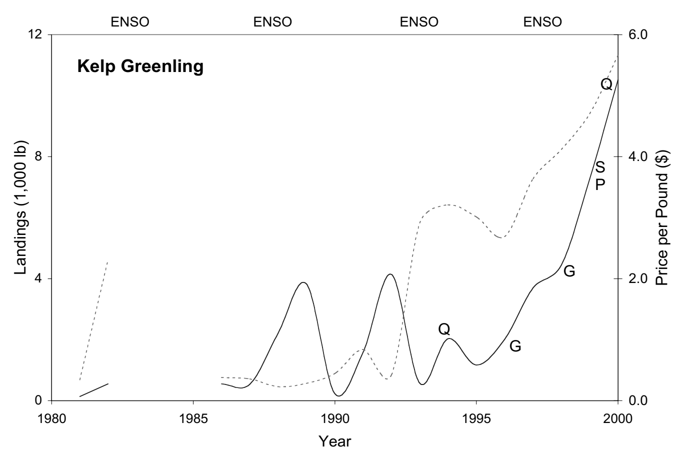


Figure 44. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of kelp greenling within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

became a target of the nearshore live-fish fishery (Fig. 44). This increase in landings led to concern among fishery managers because there is no estimate of abundance of kelp greenling in California. Because of its prevalence in the live-fish fishery, insufficient life history information, and its association with nearshore habitats, the kelp greenling was designated one of nineteen nearshore finfish species in need of management. The kelp greenling is currently managed by the CDFG through interim commercial regulations that have been enacted until the completion of the Nearshore FMP. These regulations established a 12-in minimum size limit, and daily, monthly, and depth restrictions for commercial fishing of kelp greenling, along with increased regulation of gear and permits in the nearshore fishery.

Kelp greenling is primarily caught in the recreational fishery, most often by private skiff anglers and divers. Recreational landings in Northern and Central California have declined since the early 1980s (Fig. 45). This decline may indicate a reduced population size of kelp greenling. Current CDFG recreational regulations include a size and bag limit for this species (Appendix G).

Lingcod (*Ophiodon elongatus*)

Lingcod is an important commercial species and comprises a substantial portion of the recreational landings in Northern and Central California. The majority of the commercial catch of lingcod has come from the net and trawl fisheries, but they are also taken in small numbers in the live-fish fishery. Commercial landings at ports near the MBNMS averaged 379,000 lb/yr from 1981–2000, however the catch has fluctuated greatly in the last 19 years, presumably due to the influx of periodic strong year-classes into the fishery (Fig. 46). This cyclical trend has also been evident coastwide since the onset of the fishery in the early 1900s (Fig. 47). Another indication of episodic recruitment is that mean lengths of both males and females decreased by approximately 10 cm between 1978–83 and 1992–93. Commercial landings at ports associated with the MBNMS of this species have declined steadily since 1993. This decline is most likely attributable to major regulation changes implemented in response to depressed lingcod stocks.

Lingcod is a highly valued sport fish, and is most often taken by hook-and-line fishing and spearfishing. From 1981–2000, an aver-

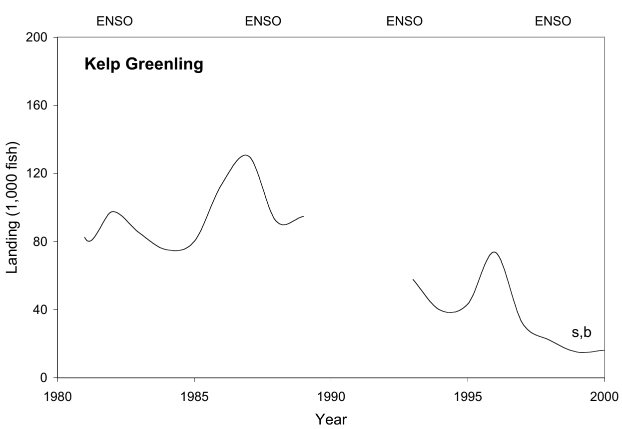


Figure 45. Reported recreational landings of kelp greenlings in Central and Northern California from 1981–2000. No RecFIN data are available for years 1990–1992. See Appendix G for specific yearly meanings of each regulatory symbol.

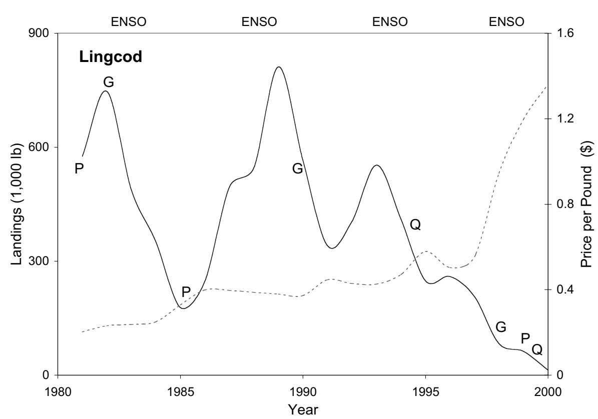


Figure 46. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of lingcod within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

age of 143,000 lingcod were caught annually in the recreational fishery in Central and Northern California. The number of fish landed recreationally has decreased gradually since 1989. The decline in recreational landings in Northern California of lingcod may be a result of lowered size and bag limits, along with a decrease in fishing effort since the 1980s (Fig. 22). Recreational regulations include monthly restrictions, a two-hook limit, a bag limit of two, and a current minimum size of twenty-four inches total length.

Lingcod stocks along the West Coast have been heavily utilized. NMFS models suggest that from Northern Oregon to Southern British Columbia, lingcod stocks are overfished. In Southern Oregon and California, the commercial catch is predominately young fish, and 50% of the females are immature, leading to concerns about population status in this area as well. The 2000 PFMC lingcod stock assessment states that estimated lingcod biomass has increased from very low stock sizes in the mid-1990s to 36% and 49% of 1980s levels for the northern and southern stocks, respectively. Stocks remain low compared to historical levels. The high productivity of the lingcod may provide a means by which the stocks can increase in the future. Lingcod fisheries are regulated in California by both state and federal agencies. For additional information see Leet et al. *California's Living Marine Resources: A Status Report* (2001).

Cabezon (*Scorpaenichthys marmoratus*)
Cabezon are highly sought by divers and recreational anglers. They do not make up a large portion of CPFV catches but are generally one of the larger fishes caught by anglers, with an average weight of about 4.4 lb. Cabezon are harvested in the commercial fishery primarily by hook-and-line and trap fishers. Commercial landings of cabezon in this region averaged 55,000 lb/yr from 1981–2000. Commercial landings increased substantially in 1994–95 (Fig. 48), due primarily to an increase in the nearshore live-fish fishery. They are caught mostly in the southern portion of the Sanctuary (near Morro Bay) in traps, which allow fishers to fish during bad weather.

Cabezon is one of the nineteen finfish species that will be managed under the Nearshore FMP. The cabezon was chosen based on the need for management and con-

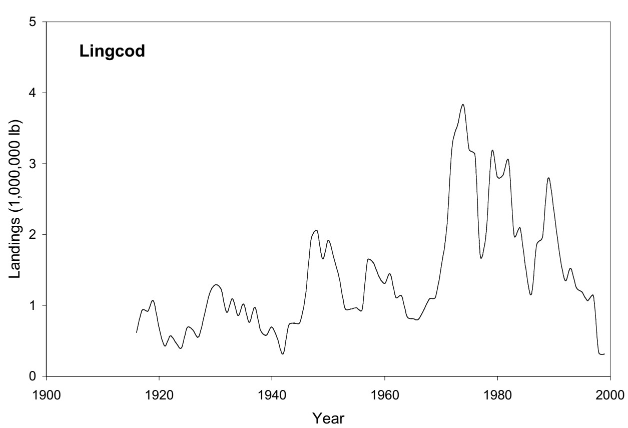


Figure 47. Reported commercial landings of lingcod in California from 1916–1999.

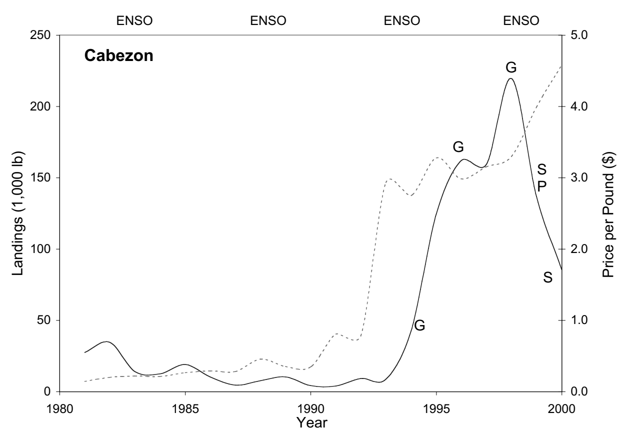


Figure 48. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of cabezon within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

cerns about the potential for overharvest of small cabezon in the nearshore live-fish fishery. Data collected by CDFG biologists indicate that a majority of cabezon caught in the live-fish fishery is below the length of 50% maturity. This practice causes concern because historically, a species harvested before most of the population reaches sexual maturity experiences dramatic declines in abundance. Cabezon are currently managed by the California Department of Fish and Game through interim commercial regulations that have been enacted until the completion of the Nearshore FMP. These regulations established a 15 inch size limit for cabezon, and include daily, monthly and depth restrictions for commercial fishing of cabezon. In September 2001, the commercial fishery for cabezon was closed for the rest of year to prevent the total cabezon OY of 178,728 pounds from being exceeded. No action was taken regarding the recreational fishery, since CDFG did not anticipate that the recreational cabezon fishery would exceed its OY of 63,608 pounds. Recreational landings of cabezon have been highly variable since 1980 (Fig. 49), although landings from 1995–2000 have been consistently low. This may be related to a decreasing trend in effort since the 1980s. Sport catch of cabezon is regulated by size and bag limits under the general finfish provisions of the California Fish and Game Code (Appendix G).

Surfperches (Embiotocidae)

The commercial fishery for surfperch is much smaller than the recreational fishery. Larger aggregating species, such as barred and redtail surfperch, typically provide the bulk of the commercial surfperch landings in Northern and Central California. Commercial landings averaged 26,000 lb/yr from 1981–98 (Fig. 50). However, landings at ports near the MBNMS in 1999-2000 averaged less than 9,000 lb/yr. Limits imposed on hook-and-line gear in 1996 may have contributed to recent declines in catch. The current price per pound

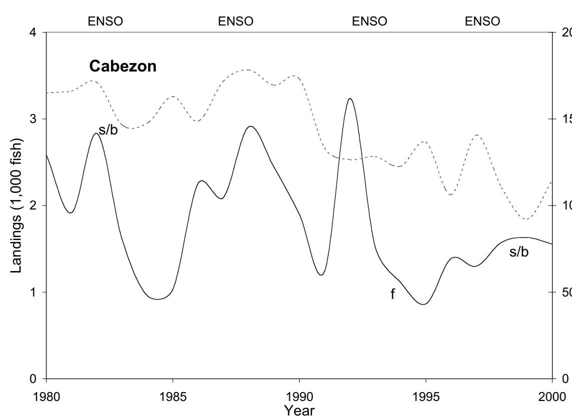


Figure 49. Total cabezon CPFV landings (solid line) and effort (in anglers; dotted line) within the MBNMS. See Appendix G for specific yearly meanings of each regulatory symbol.

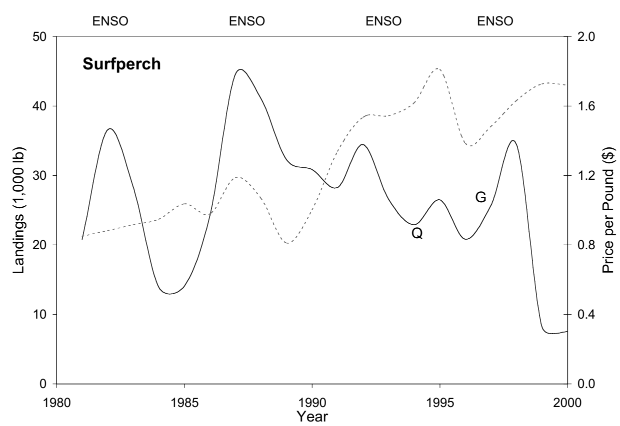


Figure 50. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of surfperch within nearshore rocky reef and kelp habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

of surfperch is more than doubled that in 1980. This price increase can be attributed to take of surfperch in the live-fish fishery. Currently, there is no regulation of commercial landings of surfperch.

Surfperch are easily caught by both boat and shore based anglers and therefore constitute a significant portion of the recreational fishery. The majority of surfperch are landed by hook-and-line gear. Divers with pole spears and spear guns also frequently catch surfperch. Recreational landings in Northern and Central California have averaged 661,000 lb/yr from 1980–2000 (Fig. 51). The majority of this catch, however, is attributable to Northern California ports. Important species in sport fishery catches include barred, striped, redtail, walleye, rubberlip, pile, and shiner surfperch. The majority of these catches occurred in shore based fisheries. Historical catch data show that between 1958–61 and 1981–86, surfperch average weight declined. Recreational surfperch catches in Northern and Central California have also declined from approximately 1.3 million lb in 1980 to 200,000 lb in 2000. These declines are attributed primarily to reductions in catches of barred and redtail surfperch. Environmental variation, lower fecundity of smaller fish, habitat degradation, and increased fishing pressure may be contributing factors to the steady declines in surfperch populations. Current recreational limits on surfperch catches include a minimum size limit of 10 inches for redtail surfperch, and daily recreational bag limits of five surfperch for all species, with the exception for shiner surfperch (a total of 20 shiner surfperch may be taken and possessed).

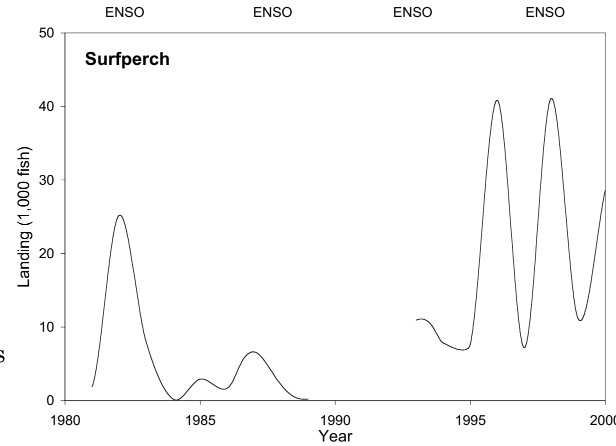
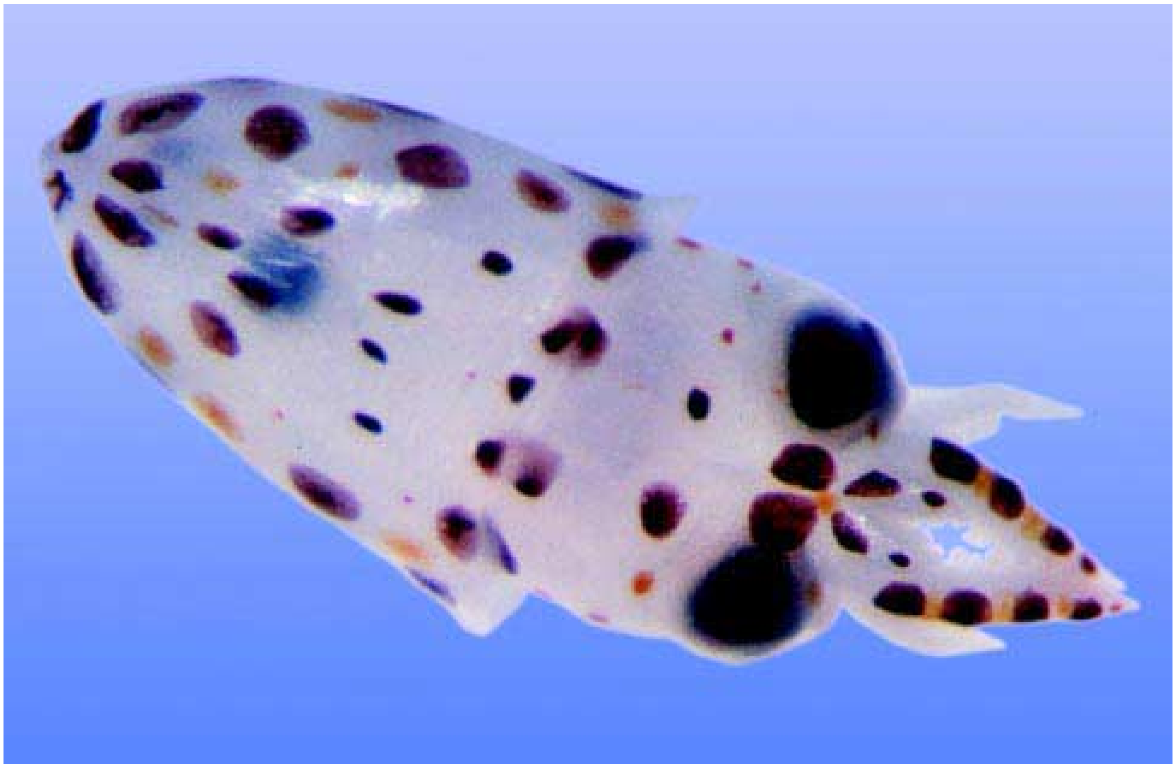


Figure 51. Reported recreational landings of surfperches in Central and Northern California from 1981–2000. No RecFIN data are available for years 1990–1992.

Nearshore Soft Bottom Habitats



Nearshore soft bottom habitats are primarily located in Monterey Bay and in the northern portion of the MBNMS, although these habitats are also numerous just south of the sanctuary boundaries (Fig. 2–4). Nearshore soft bottom habitats are home to many fishes and invertebrates. The long-time exclusion of trawlers and more recent ban of gill nets in this environment has led to a limited and highly regulated fishing effort in this area. Currently, there are a small number of commercial fisheries directed in these habitats. Commercial landings in nearshore soft bottom habitats comprised 25% of all landings at ports near the MBNMS from 1981–2000 (Table 8), although landings have fluctuated greatly since the early 1980s. Total landings from nearshore soft bottom habitats averaged 17.3 million lb/yr from 1981–2000. Market squid is the main constituent of the nearshore soft bottom fishery, contributing more than 97% of the total landings from these habitats (Table 8). The trends of overall commercial landings in this habitat thus mirror those of the market squid and decreases in landings can be attributed mainly to El Niño effects on this species and to regulations imposed on the fishery in the late 1990s (Fig. 52).

Commercial landings of fishes within nearshore soft bottom habitats have declined over the past twenty years since highs in the 1980s (Fig. 53). Species in this category include the leopard shark, Pacific angel shark, and white seabass, but the primary component of the catch is white croaker. Common gear currently used in this environment includes various line gears (hook-and-line and trolling) and purse seines. The recreational fishery in this habitat takes the same species as does the commercial fishery, in addition to a large number of surfperch and nearshore flatfish.

Table 8. Primary species landed in commercial fisheries in the MBNMS that were caught in nearshore soft bottom habitats, and the percentage that each species contributed to the landings from this habitat group and total landings in the MBNMS. Landings from soft bottom habitats during the period equaled 286.422 million pounds from 1981–2000. Total landings in all of the MBNMS equaled 1.14 billion pounds from 1981–2000.

Guild	Common Name	Scientific Name	% habitat	% total
Invertebrates				
	Market Squid	*Loligo opalescens*	97.5	24.4
Vertebrates				
Elasmobranchs	Leopard shark	*Triakis semifasciata*	0.1	< 0.1
	Pacific angel shark	*Squatina californica*	0.2	< 0.1
Sciaenids	White croaker	*Genyonemus lineatus*	2.3	0.6
	White Seabass	*Atractoscion nobilis*	< 0.1	< 0.1

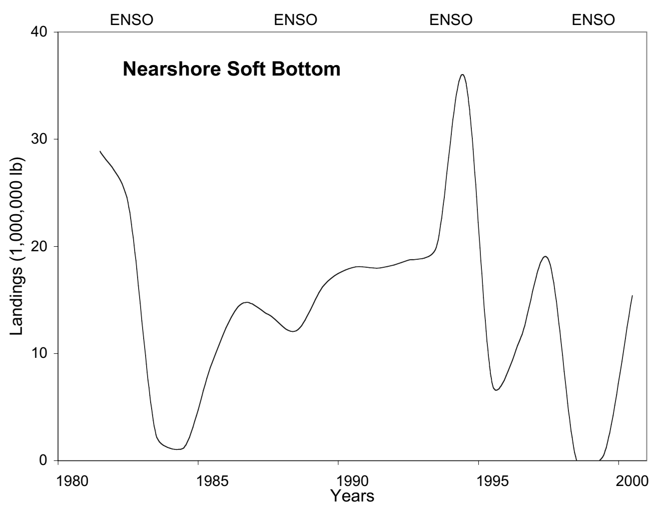


Figure 52. Reported commercial landings from 1981–2000 of all species within nearshore soft bottom habitats at the five major ports associated with the MBNMS.

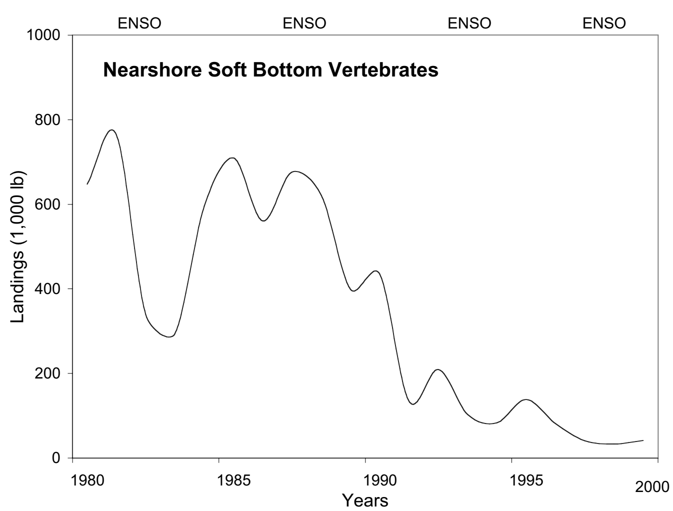
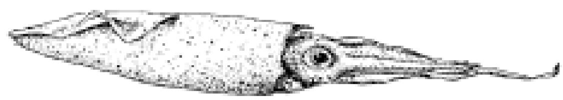


Figure 53. Reported commercial landings from 1981–2000 of fishes within nearshore soft bottom habitats at the five major ports associated with the MBNMS.

Invertebrates

Market Squid (*Loligo opalescens*)



Historically, the market squid fishery has been important throughout California. In 1863, Chinese settlers on the Monterey Peninsula established a small fishery using multiple skiffs with torches and hand-held seines to capture squid. The lampara net, a much more effective gear, was introduced by Italian immigrants in 1905, increasing catches to 40,000 lb/haul. In 1946, California landings increased to 38 million lb because of increased demand in both the local and foreign markets (Fig. 54). Monterey catches dominated California landings prior to 1961; since that time, landings in Southern California have been greater. Squid are marketed for human consumption (fresh, frozen, or canned) or sold as fresh/live bait. Currently, most of the catch is exported.

Purse seining within Monterey Bay (from Pt. Piños to Sand City) was outlawed in 1953 because of its possible disruption of egg cases. In 1959, the use of lights to concentrate squid schools also became illegal, effectively excluding the brail and pump systems. Fishers requested this ban to prevent processors from directly luring squid to docks for harvest by dip nets and because they felt lights disrupted spawning activity. Thus, fishers had to rely on scouts and the use of lampara nets to catch the squid. In 1987, lights were again legalized and a modified purse seine with no bottom chain was first used in the bay. By 1989, the use of the modified purse seine was legalized throughout the bay, and by 1990 all lampara net use ceased. Today, market squid is the top commercial fishery in California by pounds landed and by value. Commercial landings of market squid for all of California in 1999 totaled nearly 200 million lb and were worth nearly 35 million dollars.

From 1981–82, squid catches within the MBNMS were relatively high, with annual landings totaling more than 20 million lb (Fig. 55), but landings decreased drastically to a low of 1 million lb in 1984, a result of the 1982-83 El Niño conditions. From 1985–88, annual landings stabilized at approximately 10 million lb, then increased. In 1994, landings reached the highest level since 1946. The fishery for market squid was the largest and most profitable fishery in the Monterey Bay area in 1994. A total of 35.8 million lb of squid

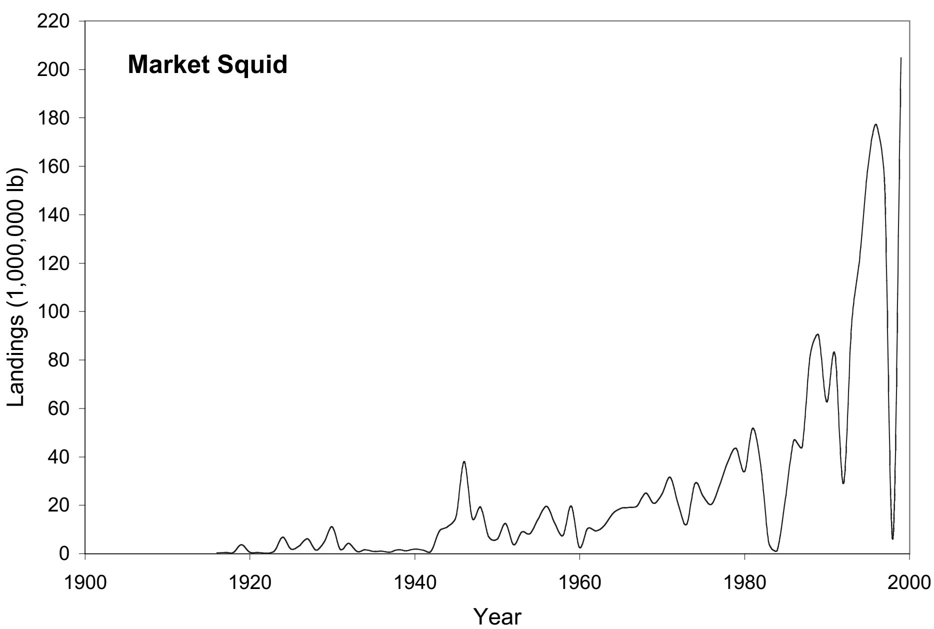


Figure 54. Reported commercial landings of market squid in California from 1916–1999.

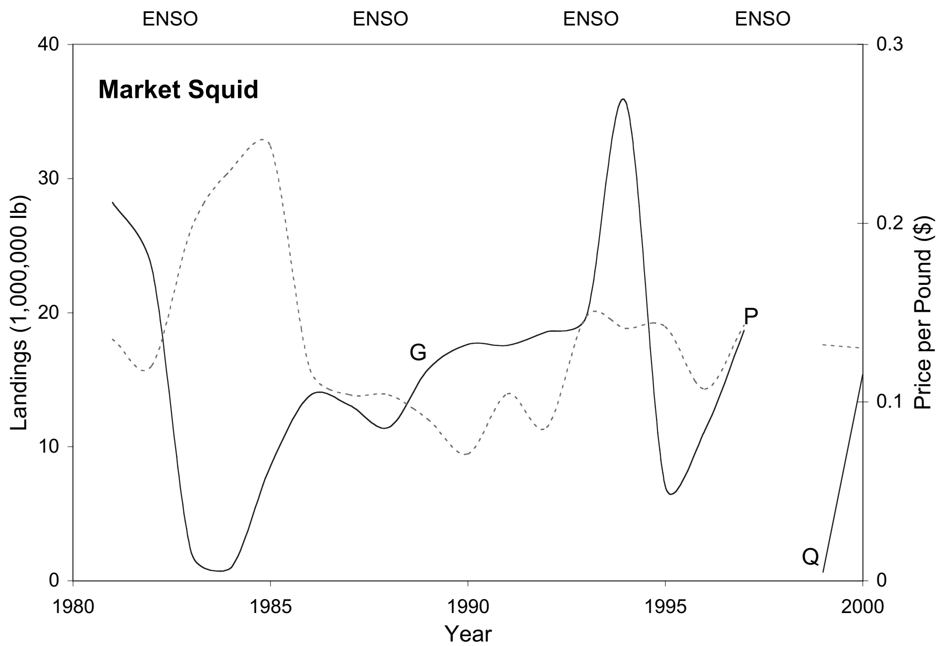


Figure 55. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of market squid within nearshore soft bottom habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

worth over $5.2 million was landed at the ports near the MBNMS during 1994. Moss Landing and Monterey accounted for 30% and 57% of this catch, respectively. Landings dropped drastically in 1995, again related to the El Niño years of 1992–93, followed by an upward trend until 1997. The El Niño conditions of 1997–98 caused a complete collapse of the squid fishery in Monterey for almost two years.

The commercial squid fishery is thought to annually harvest a large portion of adult spawning aggregates in small areas such as Cannery Row. Total squid landings have historically exhibited large fluctuations, rather than decreasing trends, despite this intense fishing pressure (Fig. 54). This fluctuation, and the occurrence of squid spawning in unfished areas along the open coast, has led many fishery biologists to believe that the market squid population size is more a function of environmental variables than fishing pressure. However, the record harvests in the 1990s combined with the importance of squid as prey items for many species, caused some biologists to suggest a more precautionary approach to squid fishery management.

Historically, regulations pertaining to the harvest of squid were minimal and were related more to fishery conflicts and social concerns than to resource protection. Prior to 1998, the squid fishery was largely unregulated. The large harvests of squid prompted some concerned fishers to request new legislation to restrict the number of boats in the fishery, in an attempt to reduce the risk of overfishing, maintain economic viability of the fishery, and limit negative effects of fishing gear on squid eggs. In 1998, a three-year moratorium was enacted that restricted the number of vessels in the fishery, established a permit fee to fund research, and gave CDFG regulatory control of the fishery during the moratorium. In 1999, the PFMC began to manage the fishery under the Coastal Pelagic Species FMP. This species is monitored by the PFMC and managed via annual status reviews and management regulations, such as gear and areas restrictions. A squid fishery management plan is near completion. Currently, there is no estimate of the abundance or status of this population.

Vertebrates

Nearshore Sharks

In the early 1980s, processors began carefully dressing and marketing shark products, resulting in an increased demand for shark meat as a food item. This led to the rapid increase in, and demise of, the Pacific angel shark fishery in 1989. The gill net ban in 1990 also lowered fishing effort on nearshore shark species in California. Presently, there are no large-scale directed commercial fishing operations in Monterey Bay for nearshore shark species. Almost all current landings of sharks occur as incidental catches from other fisheries. However, there is a small-scale commercial harvest of leopard shark in the live-fish fishery. Unfortunately, the unknown number of fish that are landed under the market category shark/unspecified confounds estimates of the commercial catch of sharks.

Commercial landings of nearshore soft bottom sharks in Central California have decreased since 1987 (Fig. 56). This decline can be mainly attributed to regulatory changes that have affected the nearshore fishery. The main gear used to catch nearshore sharks was net gear. The restrictions in the 1980s, and eventual banning of gill netting in nearshore areas, was the major contributor to the decline in leopard shark and Pacific angel shark landings in Central California. Nearshore sharks are also targeted as popular game fish and are landed by recreational anglers throughout California. The recreational landings of nearshore sharks (made up almost exclusively of leopard sharks) in Northern California fluctuated in the 1980s, but generally stayed above 500 fish/yr until 1993. Since that time landings have declined to less than 500 fish/yr (Fig. 57). This decreasing trend in the 1990s is most likely related to the implementation of minimum size limits, gear restrictions, and may reflect current low abundance due to past overfishing. The commercial and recreational landing of the leopard shark and Pacific angel

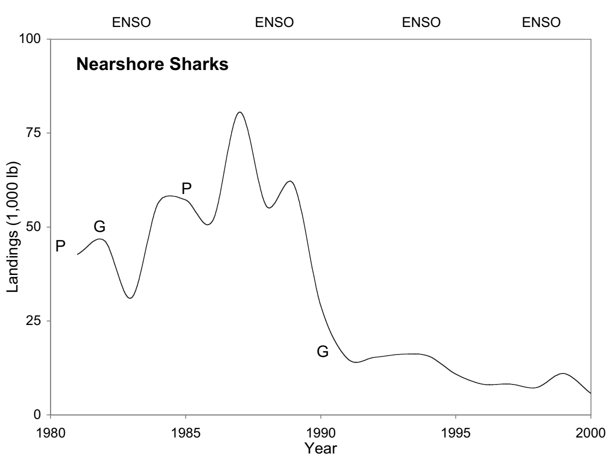


Figure 56. Reported commercial landings from 1981–2000 of nearshore sharks within nearshore soft bottom habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

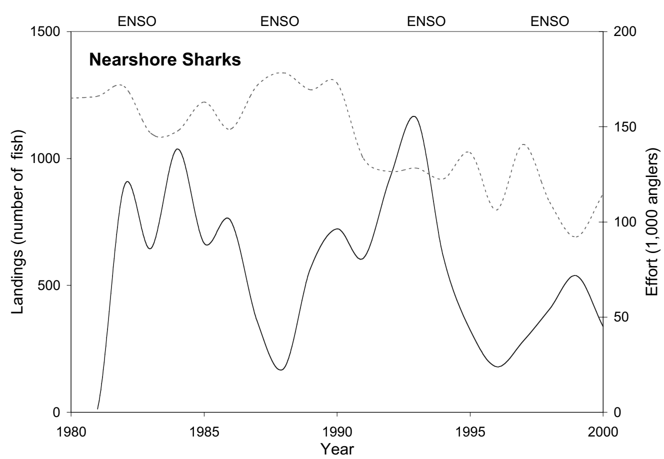
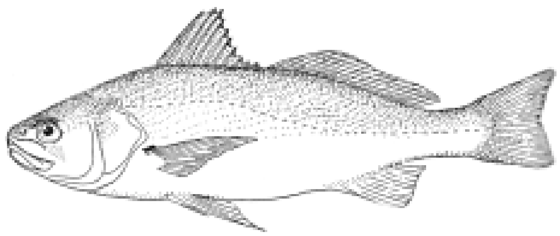


Figure 57. Reported CPFV landings (solid line) and effort (dotted line) from 1981–2000 of nearshore sharks within nearshore soft bottom habitats at the five major ports associated with the MBNMS.

shark, are managed under the general provisions of the California Fish and Game Code, most often by size and gear regulations. No population estimates exist for these two species.

White Croaker (*Genyonemus lineatus*)



Statewide, the white croaker is frequently caught in recreational fisheries and is an important constituent of the commercial catch as well. The white croaker is not landed commercially in great numbers in Monterey Bay and is often sold as bait fish. After the Vietnam War, many Vietnamese fishers immigrated to the Monterey Bay area and were encouraged to fish for white croaker. These fishers have since gradually moved on to other, more profitable fisheries. In addition, the 1990 ban of gill nets in nearshore waters lowered fishing pressure on the white croaker. As a result, white croaker landings have dramatically declined at ports near the MBNMS in the last 10 years, despite the increase in biomass estimated by NMFS (Fig. 58). The fishery is managed exclusively by CDFG.

The majority of white croaker sport catch is from Southern California; the average recreational catch by the CPFV fishery in MBNMS from 1981–2000 was 489 fish/year. Recreational landings of white croaker peaked in 1985, declined until 1995, and then increased to the present. Catch per angler also increased in the late 1990s, indicating a possible increase in abundance. (Fig. 59). The general provisions for finfish in the California Fish and Game Code regulate the recreational catch of white croaker.

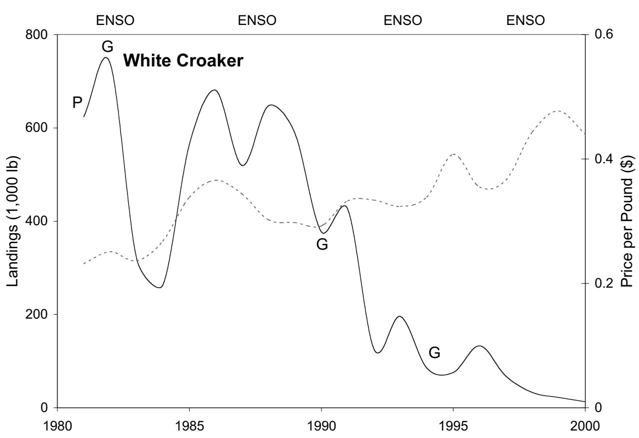


Figure 58. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of white croaker within nearshore soft bottom habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

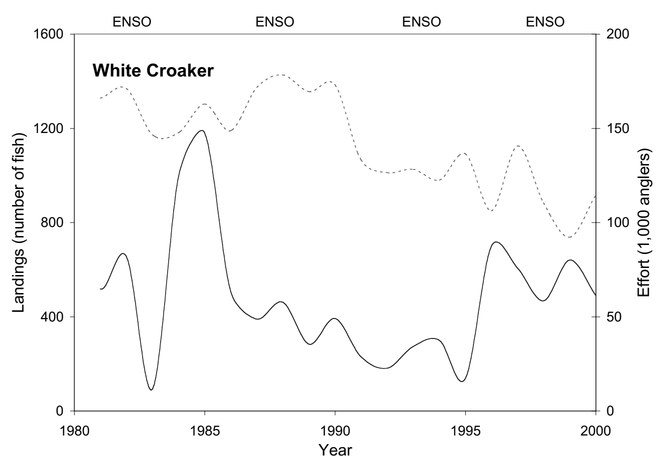
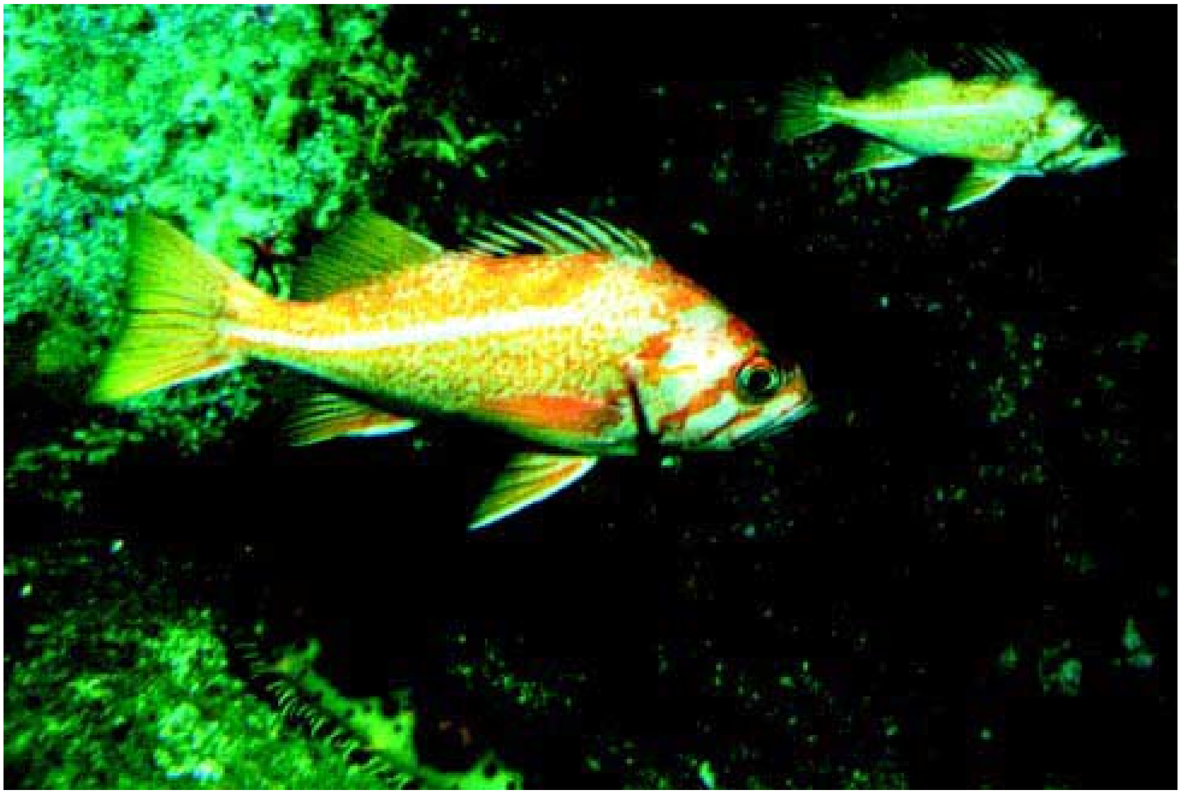


Figure 59. Reported CPFV landings (solid line) and effort (dotted line) from 1981–2000 of white croaker within nearshore soft bottom habitats at the five major ports associated with the MBNMS.

Rocky Deep Shelf and Slope Habitats



Rocky deep shelf and slope habitats occur on the edges of submarine canyons, and on the shelf in a few other areas in the MBNMS (Fig. 2–4). These habitats are usually characterized by high relief rock pinnacles, boulders, or walls. Mud substrates often are interspersed in or around rocky outcrops. Rocky deep shelf and slope habitats are challenging environments to fish, especially within the Monterey Bay. The submarine canyons, with shear walls and high relief rocky cliffs, make bottom trawling extremely difficult and thus may provide areas of natural refuge for many species. Despite the difficult fishing, this habitat group is important to both commercial and recreational fisheries, producing high average landings. Commercial landings in the rocky deep shelf and slope habitats comprised 15% of the total landings at ports near the MBNMS over the past 20 years (Table 9). Annual commercial landings from these habitats averaged 8.6 million lb/yr from 1981–2000. The most successful commercial fishing methods in deep rocky habitats include midwater trawling, gill netting, hook-and-line fishing (mostly for rockfishes), and trap fishing (mostly for spot prawn). Semi-pelagic rockfishes are the primary component of catches in these habitats; they comprise 95% of the total landings from rocky deep shelf and slope habitats (Table 9). The trend in overall catch from rocky deep shelf and slope habitats reflects the general declining population trend of many rockfishes (Fig. 60 and Fig. 61), the reasons for which are discussed below. Recreational effort in these habitats has fluctuated widely because of the switch in recreational fishing effort between rockfish and salmon fishing.

Table 9. Primary species landed in commercial fisheries in the MBNMS that were caught in deep rocky shelf and slope habitats, and the percentage that each species contributed to the landings from this habitat group and total landings in the MBNMS. Landings from deep rocky shelf and slope habitats during the period equaled 171.112 million pounds from 1981–2000. Total landings in all of the MBNMS equaled 1.14 billion pounds from 1981–2000.

Guild	Common Name	Scientific Name	% habitat	% total
Invertebrates				
	Spot Prawn	*Pandalus platyceros*	0.6	0.1
Vertebrates				
Hexagrammids	Lingcod	*Ophiodon elongatus*	1.5	0.2
Scorpaenids	Rockfishes			
Demersal	Bronzespotted rockfish	*Sebastes gilli*	< 0.1	< 0.1
	Copper (whitebelly) rockfish	*Sebastes caurinus (vexillaris)*	0.1	< 0.1
	Flag rockfish	*Sebastes rubrivinctus*	< 0.1	< 0.1
	Greenblotched rockfish	*Sebastes rosenblatti*	0.1	< 0.1
	Greenspotted rockfish	*Sebastes chlorostictus*	0.9	0.1
	Rosethorn rockfish	*Sebastes helvomaculatus*	< 0.1	< 0.1
	Quillback rockfish	*Sebastes maliger*	< 0.1	< 0.1
	Speckled rockfish	*Sebastes ovalis*	0.3	< 0.1
	Starry rockfish	*Sebastes constellatus*	0.2	< 0.1
	Tiger rockfish	*Sebastes nirgocinctus*	0.0	< 0.1
	Vermilion rockfish	*Sebastes miniatus*	0.8	0.1
	Yelloweye rockfish	*Sebastes ruberrimus*	0.6	0.1
Semi-pelagic				
	Bank rockfish	*Sebastes rufus*	11.7	1.8
	Bocaccio	*Sebates paucispinis*	27.1	4.1
	Canary rockfish	*Sebastes pinniger*	1.2	0.2
	Chilipepper	*Sebastes goodei*	33.5	5.0
	Shortbelly rockfish	*Sebastes jordani*	0.1	< 0.1
	Pacific Ocean Perch	*Sebastes alutus*	< 0.1	< 0.1
	Widow rockfish	*Sebastes entomelas*	15.1	2.3
	Yellowtail rockfish	*Sebastes flavidus*	5.9	0.9

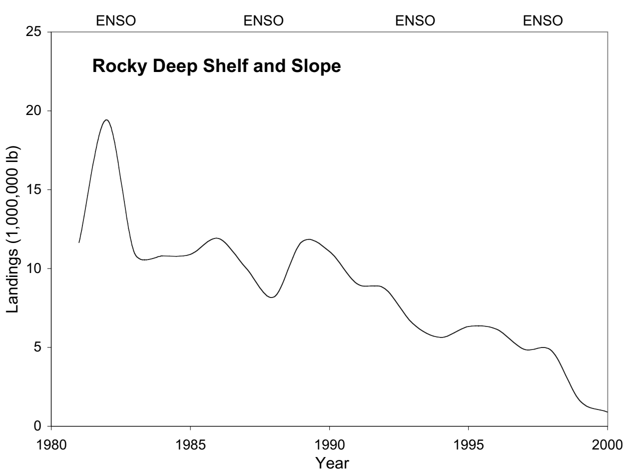


Figure 60. Reported commercial landings from 1981–2000 of all species within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS.

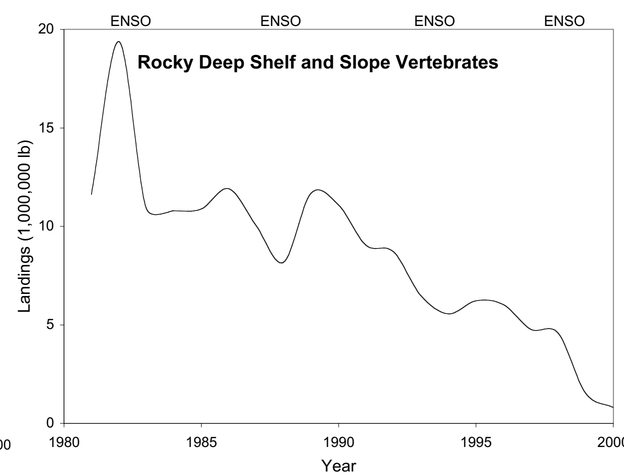


Figure 61. Reported commercial landings from 1981–2000 of fishes within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS.

Invertebrates

Spot Prawn *(Pandalus platyceros)*
Spot prawns have been harvested in California waters since 1921. In the early years, California landings were less than 2,000 lb/yr and primarily taken incidentally in octopus traps. Landings rose considerably in the 1970s, when fishers in Santa Barbara initiated a trawl fishery that specifically targeted spot prawn (Fig. 62). Total California landings reached a peak of 371,000 lb in 1981, of which more than 60,000 lb, worth over $161,000, were harvested from MBNMS waters. In 1982–83, catches dropped considerably, and by 1984 the CDFG ordered a temporary closure of the spot prawn trawl fishery. A similar closure of the trawl fishery for prawns in 1986 prompted an increased interest in the trap fishery, and created a new sales market. Fishers were able to sell live prawns to restaurants for $5.00–$6.50/lb, an increase over the $3.50/lb they received for trawl-caught prawns. With this increase in ex-vessel price and demand for live prawns, trawl fishers began fitting their boats with live wells. Commercial landings throughout California of spot prawn in 1999 totaled more than 600,000 lb and were worth more than 4 million dollars, making it one of the top earning fisheries despite the low landing volumes.

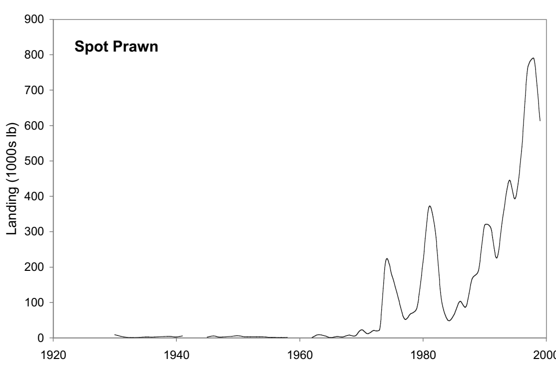


Figure 62. Reported commercial landings of spot prawn in California from 1920-1999.

Although the majority of spot prawn landed within the MBNMS in the early 1990s were taken by traps, trawls now take almost all the catch of spot prawn from the MBNMS. Trawl vessels accounted for 82% of the 1996 landings. Spot prawn landings have increased dramatically since 1992, with a peak of 372,000 lb landed in the MBNMS in 1998 (Fig. 63). This increasing trend is related to increasing demand and increasing landed value.

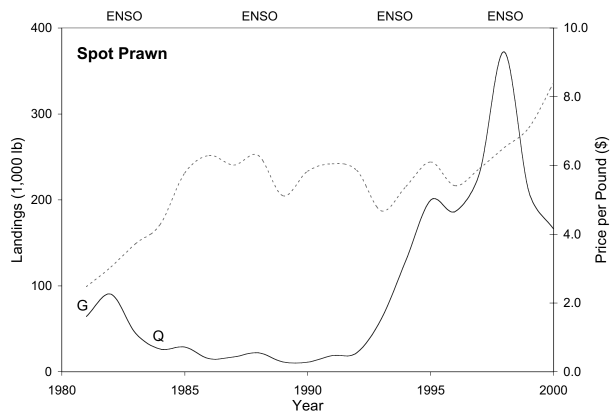


Figure 63. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of spot prawn within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

The spot prawn fishery is presently open to all trawl and trap vessels, but is slated to become a limited entry program for trap vessels in early 2002. Additional regulations for trawlers include seasonal closures, minimum mesh size, and incidental catch limits. Trap fishing is also regulated by seasonal closures and by the number of allowable traps per boat. Traps are required to be less than 6 ft around with openings of less than 5 inches and must have a destructive device to prevent them from capturing animals if lost from the buoy. In 2000, the California Fish and Game Commission adopted regulations that established January 1, 1999 as a control date for entry into the restricted access program spot prawn trap fishery and spot/ridgeback prawn trawl fishery. In addition, a one year regulation (2000 to 2001) was enacted requiring an on-board observer program for the spot prawn trawl and trap fisheries. Currently, no population estimates exist for this species. For additional information see Leet et al. *California's Living Marine Resources: A Status Report* (2001).

Vertebrates

Rocky Deep Shelf and Slope Rockfishes
Rocky deep shelf and slope habitats include commercial and recreational fisheries for some of the most important species in Central California. Rockfish species harvested from these habitats (such as bocaccio, chilipepper, widow rockfish, yelloweye, and yellowtail rockfish) comprise 98% of the total commercial catch within these habitats in the MBNMS. In the recreational fishery, almost 50% of the catch from 1959 to 1994 was taken within these habitats, and eight of the ten most numerous species taken in the CPFV fishery utilize these habitats. Also important ecologically, the fishes in deep rocky habitats form two major associations: 1) demersal rockfishes that inhabit the cracks and crevices of rocky structures, and 2) semi-pelagic species that form schools over rocky peaks and pinnacles. The semi-pelagic species are the most accessible to trawlers and make up 95% of the total catch from these habitats.

Rockfishes have been harvested in commercial fisheries in California since the mid-1800s. California landings greatly increased in the 1970s as more American vessels entered the groundfish trawl fishery after passage of the FCMA (Fig. 64). Between 1980 and 1992, trawling effort declined while the use of gill nets to catch rockfishes increased. Overall, rockfish catches for the MBNMS in rocky deep shelf and slope habitats have declined over the past twenty years (Fig. 65).

Historically, rockfishes have been marketed under a variety of names such as rockcod, snapper, or red snapper. The grouping of species into market categories makes trends in abundance difficult to delineate from catch data. To provide some idea of population trends, fishery scientists record the species composition of samples of fish that are sold at the docks by market category, and then attempt to evaluate indices of abundance by partitioning catches by species, depth, and life history characteristics. These indices have been particularly useful to understand changes in rockfish populations in rocky deep shelf and slope habitats.

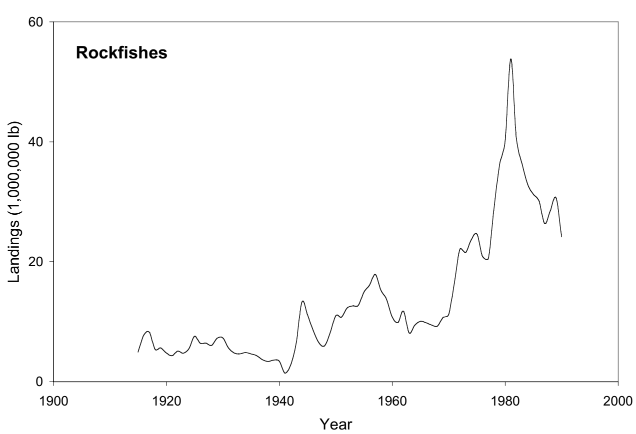


Figure 64. Reported commercial landings for all rockfishes in California from 1916–1991.

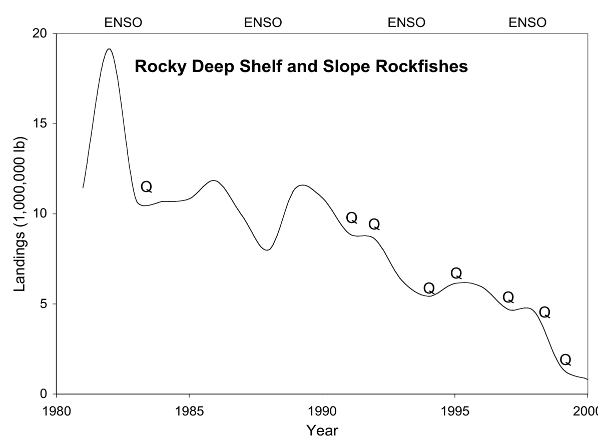


Figure 65. Reported commercial landings from 1981–2000 of rockfishes within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Scientific stock assessments exhibit a range of population trends for rockfishes within rocky deep shelf and slope habitats along the West Coast of the United States. Stock assessments indicate stable or increasing trends in abundance for chilipepper and shortbelly rockfish. Similarly, yellowtail populations seem to be healthy and productive. The biomass of bank rockfish has declined, but it is not known if a problem exists with this heavily fished species. Bocaccio, canary, cowcod, and widow rockfish have been declared to be overfished and are now managed under stock rebuilding plans. Most of these deep-water rockfishes are slow growing, long-lived, and have experienced high exploitation rates (Appendix H). Managers are concerned about the capability of some of these species to recover from high harvest rates, especially because some species are prone to long periods of failed recruitment. For example, bocaccio is considered to be at a population level of about 2% that of estimated unfished biomass and has recently been considered a candidate for inclusion as an endangered species. Similarly, off parts of the West Coast, the canary rockfish population is 50% of what it was thought to be in 1977. In addition to reduced numbers of canary rockfish, managers are concerned that the age structure of canary rockfish has shifted so that few older fish remain in the population. Survey estimates of abundance for yellowtail rockfish have been highly variable, but the most recent stock assessment indicates a downward trend. More information is needed for all species to adequately estimate stock size for management purposes. A positive note is that there are indications that large numbers of small bocaccio are present in many locations within the MBNMS.

The recreational fishery for rockfishes in the MBNMS switched from shallow nearshore rockfishes to deeper species in the 1960s to compensate for the decline in nearshore catch rates. By 1977, advanced echosounder technology allowed vessels to also fish for deeper species at the edge of the Monterey submarine canyon. This shift to rocky areas in deeper water provided catches of larger fishes and at locations much closer to port. Catches of deep-water species in the CPFV fishery increased from 2% of the total catch between 1959 and 1972 to 21% of the total catch between 1986 and 1994. For canary and greenspotted rockfish, over 60% of their catch weight was taken in the CPFV fishery. Total rockfish catches on CPFVs have declined (Fig. 21–p. 29) over the past twenty years, while overall catch per effort has also shown a slight decline (Fig. 42–p. 63).

Catch statistics alone, however, are not always a good indicator of population status. Length and weight data, when available, can sometimes provide further information on stock size, recruitment success, and fishing pressure. Rockfish length data were collected from the recreational fishery intermittently from 1959–1973, and nearly continuously from 1977–1994. In the time from 1959 to 1994, eight rocky deep shelf and slope rockfishes demonstrated declines in length, with chilipepper decreasing over 27% (Table 10). It has been reported that some of the decreases in mean length evident in these data may be the result of successful recruitment of smaller fishes in recent years. As large numbers of small fish become available to the fishery, the overall mean size of rockfish caught would thus decrease. Biologists base this conclusion on increasing catch rates coincident with declining mean lengths. Fishing pressure has also contributed to the decreasing trends in length, though it is unknown to what extent. Regardless of the reason, continued catch of individuals of sizes at or below maturity will increase the likelihood of poor recruitment in fishes already prone to recruitment failure. Juvenile abundance surveys over the past 20 years already show dramatic declines in abundance for rockfishes.

Uncertainty in the health of rockfish populations has led to increased regulations in both commercial and recreational fisheries.

Table 10. Rockfish species exhibiting significant declines in mean length, for three periods of time from 1959–94. Overall percent change in length is also included.

	Period of Decreasing Mean Length			% overall change
Species	1959–94	1977–94	1987–94	1959–94
Chilipepper	**	**		–27.3
Olive Rockfish	**	**		–8.9
Bocaccio	*	*		–12.3
Greenstriped Rockfish	*	*		–4.3
Yellowtail Rockfish	*	*		–12.1
Widow Rockfish	*			–11.4
Blue Rockfish		**		–6.8
Rosy Rockfish		**		–1.9
Greenspotted Rockfish		**	*	–4.1
Canary Rockfish			**	–1.4

*Regression Significant ($0.01 < p < 0.05$)

**Regression Significant ($p < 0.01$)

Note: Data provided by Janet Mason; see also Mason (1998)

In 1983, the first coastwide limit on catches of all rockfishes was implemented, but it was not until the 1990s that catch regulations consistently decreased the commercial take, with additional regulations aimed specifically at a few of the rocky deep shelf and slope species. Regulations included weekly or monthly trip limits and geographically varying management schemes. These regulations promoted the consistent decline in rockfish catches starting in 1991 and continued to lower landings in the mid-1990s (Fig. 65). In 2000, general recreational bag limits for rockfishes decreased from 15 to 10 individuals (see individual species for species-specific limits), with the use of no more than 2 hooks per line.

Though regulations on rockfish landings are becoming stricter, bycatch issues are still a major concern. Mortality of deep-dwelling rockfishes is essentially 100% when fish are brought to the surface, and rockfishes are captured at high levels in some fisheries. The PFMC has used working estimates of rockfish bycatch for harvest modeling and management purposes of 15% to 30% of total catches in all fisheries, but actual bycatch rates are not well understood, and may be higher than suspected. This increases uncertainty in harvest limitations set to manage already dangerously low populations.

Demersal Rockfishes

Demersal rockfish catch was steady in the MBNMS in 1980s, but increased sharply in the 1990s with the introduction of roller gear to the Central Californian trawl fishery (Fig. 66). All rockfishes within this habitat group caught within the MBNMS are under restrictions set for the *Sebastes* complex. Those limits decreased drastically in the mid to late 1990s, as indicated by the drop in catches after 1996. In addition to relatively small levels of commercial landings in rocky deep shelf and slope habitats, copper, flag, quillback and vermilion rockfishes are caught commercially in the nearshore environment. Overall landing trends for these species within the MBNMS are discussed in the Nearshore Rocky Reef and Kelp habitats section.

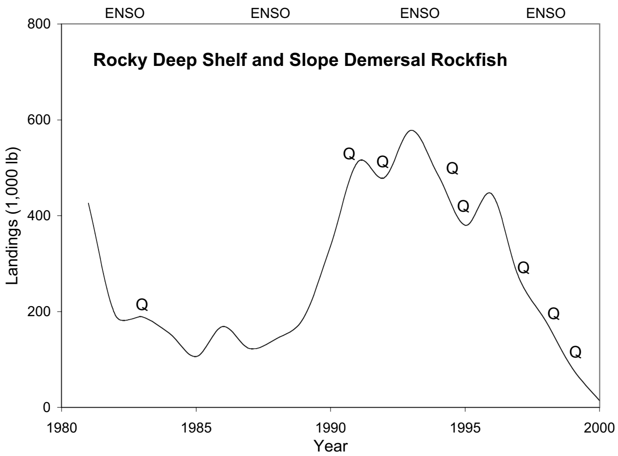
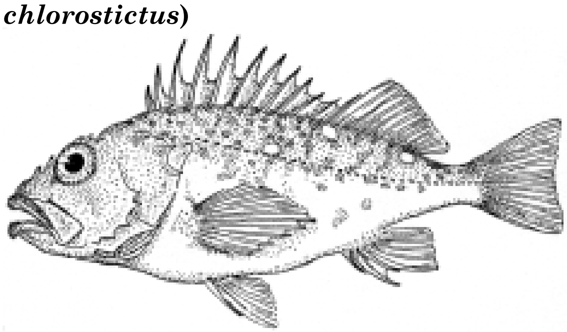


Figure 66. Reported commercial landings from 1981–2000 of demersal rockfishes within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Greenspotted Rockfish (*Sebastes chlorostictus*)



The greenspotted rockfish is abundant from Monterey south into the Southern California Bight. Greenspotted rockfish are an important component of the recreational fishery within the MBNMS, comprising 3% of the total CPFV catches from 1959 to 1994 in Monterey. Northern and Central California CPFV catch per unit effort (CPUE) for this species peaked in the mid-1980s with fluctuating CPUE since that time (Fig. 67). Greenspotted rockfish are relatively less important in the commercial fishery, with 65% of the combined commercial and CPFV catch (by weight) being attributed to the CPFV fishery. This heavy take by the recreational fishery declined in the 1990s because sport fishers turned back to the nearshore habitats for fish. Average total length of greenspotted rockfish landed in the sport fishery has declined over 4% since 1960. Commercial take from 1980 to 2000 averaged just over 74,000 lb/yr and was generally low in the 1980s (Fig. 68). By the 1990s, roller gear trawling within the MBNMS had increased landings of greenspotted rockfish.

Greenspotted rockfish are currently managed under the *Sebastes* complex group. There is no stock assessment of this species and no special recreational regulations.

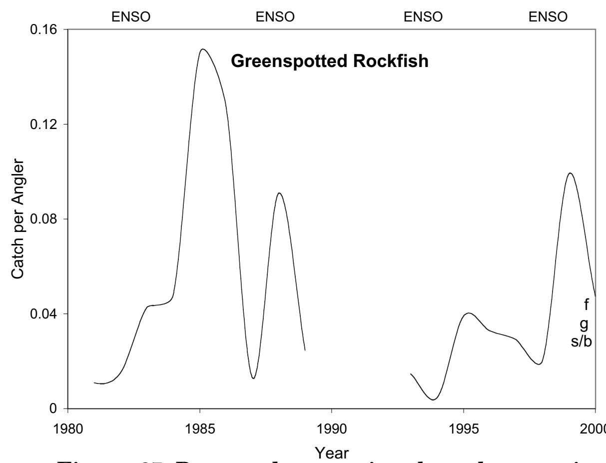


Figure 67. Reported recreational catch per unit effort from 1981–2000 of greenspotted rockfish within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. California from 1981–2000. No RecFIN data are available for years 1990–1992. See Appendix G for specific yearly meanings of each regulatory symbol.

Semi-pelagic Rockfishes

Semi-pelagic rockfishes make up the majority of catches within rocky deep shelf and slope habitats, and landings reflect the same general declining trends as the overall habitat group (Fig. 69). These declines are due in most part to a combination of overfished populations, poor recruitment, and intense regulation. Semi-pelagic rockfishes showed

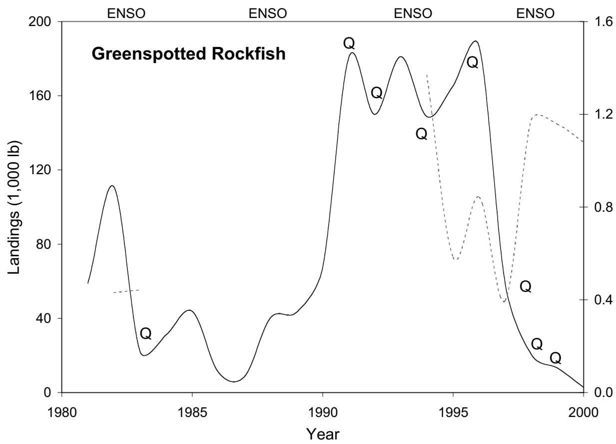


Figure 68. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of greenspotted rockfish within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

declining trends sooner than demersal rockfishes because they were easier to catch until the advent of roller gear. Catches in the 1990s were low primarily because of severe quota limitations for these species.

Bank Rockfish *(Sebastes rufus)*

Bank rockfish are commercially caught using gill nets or otter trawls equipped with roller gear; small amounts are harvested with hook-and-line gear. In 1987, Monterey gill net landings of bank rockfish doubled when California regulations forced gill net fishing operations deeper than the 100-fathom isobath. The commercial landings of bank rockfish in the MBNMS averaged over 1.1 million lb/yr from 1980–95. Catches steadily declined, however, from 1988–2000 (Fig. 70), and catches in 2000 were estimated to be only about 95,000 lb (Appendix C). Some of this decline may have resulted from gill net fishers changing over to longline gear, enabling them to fish within state waters, but it is primarily the effect of increased regulation of the *Sebastes* complex.

NMFS population surveys conducted every 3 years between 1977 and 1995 indicate that more than 90% of the bank rockfish population occurs off Central and Northern California. A bank rockfish stock assessment prepared in 2000 indicated that stock level is at 30 to 40% of the unfished population. There was also a significant decline in mean length of bank

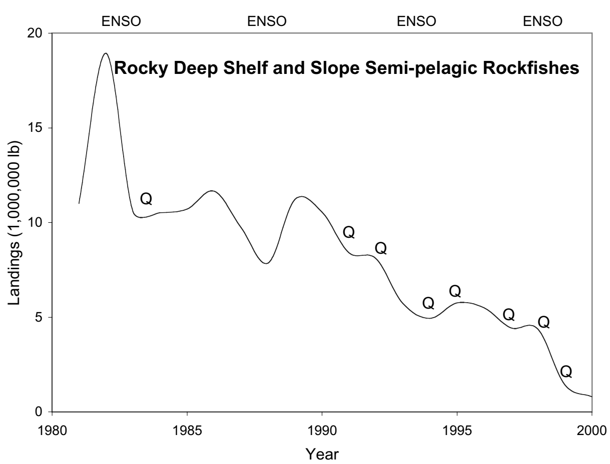


Figure 69. Reported commercial landings from 1981–2000 of semi-pelagic rockfishes within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

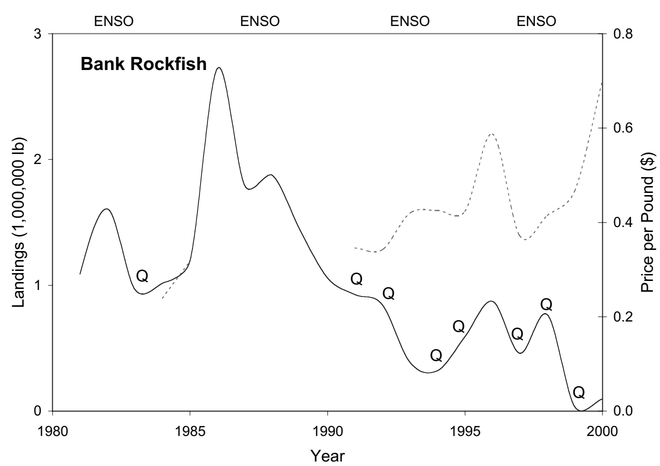
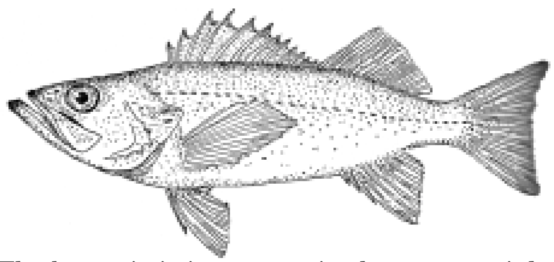


Figure 70. Reported commercial landings from (solid line) and ex-vessel prices (dotted line) 1981–2000 of bank rockfish within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

rockfish landed in Central and Northern California from 1978–88. Although the population is not currently overexploited, it is at a level that may be highly vulnerable to periods of failed recruitment and intense harvesting. The PFMC currently does not specifically limit the catch of bank rockfish; they are managed as a part of the *Sebastes* complex.

Bocaccio (*Sebastes paucispinis*)



The bocaccio is important in the commercial trawl and hook-and-line fisheries in Monterey Bay. They usually are marketed as red snapper or rockcod. They are also important in the sport catch, comprising 7% of the CPFV catch from 1959 to 1994. Current recreational limits set a bag limit of 2 bocaccio, with a minimum size of 10 in. Commercial landings at ports near the MBNMS averaged 2.55 million lb/yr from 1980–2000, with an unusually large catch in 1980 of 7.2 million lb from gill net catches in Half Moon Bay. Since 1982, bocaccio catches have consistently declined each year to just over 26,000 lb in 2000 (Fig. 71), primarily due to severe limitations on allowable catch.

Stock assessment models show that bocaccio spawning stocks are severely depleted. Recruitment levels for bocaccio are highly variable, but have generally dropped as spawning stocks have declined. Stock assessments suggest that bocaccio abundance is 2% that of estimated 1970 levels, which is thought to have been an anomalously high abundance year for bocaccio. In 1999, the first strong recruitment episode since 1984 was seen and it is hoped this will start to rebuild the already depleted Central California populations.

From 1983–90, bocaccio was managed by PFMC in combination with other rockfish in the *Sebastes* complex. The PFMC uses trip, frequency, and geographical limits to constrain total complex landings. After 1990, specific bocaccio trip limits were established to keep catch within the harvest guidelines

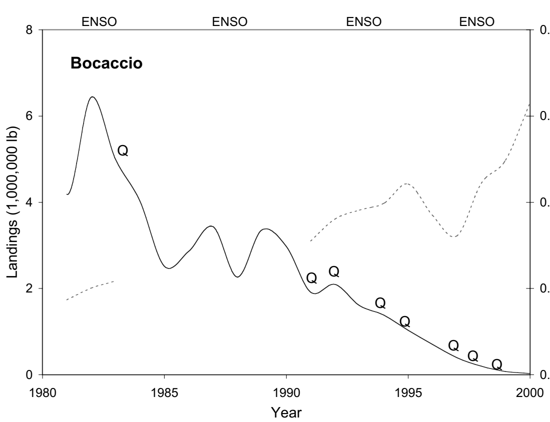


Figure 71. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of bocaccio within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

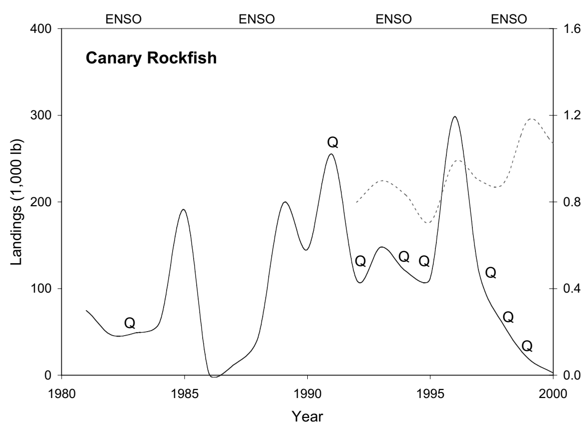
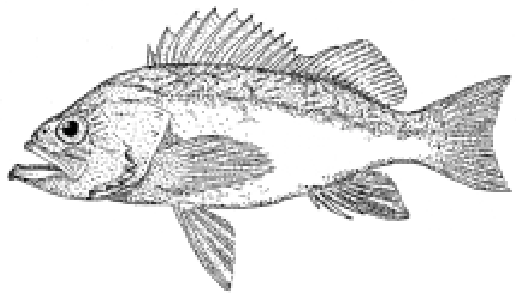


Figure 72. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of canary rockfish within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

(Appendix F). For additional information see Leet et al. *California's Living Marine Resources: A Status Report* (2001).

Canary Rockfish *(Sebastes pinniger)*



Canary rockfish are a major component of the Pacific Northwest groundfish fishery; populations are centered off the Washington/ British Columbia coast. Canary rockfish are caught both in trawls and by hook-and-line gear. In Central California, canary rockfish contribute only a small portion to commercial landings in rocky deep shelf and slope habitats. Catches in the past twenty years are highly variable, with moderate increases in the 1990s attributable to increased fishing effort for canary rockfish below Fort Bragg (Fig. 72). The average estimated catch from 1981–2000 was 102,000 lb/yr, with a high of more than 298,000 lb in 1996. Declining catches in subsequent years are a reflection of the intense regulations placed upon the *Sebastes* complex (under which the canary rockfish was managed in the MBNMS). In 1999, specific coastwide regulations were implemented for the canary rockfish by the PFMC. A steady decline in recruitment since 1991 may also have contributed to declining catches. Recruitment was lower than average in the late 1970s to early 1980s, returned to average and slightly above average in the mid-1980s to 1990, but has since steadily declined. Recreational catches of canary rockfish off Northern and Central California have also declined over the past 20 years (Fig. 73).

A 1999 stock assessment for canary rockfish concluded that the population was less than 10% (maybe as low as 5.5%) of unfished levels, indicating the stock is currently overfished.

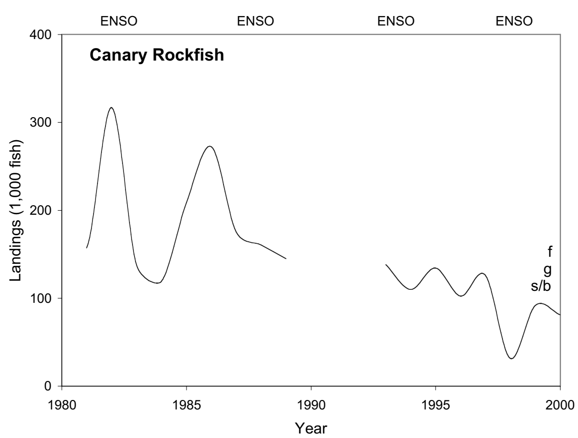
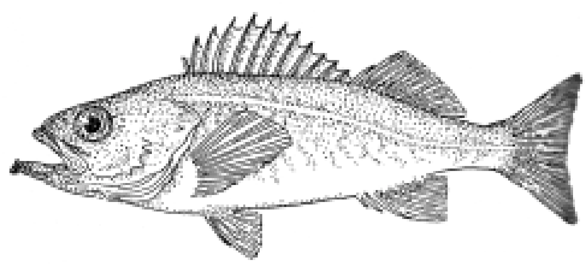


Figure 73. Reported recreational landings of canary rockfish in Central and Northern California from 1981–2000. California from 1981–2000. No RecFIN data are available for years 1990–1992. See Appendix G for specific yearly meanings of each regulatory symbol.



Chilipepper *(Sebastes goodei)*

Chilipepper are a very important component of the commercial trawl and sport fisheries in Central California. Commercial landings at ports near the MBNMS regularly fluctuated around an average of about 3 million lb/yr from 1980–98, but a sharp decline in catches followed in 1999 and 2000 (Fig. 74). Abundance estimates from catch data, age composition data, and length data all indicate that the stock size of chilipepper is increasing. Historical fluctuations of chilipepper catches have been mainly caused by environmental changes and/or effort switches over to salmon, but the current extreme decline in catches can be attributed to the close association chilipepper have with bocaccio. Because bocaccio and chilipepper schools are often mixed, and bocaccio quotas are very small, chilipepper landings have dropped as fishers try to avoid catching bocaccio. Chilipepper are currently managed by the PMFC under the *Sebastes* complex.

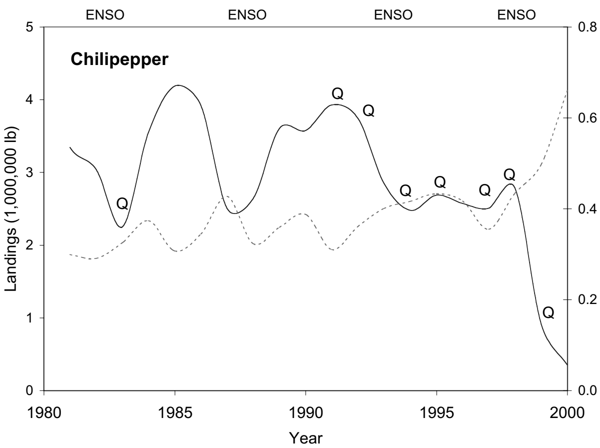


Figure 74. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of chilipepper within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Shortbelly Rockfish *(Sebastes jordani)*

The shortbelly rockfish is thought to be the most abundant rockfish off the coast of California, but it has been fished very little (Fig. 75). NMFS trawl surveys estimate a population size of over 145 million fish, equaling approximately 33 million lb in biomass, with over 80% of the population off Central California. If this fishery is developed in the future, there is a major concern regarding mesh size for nets designed to target this species. Because these fish are relatively small, the mesh sizes required to catch them in profitable numbers would also capture large quantities of other economically important fishes that are undersized. In the 1989 stock assessment, the shortbelly rockfish was considered an underutilized stock.

General provisions of the take of finfish for commercial and sport fisheries in the California Fish and Game code govern the take of this species. Biologists have recommended against bottom trawling for this species because of the hazard to young fish of other commercially important species.

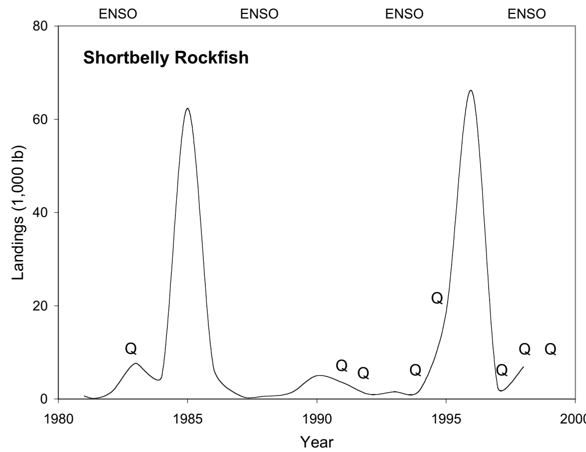


Figure 75. Reported commercial landings from 1981–2000 of shortbelly rockfish within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Widow Rockfish (*Sebastes entomelas*)

Widow rockfish are the third most frequently caught scorpaenid in California commercial fisheries, with landings less than that of chilipepper and thornyheads. They are also a significant component of the sport landings. Commercial landings at ports near the MBNMS averaged 1.3 million lb/yr from 1981–2000 (Fig. 76). Widow rockfish landings peaked in 1982 at 7.3 million lb/yr when the trawl fishery began targeting the species. Landings have been much lower since then because of decreased population sizes and increased regulations. The widow rockfish stock coastwide is estimated to be about 18% the biomass in 1980. This stock is overfished and is expected to take a long time to recover despite current low harvest levels, partly because recruitment has decreased. Since the mid-1970s, this species has shown a decline in both spawning output and biomass.

This species is managed by the PFMC. Quotas and gear regulations such as mesh size are some of the measures used to regulate this fishery.

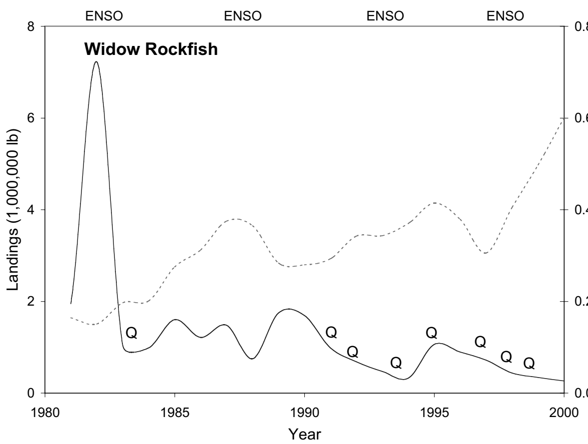
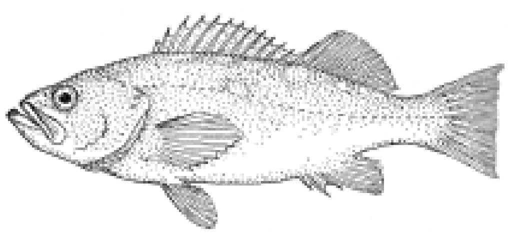


Figure 76. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of widow rockfish within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Yellowtail Rockfish (*Sebastes flavidus*)



Yellowtail rockfish are landed commercially in both the trawl and hook-and-line fisheries. They also make up a considerable component of sport landings. Coastwide, yellowtail rockfish landings increased from 2.6 million lb in 1967 to 21.2 million lb in 1983, then declined after trip limits were implemented. From 1990–99, coastwide landings averaged 13 million lb/yr. Because yellowtail rockfish are centered off Northern California and Oregon, landings of this species in the MBNMS contribute a small portion of California landings. Commercial landings at ports near the MBNMS averaged 506,000 lb/yr from 1980–2000, but have been less than 310,000 lb/yr since 1992 (Fig. 77). A large reduction of yellowtail rockfish catches in 1991, and a corresponding huge spike in reported catch of olive rockfish (Fig. 40) landings might be due to confusion identifying the two species.

Population estimates for yellowtail rockfish are highly variable, making conclusions concerning trends difficult. Despite this high variability, the coastwide trend in abundance appears downward, consistent with a low levels of recruitment from 1995 to 1998. A recent stock assessment indicates that despite recent declines in biomass, the yellowtail rockfish stock is currently at over 50% of the target biomass and seems healthy.

The yellowtail rockfish fishery is currently managed by the PFMC as two stocks separated at Cape Mendocino, California, though a three stock structure has been suggested. The PFMC currently does not specifically limit the catch of yellowtail rockfish in the southern stock; they are managed as a part of the *Sebastes* complex.

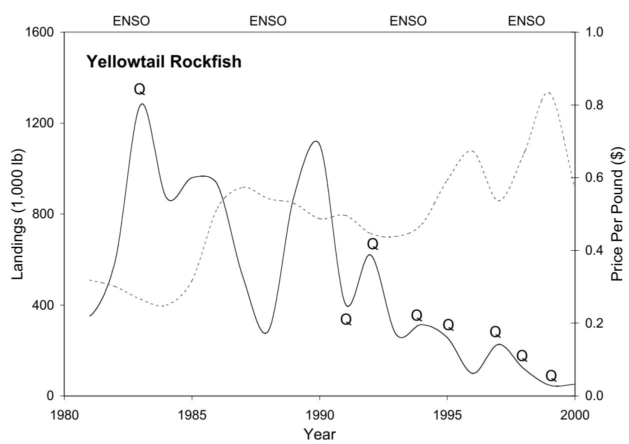
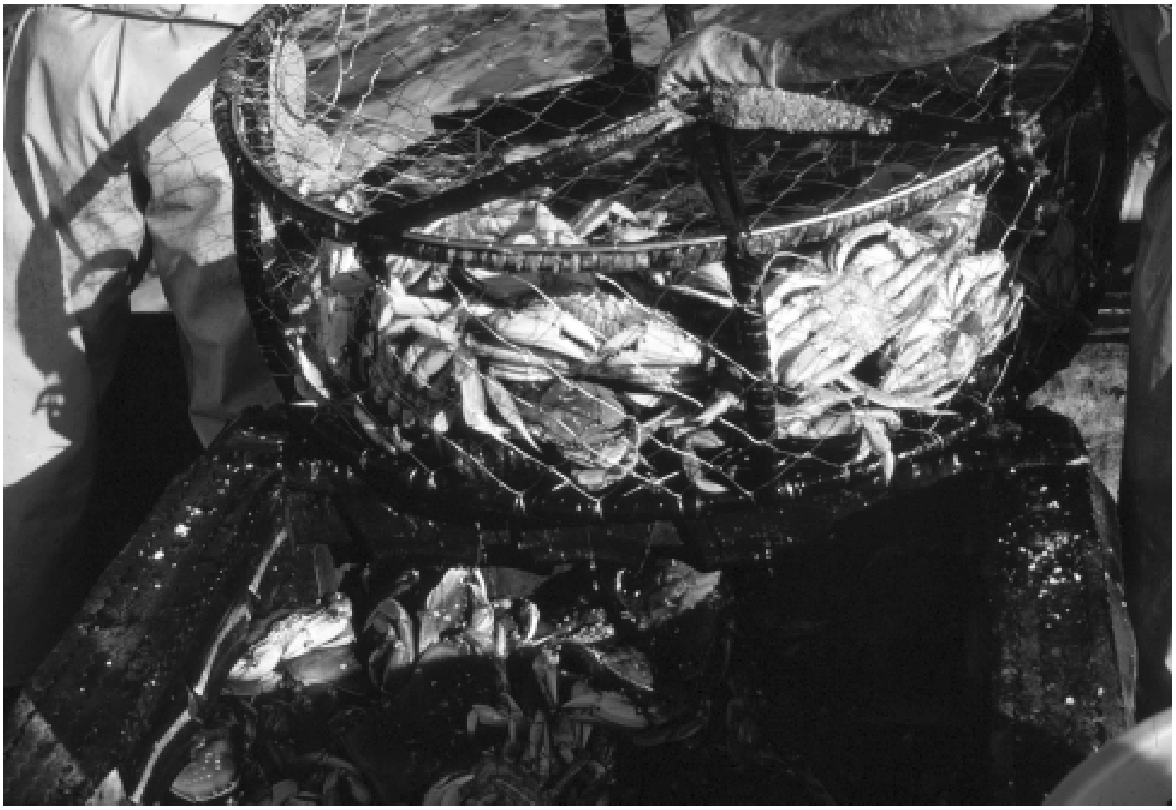


Figure 77. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of yellowtail rockfish within rocky deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Soft Bottom Deep Shelf and Slope Habitats



Soft bottom deep shelf and slope habitats are the most prevalent habitats throughout the MBNMS. They contain mud and silty sediments and contain a large number of invertebrate species. More than 30 species are routinely harvested from soft bottom deep shelf and slope habitats; and annual commercial landings from these habitats averaged 12 million lb/yr from 1981–2000 (Table 11). Bottom trawling, traps, and nets are the primary fishing gear used in this habitat. Commercial landings from these habitats comprised 21% of the total landings at ports near the MBNMS in the past 20 years. Commercial catches in these habitats remained high between 1985 and 1996, with an average estimated take of 13.5 million lb/yr, but dropped to only 5.7 million lb in 2000 (Fig. 78). A combination of regulations (for rockfishes, thornyheads, flatfishes) and environmental conditions (affecting Pacific Ocean shrimp and Dungeness crab recruitment) led to the recent decline in catch of species in this habitat group. The total landings of invertebrates in these habitats have been highly variable over the past twenty years (Fig. 79). This is due to the variable landings of Pacific Ocean shrimp and Dungeness crab since 1981, attributed mainly to environmental factors, and the spike in spot prawn landings in the

Table 11. Primary species landed in commercial fisheries in the MBNMS that were caught in soft bottom deep shelf and slope habitats, and the percentage that each species contributed to the landings from this habitat group and total landings in the MBNMS. Landings from soft bottom deep shelf and slope habitats during the period equaled 238.499 million pounds from 1981–2000. Total landings in all of the MBNMS equaled 1.14 billion pounds from 1981–2000.

Guild	Common Name	Scientific Name	% habitat	% total
Invertebrates	Pacific ocean shrimp	*Pandalus jordani*	2.7	0.6
	Spot Prawn	*Pandalus platyceros*	0.4	0.1
	Dungeness crab	*Cancer magister*	3.8	0.8
Vertebrates				
Anoplopomids	Sablefish	*Anoplopoma fimbria*	13.4	2.8
Hexagrammids	Lingcod	*Ophiodon elongatus*	1.1	0.2
Scorpaenids	Aurora rockfish	*Sebastes aurora*	0.7	0.1
	Blackgill rockfish	*Sebastes melanostomus*	2.7	0.6
	Cowcod	*Sebastes levis*	0.3	0.1
	Darkblotched rockfish	*Sebastes crameri*	0.8	0.2
	Greenstriped rockfish	*Sebastes elongatus*	0.1	< 0.1
	Redbanded rockfish	*Sebastes babcocki*	0.1	< 0.1
	Sharpchin rockfish	*Sebastes zacentrus*	< 0.1	< 0.1
	Splitnose rockfish	*Sebastes diploproa*	0.1	< 0.1
	Stripetail rockfish	*Sebastes saxicola*	5.5	1.1
	Thornyheads	*Sebastolobus* spp.	15.4	3.2
Flatfishes	Butter sole	*Isopsetta isolepis*	< 0.1	< 0.1
	California halibut	*Paralichthys californicus*	1.9	0.4
	Dover sole	*Microstomus pacificus*	30.5	6.3
	English sole	*Parophrys vetulus*	4.1	0.9
	Petrale sole	*Eopsetta jordani*	3.6	0.7
	Rex sole	*Errex zachirus*	3.0	0.6
	Rock sole	*Lepidopsetta bilineata*	0.1	0.0
	Sanddabs	*Citharichthys* spp.	5.6	1.2
	Sand sole	*Psettichthys melanostictus*	0.4	0.1
	Starry flounder	*Platichthys stellatus*	0.2	< 0.1
Sharks	Leopard shark	*Triakis semifasciata*	0.1	< 0.1
	Pacific angel shark	*Squatina californica*	0.2	< 0.1
	Soupfin shark	*Galeorhinus galeus*	0.2	< 0.1
	Skates	*Raja* spp., *Bathyraja* spp.	0.9	0.2
Other species	Pacific grenadier	*Coryphaenoides acrolepis*	1.9	0.4

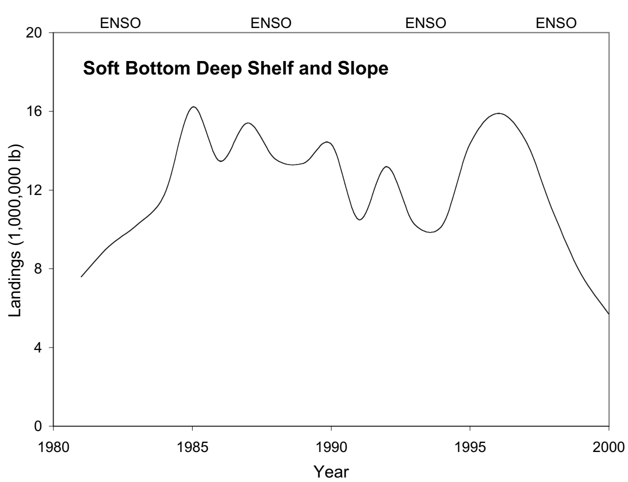


Figure 78. Reported commercial landings from 1981–2000 of all species within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

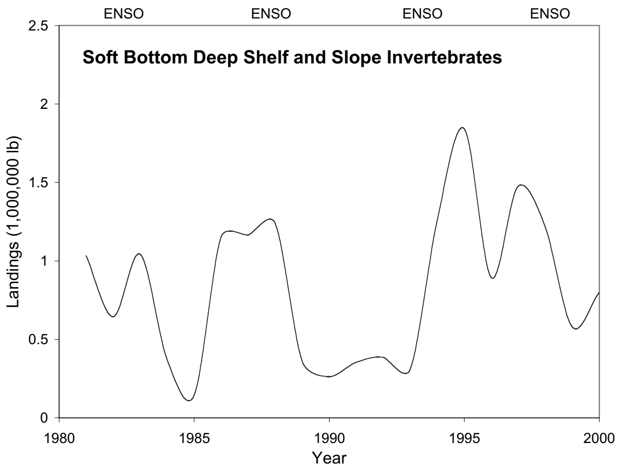


Figure 79. Reported commercial landings from 1981–2000 of invertebrate species within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

late 1990s due to demand. Vertebrates contributed the majority of landings from these habitats from 1981–2000; primary species groups caught were flatfishes (49% of total), thornyheads (15% of total), sablefish (13% of total), and rockfishes (10% of total). The recent decline in landings is primarily due to smaller quotas, but may reflect actual population declines in some species (Fig. 80 and 81). Coastwide, many species in these habitats, such as thornyheads, Dover sole, and other flatfishes, are considered to be fully exploited, but not overfished. Sablefish populations declined in the early 1990s, but the current status of stock is uncertain. Some of the soft bottom rockfishes show signs of depletion in Northern California, Oregon, and Washington, but the population status of most of the rockfishes in soft bottom deep shelf and slope habitats in the MBNMS is not well known.

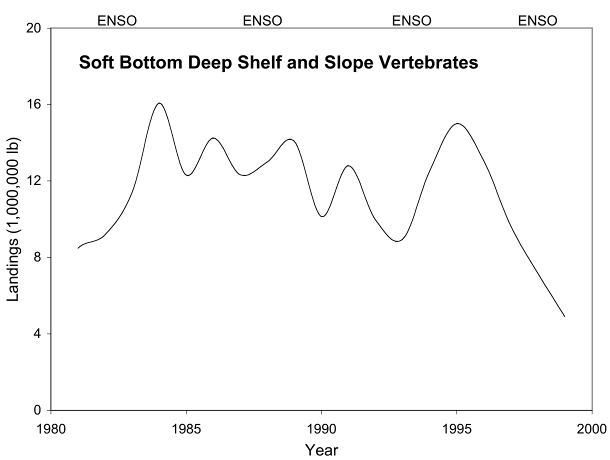


Figure 80. Reported commercial landings from 1981–2000 of fishes within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

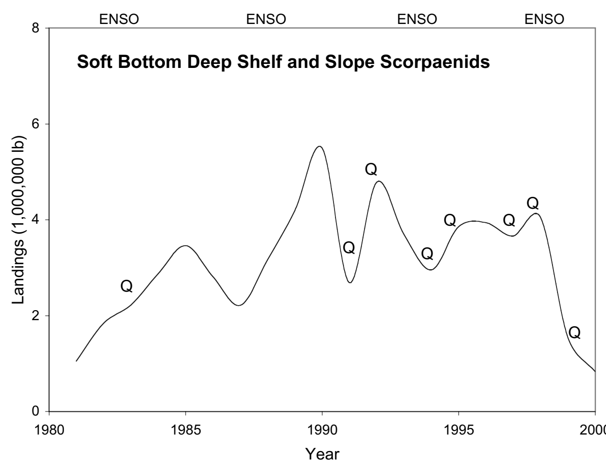


Figure 81. Reported commercial landings from 1981–2000 of scorpaenids within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Invertebrates

Pacific Ocean Shrimp (*Pandalus jordani*)

The Pacific ocean shrimp fishery comprises the majority of shrimp harvest along the Pacific coast of the United States. Pacific ocean shrimp are harvested within discontinuous areas between British Columbia and Central California, but the majority of the catches occur between Washington and Northern California. The Pacific ocean shrimp fishery began in the 1950s after the discovery of populations large enough for commercial harvest. Between 1952 and 1974, Pacific ocean shrimp were harvested by commercial vessels towing a single bottom trawl. Beginning in 1974, vessels began towing nets from each side of the boat, and catches substantially increased. Annual landings were high through the 1970s, averaging 5.7 million lb in California alone (Fig. 82). Landings in the MBNMS have fluctuated greatly over the past twenty years (Fig. 83). During 1983, El Niño conditions caused landings to drop considerably, and many vessels left the fishery. Pacific Ocean shrimp populations quickly recovered, however, and landings peaked in 1986 with 799,000 lb landed. However, a similar drop in landings occurred with the onset of El Niño conditions in 1987–88. Pacific ocean shrimp landings recovered in 1994 and increased in 1995 to a total of 746,000 lb, followed by another drop in landings. Only a small portion of this variability is attributable to fishing effort. More influential factors are variations in juvenile survival and recruitment caused by environmental conditions during larval stages.

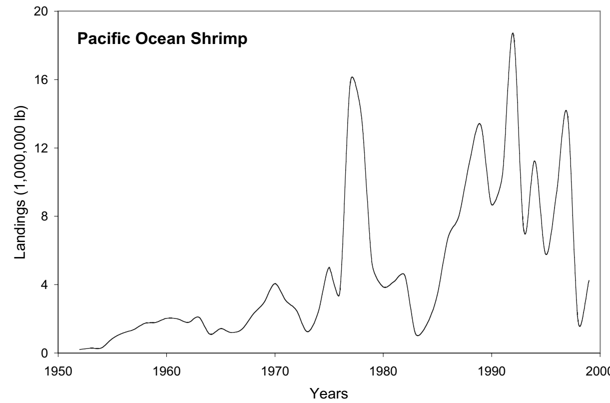


Figure 82. Reported commercial landings of Pacific ocean shrimp in California from 1952–1999.

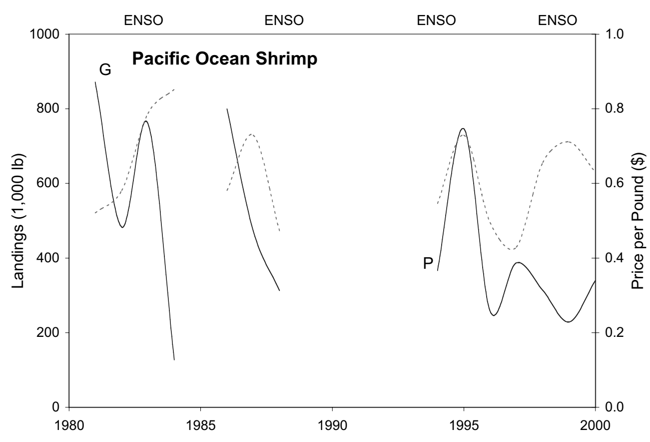


Figure 83. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Pacific ocean shrimp within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Pacific ocean shrimp are regulated by the CDFG. Pacific ocean shrimp may be harvested only between April 15 and October 31, and in water depths of 90 m or greater. In order to protect <1 and 1 yr old shrimp, net mesh size must be at least 1 3/8 inches, and shrimp count per pound must be 170 or less. In addition, fishing is only allowed when catch rates are above 350 lb/hr, to protect shrimp when population levels are low. There has been a moratorium on permits into the Pacific ocean shrimp fishery since 1994. Currently there is a restricted access program in place for the northern Pacific ocean shrimp trawl fishery.

Dungeness Crab (*Cancer magister*)

A small Dungeness crab fishery was established in 1848 off San Francisco. California landings have fluctuated with environmental changes since the onset of this fishery (Fig. 84), but the majority of the landings have always been from ports north of San Francisco. California commercial landings of Dungeness crab in 1999 totaled 8.6 million pounds and were worth over 17 million dollars, making it the second highest fishery in overall earnings.

The Dungeness crab fishery within the MBNMS comprises only a small portion of total California landings. From 1980–87, reported catch ranged from 129,000 to 344,000 lb (Fig. 85). From 1987–88, landings at ports near the MBNMS rose to nearly 1 million lb, with additional landings from MBNMS waters occurring in San Francisco. From 1989–93, landings dropped again, averaging 320,500 lb. Catches from 1994–98 fluctuated, ranging between a high of 996,000 lb in 1995 and a low of 541,000 in 1996, then dropped to 311,000 lb in 1999–2000.

A number of factors are thought to influence the Dungeness crab fishery. These include: ocean climate change, nemertean worm infestation of eggs, larval mortality, and chemical pollution of juvenile habitat. Some fishers are also concerned that trawling during the molting season is causing a decline in the fishery. Total crab landings for the coast, however, exhibit large cyclical fluctuations, rather than a steadily decreasing trend, despite the fact that commercial fishers are thought to harvest over 80% of legal-sized male crabs each year. This leads most fishery biologists to believe that coastwide, the Dungeness crab population abundance is more a function of environmental variables than fishing pressure. Dungeness crab research conducted in Washington and California supports this hypothesis.

Historically, the Dungeness crab fishery has been heavily regulated. It is presently a limited entry fishery. In the Monterey Bay area, Dungeness crab can be taken from November 15 through June 30. All traps are required to have a destruct device (e.g., twine that rots after a set amount of time) to pre-

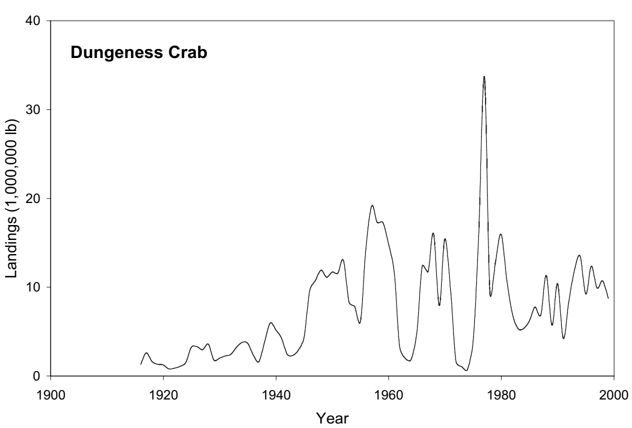


Figure 84. Reported commercial landings of Dungeness crab in California from 1916–1999.

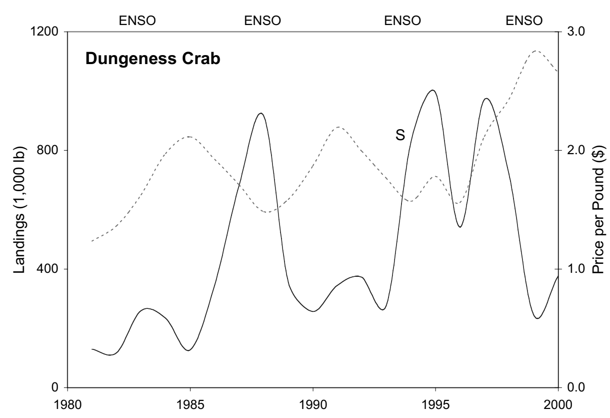
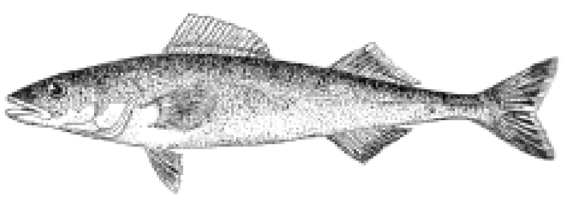


Figure 85. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Dungeness crab within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

vent ghost fishing should the trap be lost. Traps must be emptied within 96 hr of deployment, and crabs must be harvested in prime condition. Each trap buoy must display identification and permit number. The legal size of crab is 6.25 in, and only 1% of the total catch can be between 5.75 and 6.25 in. Trawlers and draggers are allowed no more than 500 lb/boat as incidental catch. The recreational season is open from the Saturday preceding the second Tuesday in November until June 30, and there is a catch limit of ten crabs per person in California and a six crabs per person each day when fishing aboard CPFVs in the Monterey Bay. Currently, no FMP or stock assessments exist for this species on the West Coast, however, available information suggests this population is healthy.

Vertebrates

Sablefish (*Anoplopoma fimbria*)



Sablefish are taken in the trap fishery, the longline fishery, and by bottom trawlers as part of the groundfish fishery. The United States commercial fishery began as early as 1905 as incidental catch by halibut fishers. During World War II, demand increased greatly with the need for sablefish livers to manufacture vitamin A. In 1958, Pacific coast landings had increased to 21 million lb, and all harvesting was by Canadian and United States fishers. In the 1960s, however, Russian and Japanese factory vessels began fishing for sablefish. Sablefish removals from California waters peaked in 1972 with 144.2 million lb caught, primarily by Japanese vessels. Only about 20% of the catch was landed in California ports (Fig. 86). In 1976, the FCMA returned the California sablefish fishery back to domestic fishers, and California became the dominant Pacific coast state for sablefish landings. Commercial landings of sablefish in California through 1999 totaled 4.3 million pounds and were worth over 4 million dollars. Monterey is one of the main ports for sablefish landings in California. The depth distribution of sablefish makes them a relatively rare catch in the recreational fishery.

Sablefish landings at ports near the MBNMS showed a decreasing trend from 1980 to 1994, increased from 1995 to 1996, reached a level of more than 2 million lb in 1996, and then declined from 1997 to the present. (Fig. 87). This decline in catch prior to 1995 has been attributed to reduced populations caused by fishing and poor recruitment in the late 1980s. The reduced landings since the mid-1990s were caused by reduced quotas that reflect a lower population size of sablefish and Dover sole, a species that is often caught with sablefish. Because market demand of sablefish is high, the value of sablefish in the marketplace has not dropped as quickly as the catch. However, most sablefish are exported and price is greatly dependent upon variable foreign markets.

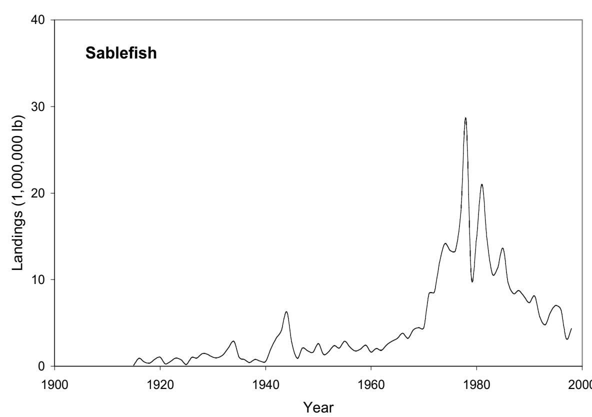


Figure 86. Reported commercial landings of sablefish in California from 1916–1999.

Until the 1970s, little direct management was enacted for sablefish. In 1982 the first commercial landing limit was imposed by PFMC for this species. Sablefish are currently federally managed under a limited entry program. The sablefish fishery is one of the few fisheries that allocate available harvest between different gear types (trawl and nontrawl). More than 90% of the catch is allocated to trawl vessels. Trip limits, size limits, quotas, and gear restrictions are also used to regulate this fishery. Trap and trawl surveys of the sablefish stock in 1994 revealed a substantial decline in numbers of sablefish from 1990–93, especially for larger females. NMFS surveys also showed consistently poor recruitment in the early 1990s, causing the PFMC to lower quotas for sablefish in the late 1990s. The sablefish stock along the Pacific coast was last assessed in 2001. Current status of the stock is uncertain, but recruitment has declined since 1990, significantly decreasing the spawning biomass. The PFMC fears this stock may fall below the overfishing threshold of 25% of the virgin spawning biomass in the next four years. The latest surveys showed evidence of a strong 2000 year class, however, which should increase sablefish abundance. This stock is currently estimated to be at 37% of its unfished biomass level, indicating that sablefish populations are fully utilized.

Blackgill Rockfish (*Sebastes melanostomus*)

Blackgill rockfish were targeted with hook-and-line gear in the 1970s and fished with gill nets in the 1980s. Currently, blackgill rockfish, along with bank and splitnose rockfishes, are caught primarily by trawlers. Within the MBNMS, recorded catches of blackgill rockfish fluctuated greatly from 1981–2000, possibly because of changes in fishing location or in gear used. Some of the higher catches in the 1980s were associated with bycatch from the sablefish longline fishery. Recently, fishers have targeted blackgill rockfish. Gradual declines in the late 1990s are concurrent with implementation of stricter *Sebastes* limits (Fig. 88).

The PFMC currently does not specifically limit the catch of blackgill rockfish; it is managed as a part of the *Sebastes* complex. A 1998 stock assessment indicated that current populations were 40 to 54% of unfished levels and that there was no evidence that the stock is depleted.

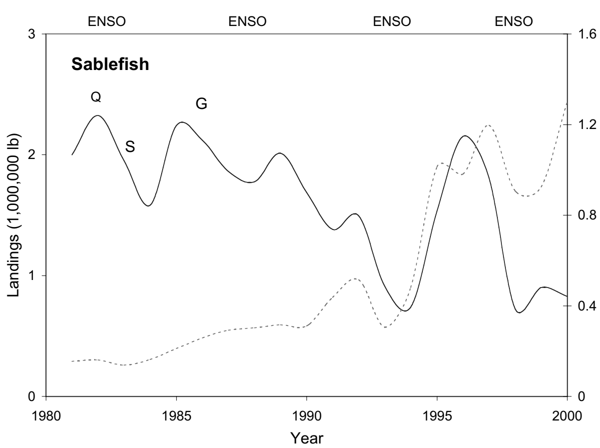


Figure 87. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of sablefish within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

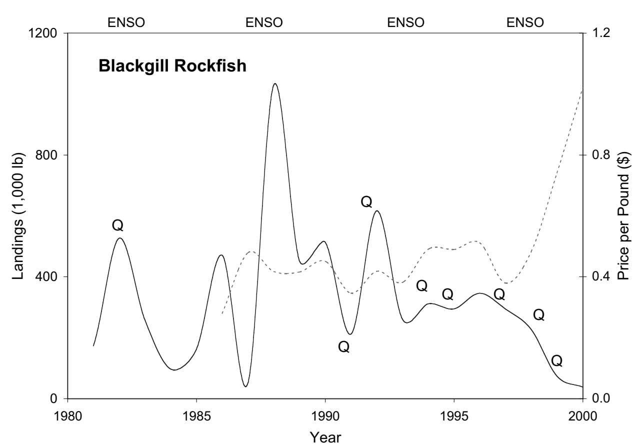


Figure 88. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of blackgill rockfish within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

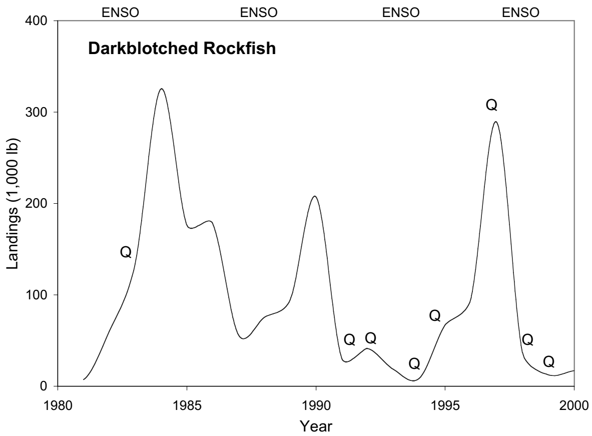


Figure 89. Reported commercial landings from 1981–2000 of darkblotched rockfish within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Darkblotched Rockfish (*Sebastes crameri*)

Darkblotched rockfish are caught primarily in deep water by trawlers. Recorded catches of darkblotched rockfish in the MBNMS averaged about 93,000 lb/yr from 1980 to 2000, although catches fluctuated widely (Fig. 89). These fluctuations are probably due to changes in fishing location or changes in gear used, rather than true reflections of changes in population sizes. There is currently insufficient data about darkblotched rockfish to enable fishery scientists to assess the stock with any certainty. The life history traits of old age and slow growth (Appendix H) indicate that harvest rates should only be 4–6% of the stock. Declining trends in mean size and abundance suggest that current harvest rates are near these equilibrium rates. The PFMC currently does not specifically limit the catch of darkblotched rockfish; it is managed as a part of the *Sebastes* complex.

Splitnose Rockfish (*Sebastes diploproa*)

Splitnose rockfish are caught primarily with trawl nets equipped with roller gear. Before 1990, there was no market for splitnose, but increasing regulation on the live-fish fishery created a market for some of the deeper rockfishes, including splitnose. Recorded catches of splitnose rockfish in the MBNMS averaged about 636,000 lb/yr from 1981–2000 (Fig. 90). Stock declines in recent years reflect the heavy regulations imposed on the *Sebastes* complex, under which the splitnose rockfish is managed by the PFMC. A preliminary stock evaluation for splitnose rockfish conducted in 1994, using four different types of surveys, showed no coastwide evidence of a declining population. Also, there was no evidence of a decline in mean lengths of splitnose rockfish from 1978–88.

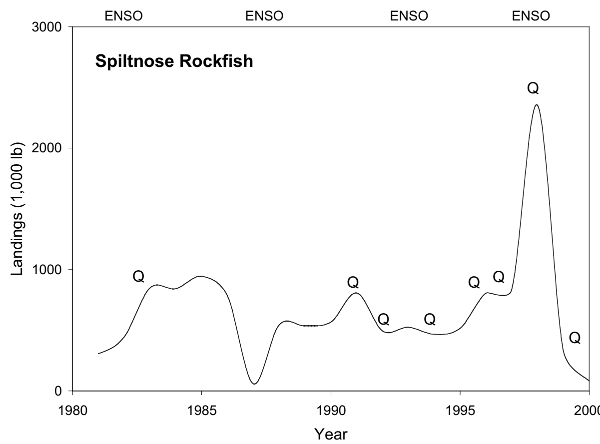
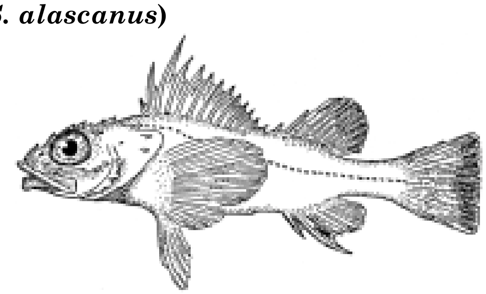


Figure 90. Reported commercial landings from 1981–2000 of splitnose rockfish within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Thornyheads (*Sebastolobus altivelis* and *S. alascanus*)



Thornyheads are an important trawl and hook-and-line caught species in the Monterey Bay groundfish fishery. The MBNMS has some of the larger, older thornyheads that occur throughout their range. Prior to 1995, the shortspine and longspine thornyheads were lumped into one category, and therefore will be analyzed as one group in this section. A market for thornyheads developed within the MBNMS in the late 1980s, and they became a major component of the trawl fishery. In 1989, thornyheads were added to the deep-water complex managed by PFMC, and in 1992, major limits were imposed on the catch. Such limits led to a dramatic drop in trawl-caught thornyheads in 1993. In 1994, a market for live thornyheads developed, and now most thornyheads are caught in the live-fish fishery. Thornyheads are good target for this fishery because they have no air bladder, allowing them to be brought up from great depths and kept alive. Recent quotas on thornyhead catches have cut into the live-fish harvest and dropped catch back to pre-trawl market levels.

Landings for both species caught in the MBNMS from 1981–2000 averaged 1.76 million lb/yr, the majority of which are shortspine thornyheads (Fig. 91). A recent stock assessment concluded, however, that the shortspine thornyhead population has not declined and that spawning abundance had increased.

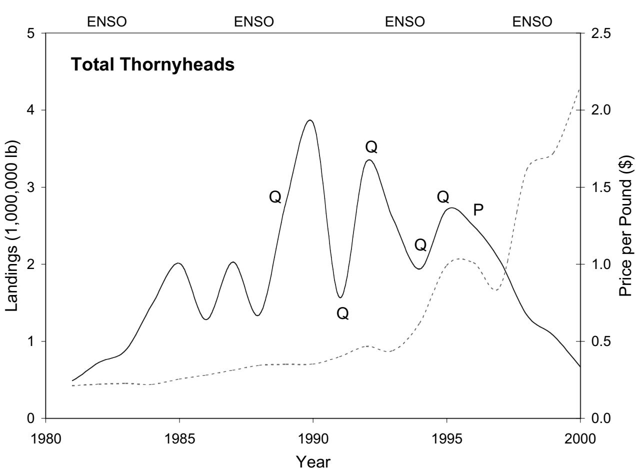
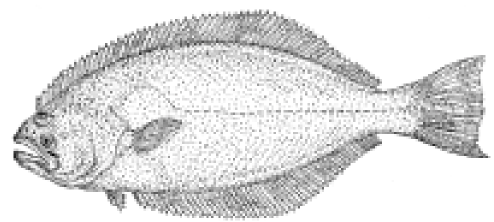


Figure 91. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of thornyheads within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

California Halibut (*Paralichthys californicus*)



Halibut are an important species in both the commercial and recreational fisheries in California. Catches of halibut are highest during the spring and summer in Central California. They are currently fished commercially using trawl, gill net, and hook-and-line gear. Fishers began using set nets to catch halibut in the 1880s. Trawls have been used since 1930, and accounted for the largest catches of halibut prior to 1969. In 1970, trawl area and season closures resulted in a change to set nets as the primary gear used to catch halibut. In 1990, the California Marine Resources Protection Act restricted gill netting to areas further than 30 fathoms from shore. The measure had a dramatic effect on halibut landings, reflected by a 32% drop in catches in Southern California between 1993 and 1994. In 1994, trawls were again the most productive method of catching California halibut, followed by hook-and-line and gill net gear.

Total commercial catch of halibut in Central California remained stable from 1981–1995 (Fig. 92). Landings of California halibut have shown an increasing trend since then, with a slight drop in catch in 2000. This increase was probably due to an increasing population of California halibut. The value of halibut landed has generally been increasing since 1980, reaching as high as $2.43 per pound in 1994. Since 1997, however, ex-vessel values have fluctuated greatly because of Mexican-caught halibut flooding the market in July.

California halibut are caught recreationally from CPFVs, private boats, and from shore. Private boats exert the most pressure on the halibut population, accounting for 75% of the recreational halibut fishing effort from 1980–87. Halibut catch from private boats is difficult to monitor, however, so trends from the private recreational fishery are not well documented. Historically, recreational halibut catches in the CPFV fishery in California fluctuated greatly. A high catch of 143,500 fish occurred in 1948. Starting in 1949, annual catches declined sharply through 1957 until a bag limit of two fish with a 22-inch minimum length was placed on fishers. Catches and regulations continued to fluctuate until the fishery declined drastically in 1971, when a five fish, 22-inch size limit was established. Between 1981–94, the number of halibut caught annually by CPFVs in the Monterey Bay area remained relatively stable (Fig. 93). CPFV landings peaked in 1995–1996 when California halibut catches averaged 13,355 fish/yr. A decline in landings followed from 1997–2000; however catches are still higher than in the 1980s and early 1990s. This is most likely a result of increased population size, but may also be due to a northward shift in the halibut population, possibly related to El Niño conditions in the early 1990s. In 1997, a total of 451,000 of California halibut were caught throughout California, approximately 73% of which was caught in Southern California.

The commercial halibut fishery is regulated using a number of methods. Gill and trammel nets are subject to depth, area, and season closures throughout the state. A minimum cod end mesh size of 7.5 inches is enforced for trawls and minimum gill net mesh size for California halibut is 8.5 inches, to allow escapement of undersized fishes. A minimum size limit for the commercial fishery is set at 22 inches. Possession of halibut as incidental catch by gill net, trammel net or trawl net is limited to 4 fish. The recreational fishery is regulated with a 22-inch size limit and catch limit of five fish south of Point Sur and 3 fish north of Point Sur. A fishery independent survey conducted in the early 1990s estimated biomass of 2.3 million lb of halibut off the coast of California and 700,000 lb of halibut in Central California. For additional information see Leet et al. *California's Living Marine Resources: A Status Report* (2001).

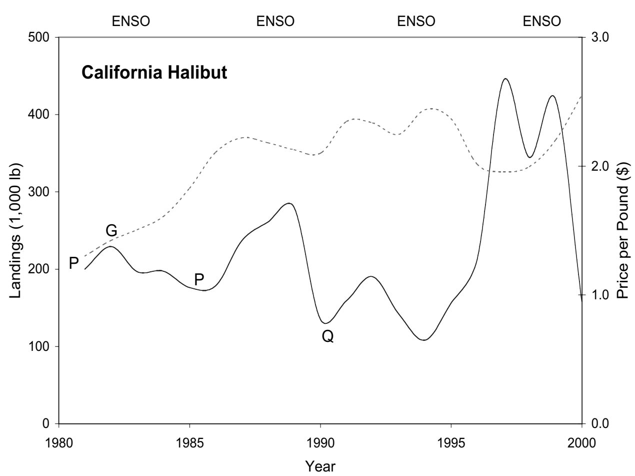


Figure 92. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of California halibut within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

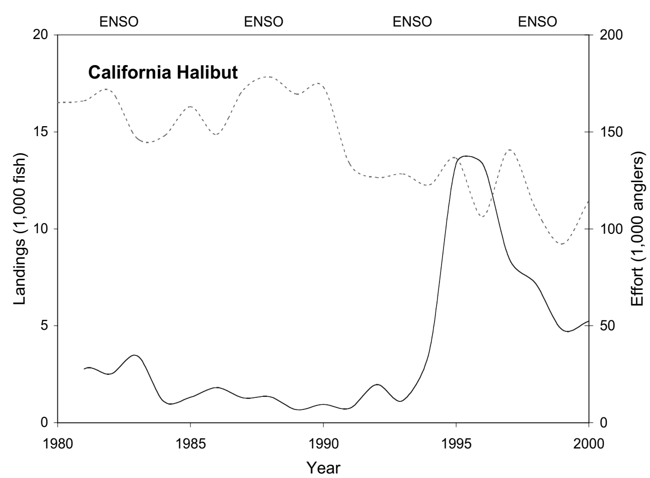
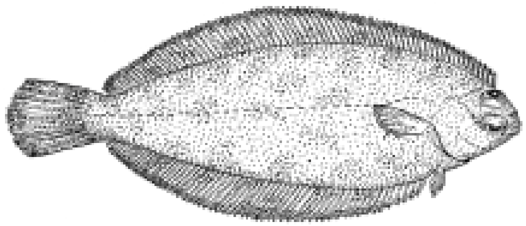


Figure 93. Reported CPFV landings (solid line) and effort (dotted line) from 1981–2000 of California halibut within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

Dover Sole (*Microstomus pacificus*)



Dover sole are one of the dominant fishes of the California commercial groundfish fishery. They are harvested by bottom trawlers and marketed as filets. Because many flatfish are caught together in the trawl fishery, effort data for individual species are not available. Commercial fishing effort for all trawl caught flatfishes, however, remained constant from 1980–95. Commercial landings throughout California in 1999 totaled 8.4 million lb and were worth nearly 3 million dollars. Historically, the port of Eureka lands the greatest amount of Dover sole, followed by Fort Bragg, Crescent City, San Francisco and Monterey. Dover sole landings at ports near the MBNMS greatly increased in the early 1980s, reaching a high of 8 million lb in 1985 (Fig. 94). Catches in the 1990s declined because of increased regulation, lower recruitment, and reduced market demand. This caused trawlers to redirect their efforts towards the more economically valuable thornyheads and sablefish.

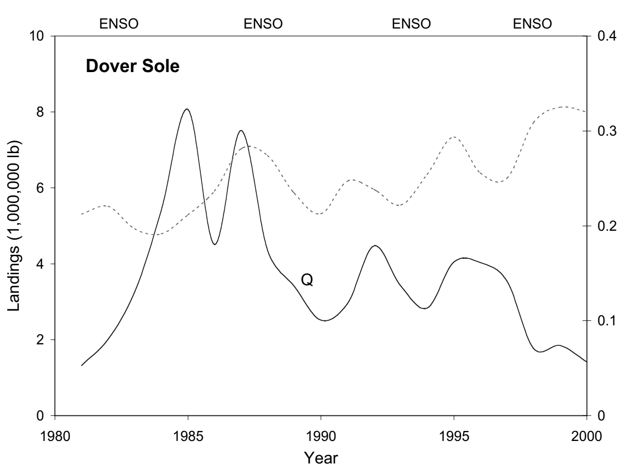


Figure 94. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Dover sole within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

A 1995 stock assessment suggested that the Dover sole populations were depressed along most of the Pacific coast. Off Oregon and Washington in the late 1970s, harvest rates were appropriate for the Dover sole abundance. However, in the 1980s and 1990s, abundance declined as catches increased, indicating a possibility of overfishing. From Cape Mendocino to Southern Oregon, stock assessments indicated that biomass was low as a result of reduced recruitment. Female spawning biomass was estimated to be only 18% of its unfished level. The low abundance estimate prompted a reduction in harvest guidelines. Recent stock assessments for the Monterey management area indicate that Dover sole biomass in this region may be above the management target level. Dover sole landings on the West Coast for the last five years have been below the recommended Acceptable Biological Catch (ABC), and NMFS survey biomass estimates have been stable since 1980.

Dover sole are managed as part of PFMC's Dover–Thornyhead–Sablefish complex. Cumulative landing limits and trip limits are used to regulate catches of this fishery. The PFMC has implemented license limitations of the complex, creating two fishing fleets: the permitted limited entry fleet and the nonpermitted open access fleet, which has more restricted harvest guidelines.

English Sole (*Parophrys vetulus*)

English sole have been harvested commercially since the 1880s as part of the California commercial groundfish fishery, but there are very few recreational landings of English sole. The majority of commercial landings are by trawl gear over deep sandy habitat. Over the last 10 years, annual landings of English sole in California have averaged 1.2 million lb, with most fish caught between San Francisco and Eureka. This is a decline since the 1980s when landings averaged 2.7 million lb. Annual English sole landings at ports near the MBNMS fluctuated between 300,000 and 1 million lb from 1981–2000 (Fig. 95). A slightly decreasing trend in both MBNMS and total California landings is evident since 1991. This is due to decreased market demand and a switch in effort towards thornyheads and sablefish.

NMFS surveys suggest that the English sole population off Oregon and Washington greatly increased from 1977–92. The increase resulted from a high recruitment during that time. High recruitment levels, combined with early age at maturity, suggest that English sole could safely withstand higher catch rates in the short term. There is no recent stock assessment for English sole in the Monterey management area, but NMFS survey indices suggest that population abundance in this region was level from 1983–95. A 1997 survey by NMFS replicated the survey completed in 1995 and found increases in the overall average CPUE estimates of English sole. Currently, English sole are managed by the PFMC through gear regulations such as trawl net mesh size.

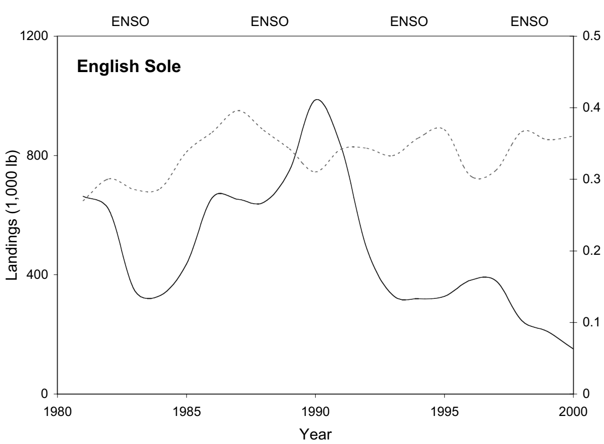
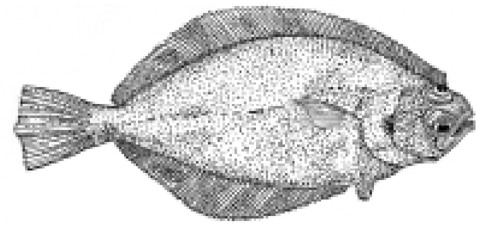


Figure 95. Reported commercial landings from (solid line) and ex-vessel prices (dotted line) 1981–2000 of English sole within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

Petrale Sole (*Eopsetta jordani*)



Petrale sole are the most highly prized food fish of the small flatfishes. Recreational anglers occasionally catch petrale sole during deepwater rockfish trips. They are also a large part of the commercial trawl fishery from California to the Gulf of Alaska. Coastwide, the petrale sole population has undergone substantial fluctuations. For the management areas off Oregon and Washington, NMFS and Oregon Department of Fish and Wildlife trawl surveys indicated a two-fold decline in biomass from the mid-1970s to the mid-1980s, followed by a general increase in biomass through 1992. Current stock assessments indicate that biomass is increasing and current landings of petrale sole in California are sustainable.

Small-scale fluctuations in petrale sole abundance have also been evident from an evaluation of catches in the Monterey Bay area. At ports near the MBNMS, annual petrale sole landings were highly variable, fluctuating between 182,000 and 750,000 lb from 1980–2000 (Fig. 96). Year class strengths of petrale sole are strongly correlated with oceanographic events, and explains the high variability in landings.

The PFMC manages petrale sole through gear regulations that include restrictions on trawl net mesh size. The PFMC has also established ABC levels for the annual harvests of petrale sole in the waters off the West Coast, though no trip limits exist. The ABC levels for the Eureka, Monterey, and Conception regions were first set in 1983 and have not been changed since their establishment. A 2001 stock assessment reported that stock biomass is increasing and that current harvest levels are sustainable. The 2001 ABC was set at 1.76 million lb for the Monterey management area.

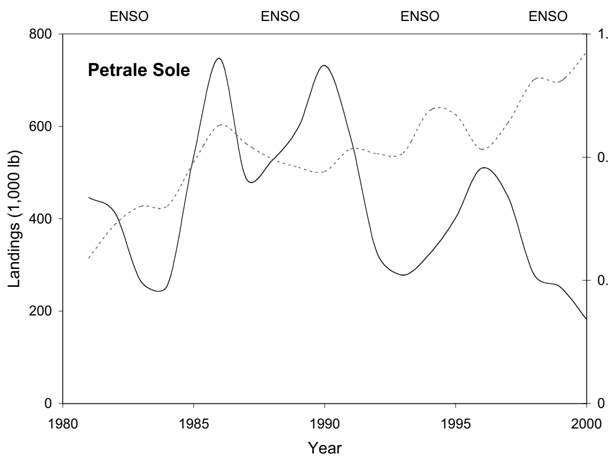


Figure 96. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of petrale sole within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

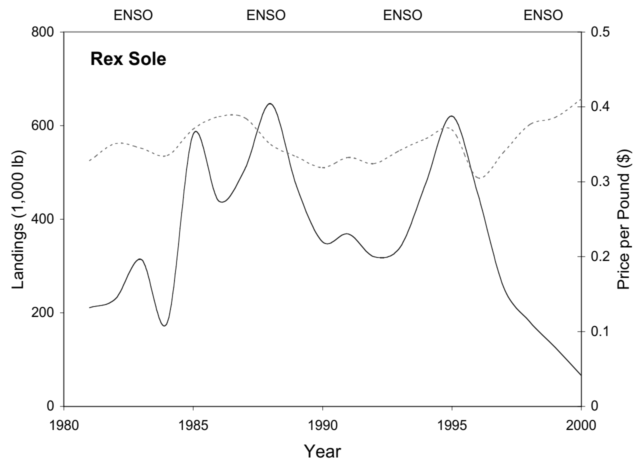
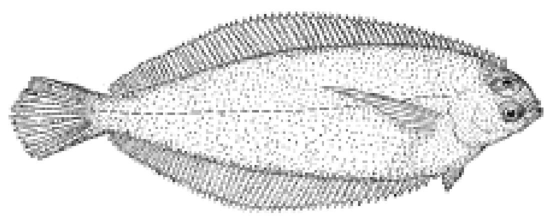


Figure 97. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Rex sole within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

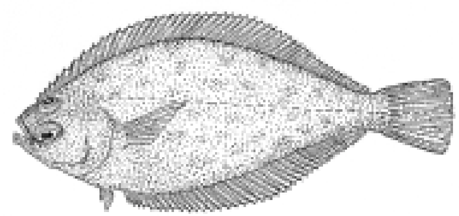
Rex Sole (*Errex zachirus*)



Rex sole are rarely taken by recreational fishers, but are a large part of the flatfish trawl fishery from California to the Bering Sea. Commercial landings for rex sole within the MBNMS are highly variable (Fig. 97).

The coastwide biomass of rex sole was estimated to be 6.6–8.8 million lb in the late 1970s to early 1980s. Biomass estimates in the mid-1980s to mid-1990s then increased almost four-fold to 24.3–30.9 million lb. The biomass estimates of the rex sole population in the Monterey management area followed a similar trend. Biomass in this region was estimated at approximately 1.9 million lb during the 1970s and early 1980s, with biomass peaking at approximately 4.7 million lb in 1983. The high abundance of rex sole is reflected in the increase in commercial landings from 1980–88. Commercial landings of rex sole within the MBNMS are highly variable, rising in the 1980s and showing an overall decline during the 1990s, with a peak in 1995. Rex sole are managed through gear regulations including trawl net mesh size. In PFMC stock assessments, rex sole are lumped into an "other flatfish" category.

Sanddabs (*Citharichthys spp.*)



Sanddabs are important species in the commercial trawl and longline fisheries. Commercial sanddab landings consist of three species, the Pacific sanddab (*Citharichthys sordidus*), speckled sanddab (*Citharichthys stigmaeus*) and the longfin sanddab (*Citharichthys xanthostigma*), with the Pacific sanddab composing the majority of landings. Commercial landings within the MBNMS have increased since 1981 (Fig. 98) and nearly all commercial landings of sanddabs are taken in trawl gear. This is a very stable and most likely underutilized resource throughout their range. Pacific sanddab are sold fresh and

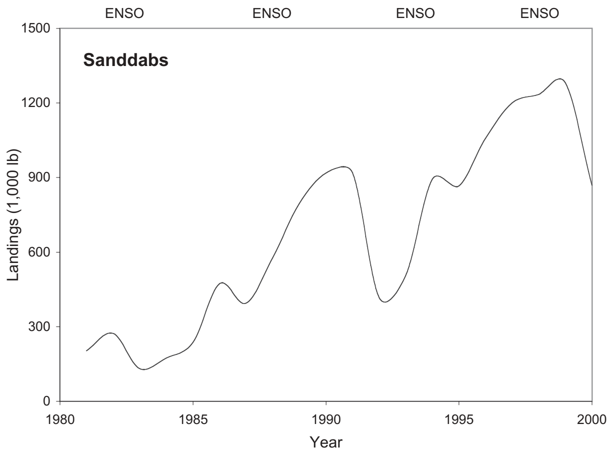


Figure 98. Reported commercial landings from 1981–2000 of sanddabs within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

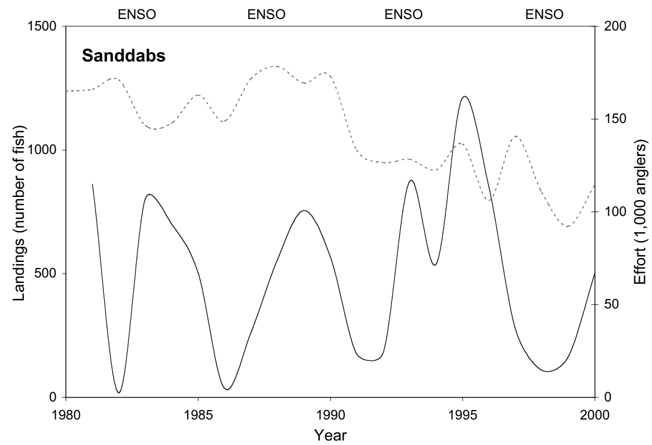
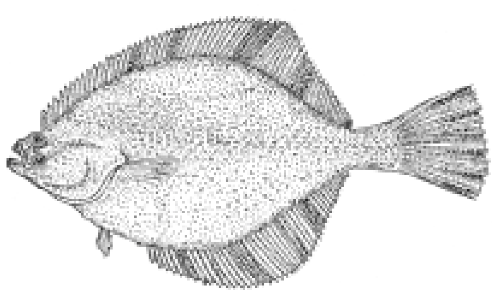


Figure 99. Reported CPFV landings (solid line) and effort (dotted line) from 1981–2000 of sanddabs within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

whole in markets and restaurants. Sanddab are also often taken by anglers aboard CPFV and private vessels, and used for both consumption and as baitfish. Recreational landings by CPFV are highly variable for sanddabs (Fig. 99), although effort has remained relatively stable. The PFMC currently manages the Pacific sanddab, and there are no quotas or size limits for the commercial or recreational take of sanddabs. No population estimates exist for these species, however, commercial catch rates indicate a healthy population.

Starry Flounder (*Platichthys stellatus*)



The starry flounder is taken in both the commercial and recreational fishery, although it is seldom the target of the commercial fishery because it is low in value compared to the petrale sole and California halibut. Currently, starry flounder are nearly all caught in the commercial trawl fishery; however in the 1980s, they were also caught by gill nets and trammel nets. Landings in ports near the MBNMS have declined since a high of 80,000 lb in 1985 (Fig. 100). Since the starry flounder is a nearshore species, the decline in landings through the 1990s can be attributed to the banning of gill and trammel net gear from nearshore waters. Landing data for this species, however, may not be accurate since a large portion may be reported in the unspeci-

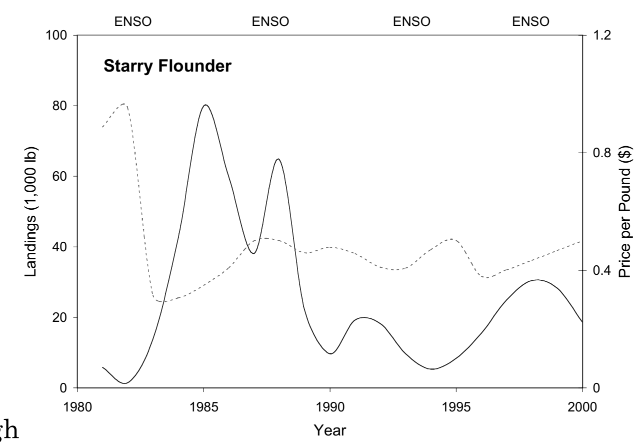


Figure 100. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of starry flounder within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.

fied flounder or sole categories. Decreased abundance in areas of common occurrence, such as Elkhorn Slough, also may indicate actual population declines.

Recreational anglers fish for starry flounder from piers, boats, and shore. Recreational landings at ports in Northern and Central California have declined since highs in the 1980s of 57,000 fish. Landings since 1993 have averaged 6,000 fish/yr (Fig. 101). The starry flounder is managed by the state. Currently there are no commercial or recreational size or number limits on the take of starry flounder.

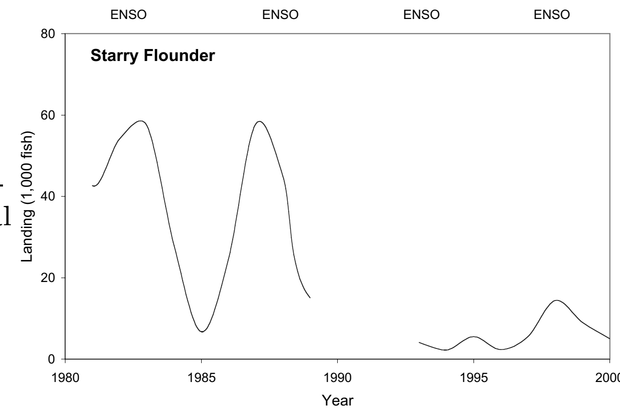


Figure 101. Reported recreational landings of starry flounder in Central and Northern California from 1981–2000. No RecFIN data are available for years 1990–1992.

Pacific Grenadier (*Coryphaenoides acrolepis*)

Once discarded as a junk fish, innovative fishers in the 1980s and 1990s attempted to develop a new fishery for the grenadier. The mild, light meat of this species makes it a desirable market fish. These fish are abundant on the continental slope and are caught primarily with longline and trawl gear. The landings of grenadier at ports associated with MBNMS rose through the mid-1990s, peaking in 1996 with nearly 2 million lb landed, but have since decreased to considerably lower levels (Fig. 102). Currently there are no restrictions on landings, season, or vessels in this emerging fishery, but there is concern for this species because of the rapid expansion of the fishery and the identification as this species as slow growing.

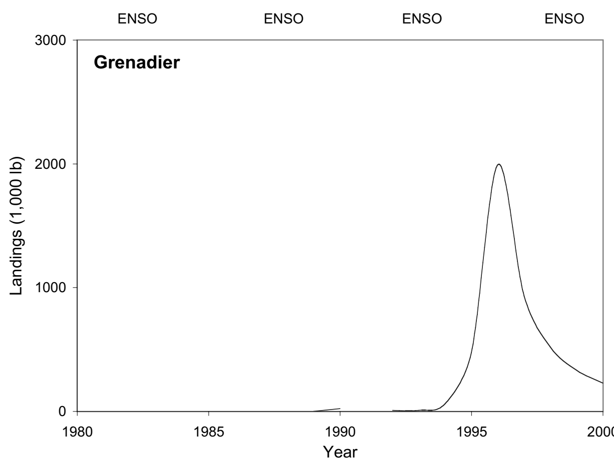
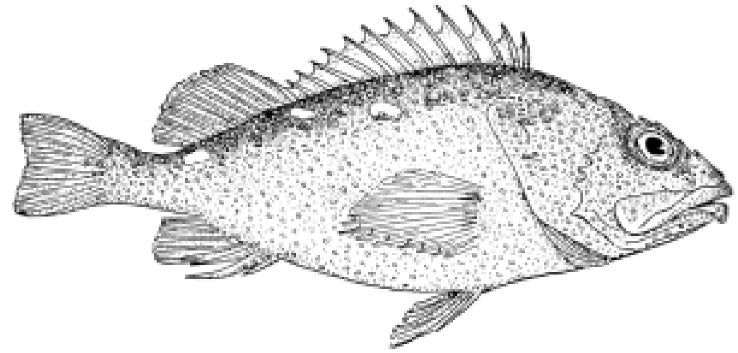
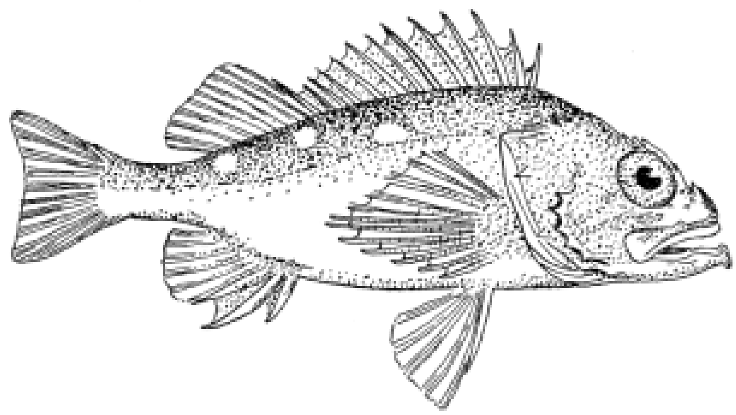
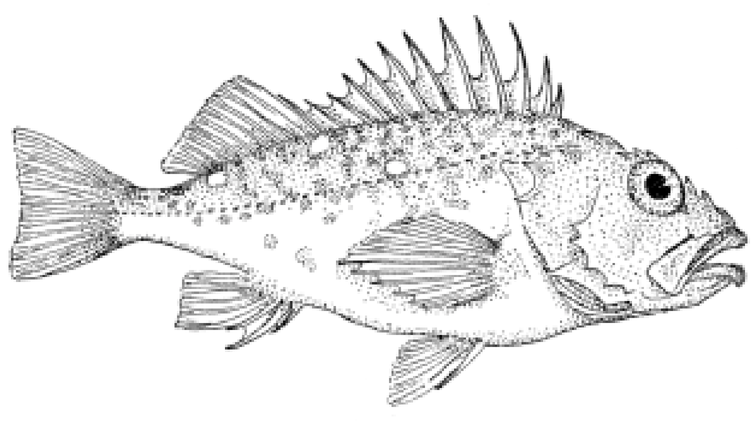


Figure 102. Reported commercial landings from 1981–2000 of Pacific grenadier within soft bottom deep shelf and slope habitats at the five major ports associated with the MBNMS.







Open Water Habitats

Open water species dwell within the water column, away from the protection and shelter of bottom habitats. The species living in open water habitats can be divided into three sub-groups (guilds) termed small coastal pelagics, coastal migrants, and pelagic migrants. The small coastal pelagics guild is a management unit of the PFMC and includes Pacific mackerel, jack mackerel, Pacific sardine, and northern anchovy. These fishes live most of their life cycle in waters close to the continents, taking advantage of the high productivity of coastal waters. The coastal migrants guild is characterized by mobile, nonresidential, neritic species such as Chinook and Coho salmon, spiny dogfish, smelt, Pacific bonito, Pacific hake, Pacific herring, and yellowtail. We created this category to include species that do not fit in the PFMC management categories of small coastal pelagics or highly migratory species. The pelagic migrants guild, also a management unit of the PFMC, includes tunas, swordfish, and thresher and mako sharks. These species spend much of their life cycle in the open ocean and are known to make extensive migrations across the open ocean, occasionally entering the coastal zone.

Commercial landings from open water habitats averaged 20.6 million lb/yr from 1981–2000, and comprised 36% of the total landings at ports near the MBNMS in the last 20 years. Coastal pelagic fishes accounted for 76% of the landings from open water habitats (Table 12). Population abundances of most open water species are greatly determined by large-scale environmental phenomena, such as decadal-scale shifts in major currents that affect the success of spawning and recruitment. However, high fishing pressure at a time of changing environmental conditions can also influence population sizes. Many of these pelagic species are targeted by large fishing fleets with large fishing capacity. The high fishing capacity of large vessels and fleets can quickly reduce populations of schooling fishes, because the catchability of the fish does not diminish at the same rate as does population size. Some spe-

Table 12. Primary species landed in commercial fisheries in the MBNMS that were caught in open water habitats, and the percentage that each species contributed to the landings from this habitat group and total landings in the MBNMS. Landings from open water habitats during the period equaled 412.72 million pounds from 1981–2000. Total landings in all of the MBNMS equaled 1.14 billion pounds from 1981–2000.

Guild	Common Name	Scientific Name	% habitat	% total
Small Coastal Pelagics				
Vertebrates				
	Chub (Pacific) mackerel	*Scomber japonicus*	10.4	3.7
	Jack mackerel	*Trachurus symmetricus*	5.7	2.1
	Northern anchovy	*Engraulis mordax*	20.8	7.5
	Pacific sardine	*Sardinops sagax*	39.2	14.2
Coastal Migrants				
Vertebrates				
Anadromous	Chinook salmon	*Oncorhynchus tshawytscha*	10.7	3.9
	Coho salmon	*Oncorhynchus kisutch*	0.1	< 0.1
Elasmobranchs	Spiny dogfish	*Squalus acanthias*	< 0.1	< 0.1
Other species	Smelt	*Osmeridae, Atherinidae*	0.1	< 0.1
	Pacific bonito	*Sarda chiliensis*	0.2	0.1
	Pacific hake	*Meluccius productus*	< 0.1	< 0.1
	Pacific herring	*Clupea pallasii*	0.7	0.3
	Yellowtail	*Seriola lalandi*	< 0.1	< 0.1
Pelagic Migrants				
Vertebrates				
Elasmobranchs	Shortfin mako shark	*Isurus oxyrinchus*	0.2	0.1
	Bigeye Thresher Shark	*Alopias superciliosus*	0.1	< 0.1
	Common Thresher Shark	*Alopias vulpinus*	0.8	0.3
Scombrids	Albacore	*Thunnus alalunga*	7.4	2.7
	Bluefin tuna	*Thunnus thynnus*	0.1	< 0.1
	Skipjack tuna	*Euthynnus pelamis*	< 0.1	< 0.1
	Yellowfin tuna	*Thunnus albacares*	< 0.1	< 0.1
Other species	Swordfish	*Xiphias gladius*	3.4	1.2

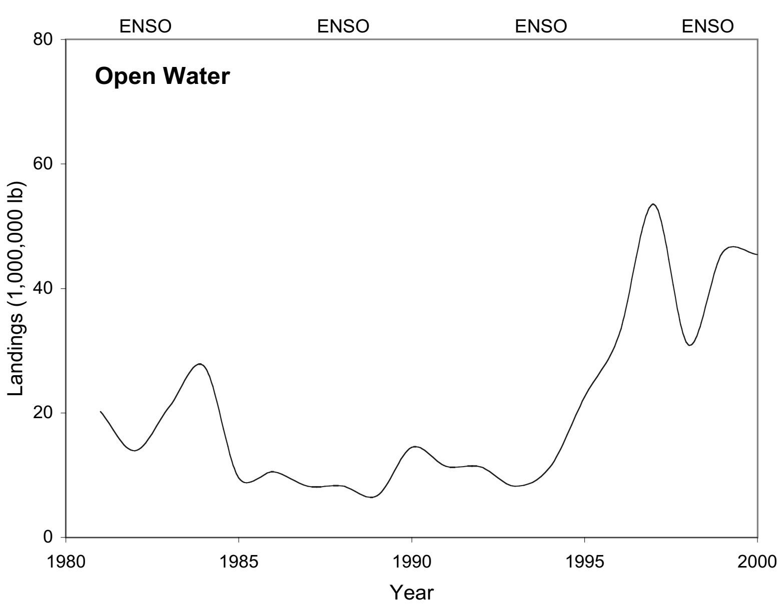


Figure 103. Reported commercial landings from 1981–2000 of all species within open water habitats at the five major ports associated with the MBNMS.

cies, such as the small coastal pelagics, are schooling fishes that remain in groups that are relatively easy to catch with large nets until population abundance becomes very small. This makes fishery management of schooling pelagic species more difficult. And because many pelagic fishes move across international boundaries, fishery management of this guild is more difficult than for residential species.

The overall trend in landings from species occupying open water habitats has increased since the 1980s (Fig. 103). The majority of landings from these habitats are from the small coastal pelagics group, for which population abundances are often heavily influenced by environmental factors (Fig. 104). The recent upward trend in landings for this group is largely caused by the reopening of the Pacific sardine fishery that boomed in the late 1990s. The landings of the coastal migrants group have been highly variable over the past twenty years (Fig. 105). Chinook salmon is the predominate species in this group; salmon catches have fluctuated based on abundance and regulations. The pelagic migrants group has shown a decline in landings since the 1980s (Fig. 106). This group is dominated by albacore catch, which shows the same declining trend in catch. This trend is primarily related to the influence of oceanographic conditions that cause albacore to be distributed further from Central California ports.

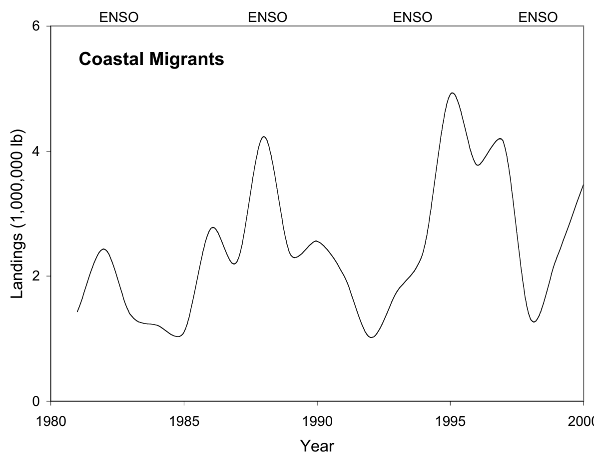


Figure 105. Reported commercial landings from 1981–2000 of coastal migrants within open water

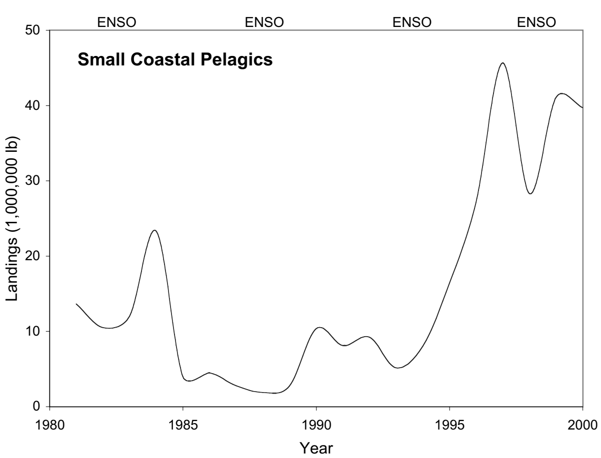


Figure 104. Reported commercial landings from 1981–2000 of small coastal pelagics within open water habitats at the five major ports associated with the MBNMS.

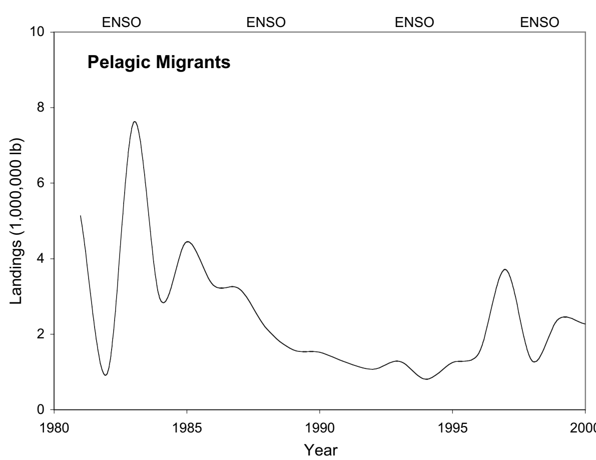


Figure 106. Reported commercial landings from 1981–2000 of pelagic migrants within open water habitats at the five major ports associated with the MBNMS.

Small Coastal Pelagics

Pacific Mackerel (*Scomber japonicus*)
Prior to 1928, Pacific mackerel were sold primarily as a fresh fish item and market demand was low. In the late 1920s, processors began canning Pacific mackerel. With this increased market demand, sardine fishers started using seine nets to catch mackerel. Off-season albacore fishers also began targeting mackerel by herding them into a concentrated frenzy and using large dip nets to scoop the mackerel out of the water. Currently, seine nets account for nearly all the commercial fishing effort for Pacific mackerel. Pacific mackerel also are commonly caught as bycatch in trawl and hook-and-line fisheries.

The California fishery peaked in 1925 at 146 million lb, followed by several decades of fluctuating decline (Fig. 107). In 1953, the fishery seemed defunct, but was rejuvenated for several years after a good recruitment year. After a series of poor recruitment years in the 1960s, a moratorium was placed on mackerel fishing in 1970. The populations recovered and fishing began again in 1976 under a quota-based management system, with California-based seine vessels accounting for nearly all of the commercial fishing effort for Pacific mackerel in United States waters.

California landings of Pacific mackerel declined from 1990–1996, followed by higher landings in the years 1997, 1998, and 2000. Decline in landings is thought to be a result of low population size caused by poor recruitment and a decrease in effort by seine fishers, who have shown increased participation in the more lucrative winter squid and summer tuna fisheries. Peaks in landings may be associated with the warm water conditions associated with El Niño events that contributed to good recruitment years for mackerel.

Less than 5% of the California catch of Pacific mackerel is taken from MBNMS waters. At ports near the MBNMS, annual landings fluctuated greatly from 1981–2000, varying from highs of more than 7 million lb in 1984 and 1997 to a low of 6000 lb in 1999 (Fig. 108). This high variability is most likely related to the effect of environmental conditions on recruitment and distribution of the Pacific mackerel. Pacific mackerel landings represent 10% of the landings from open water habitats (Table 12).

Pacific mackerel have been managed by NMFS since 1999 under the Coastal Pelagic Species FMP. This plan established a process for setting annual ABCs and harvest guide-

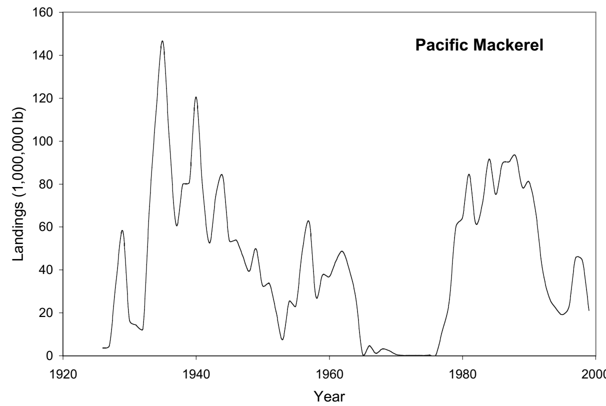


Figure 107. Reported commercial landings of Pacific mackerel in California from 1916–1999.

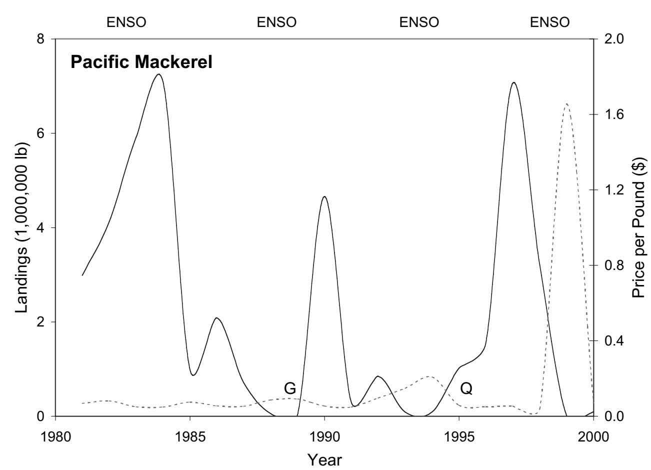


Figure 108. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Pacific mackerel within open water habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

lines and created a limited entry system south of Pt. Arena, California. The Pacific mackerel is designated an "actively managed species," meaning that stock biomass is evaluated and management is based on a quota system, with annual estimates of ABC and harvest guidelines. A 1999 stock assessment indicated that Pacific mackerel are increasing in relative abundance, with the biomass in United States waters estimated to be 527 million lb.

Pacific mackerel is also commonly caught in recreational fisheries, with tuna and mackerel species dominating recreational landings throughout California in 1997. There is currently no limit on the recreational catch of Pacific mackerel. Recreational CPFV landings within the MBNMS have declined since a high of nearly 60,000 fish in 1984, along with a slight decreasing trend in fishing effort. Peaks in recreational landings occurred in 1984, 1990, 1992, and 1997, concomitant with peaks seen in commercial landings, most likely attributable to environmental conditions (specifically El Niño) that promoted strong year classes (Fig. 109). Pacific mackerel are also caught in great numbers incidentally in the rockfish and salmon fisheries from piers and breakwaters.

Jack Mackerel (*Trachurus symmetricus*)

Jack mackerel is a pelagic schooling fish with a distinct distribution. Juveniles occur inshore off of Southern California and Baja California, and adults are found further north and offshore. Commercial landings of jack mackerel in most years are below 500,000 lb, with the exception of a rise in 1983 and peak in 1984 of 12 million lb (Fig. 110). Price has varied over the years inversely with peaks in landings. Because it is not as valuable as the Pacific sardine or Pacific mackerel in the commercial fishery, variations in landings of jack mackerel are often associated with a fleet's ability to catch the more profitable species. The increase in landings in certain years may also be due to an influx of warm water associated with El Niño conditions. Jack mackerel are also caught recreationally, primarily from CPFV boats and piers.

The jack mackerel is currently managed under the Coastal Pelagic Species FMP. Under the plan, jack mackerel are designated a "monitored species," meaning the stocks are monitored through commercial landings and do not require intensive harvest management. The plan also established a limited entry program for coastal pelagic finfish. Currently

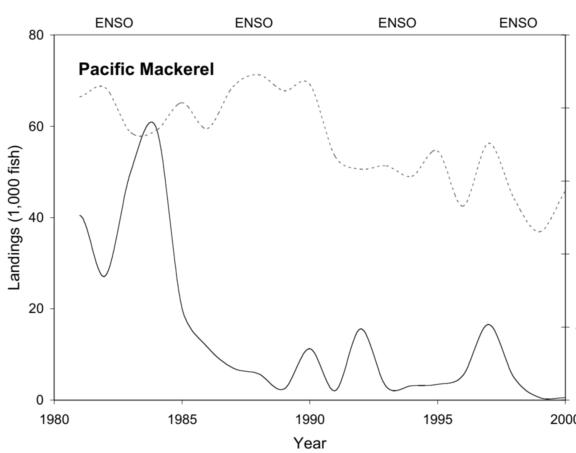


Figure 109. Reported CPFV landings (solid line) and effort (dotted line) from 1981–2000 of Pacific mackerel within open water habitats at the five major ports associated with the MBNMS.

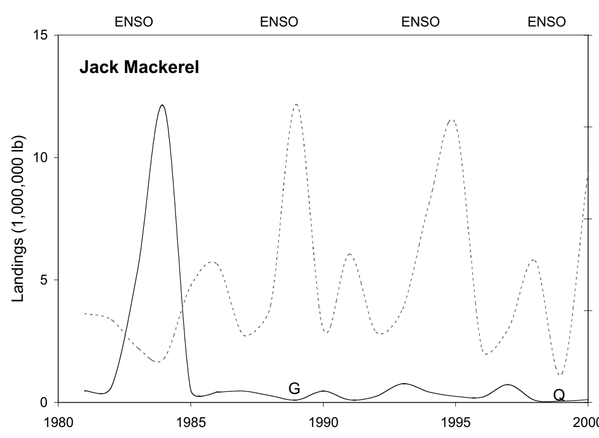
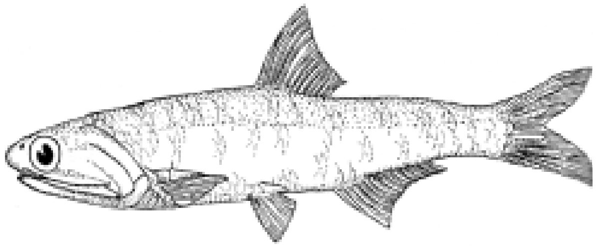


Figure 110. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of jack mackerel within open water habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

there is no harvest quota or estimate of biomass for the jack mackerel.

Northern Anchovy (*Engraulis mordax*)



Northern anchovy are harvested using lampara nets and purse seines, and sold fresh frozen or as bait. Northern anchovy are harvested as part of the "wetfish" fishery that also targets Pacific mackerel, jack mackerel, Pacific bonito, market squid, sardine, and tunas. Anchovy are often targeted when large catches of these other, more lucrative, species are not available. The anchovy fishery was small until the collapse of the Pacific sardine fishery in 1952. After a brief period of high catches, low anchovy marketability caused landings to decline in 1954. California catches remained at low levels through 1964, with anchovy landings fluctuating greatly since that time (Fig. 111). Catch fluctuations are due to variable market conditions and to environmental factors that greatly influence the population size.

Anchovy harvest in the MBNMS peaked in 1981 with landings of 10 million lb, then declined to a low of 700,000 lb in 1983 (Fig. 112). From 1985–89, landings averaged 1.9 million lb/yr, rose to about 5 million lb/yr in 1990–91, then returned to an average of 2.3 million lb/yr from 1992–95. Landings rose again in 1996 and 1997 to approximately 8 million lb/yr, followed by lower landings in 1998 and 1999, and the highest landings in the past twenty years, 14 million lb, in 2000. Landings of northern anchovy accounted for 21% of the total landings from open water habitats in the MBNMS in the last 20 years (Table 12). Total commercial landings in 2000 throughout California were nearly 26 million lb, with ports associated with the MBNMS comprising over 55 % of this catch. Price per pound for northern anchovy has been highly variable over the past twenty years, with increases in price corresponding with low catch years.

The northern anchovy has long been considered a boom-and-bust species. Anchovy abundances were probably higher in the 19th

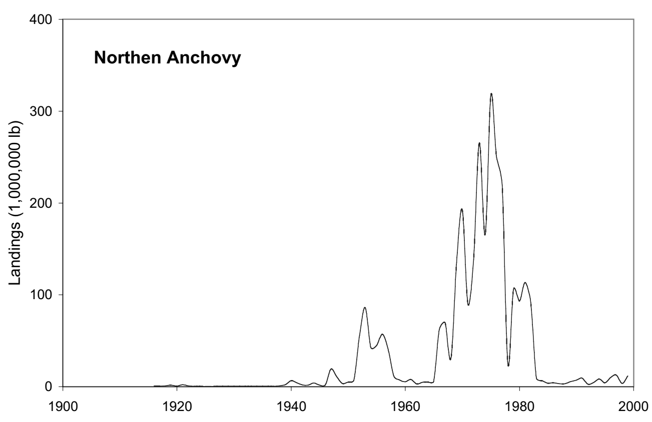


Figure 111. Reported commercial landings of northern anchovy in California from 1916–1999.

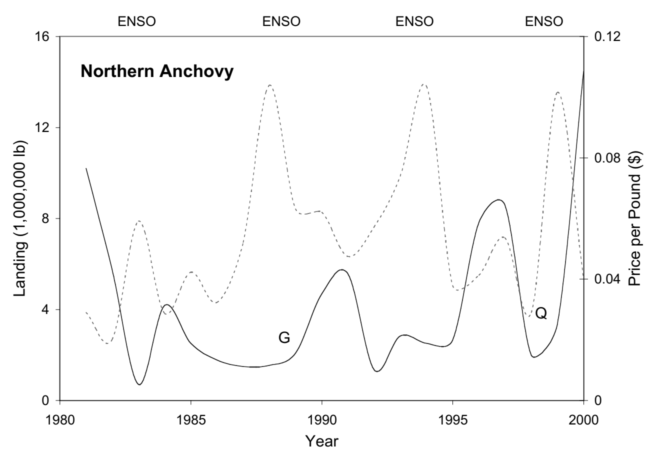


Figure 112. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of northern anchovy within open water habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

and early 20th centuries than they are presently, and may have peaked 1,600 years ago. Sediment cores taken off Santa Barbara indicate that fluctuations in population size have occurred every 30–36 years as far back as 200 AD. Population trends derived from sediment records agree with fishery-derived estimates when direct comparisons can be made. This fluctuation in population size suggests that species interactions and environmental factors play a large role in the patterns seen in the fishery.

Short-term fluctuations in northern anchovy biomass related to environmental factors are also evident. Spawning biomass within the central sub-population, as estimated from fish spotter data and egg production indices, declined after 1985 due to low recruitment. High recruitment in 1993, however, resulted in subsequent increases in population biomass for 1994–95. Current biomass is considered to be stable, but low relative to historical levels. The estimated spawning biomass in 1995 for the central sub-population was 856 million lb.

Northern anchovy stocks cross the United States–Mexico border, and at one time this fishery was managed jointly between the United States and Mexico. Currently, the Pacific Fisheries Management Council (PFMC) manages the northern anchovy under the Coastal Pelagic Species FMP. The northern anchovy is designated a "monitored species," meaning the stock is not subject to intensive harvest management and is monitored through commercial landings. The Coastal Pelagic Species plan also established a limited entry fishery to coastal pelagic finfish species south of Point Arena. Indices of abundance indicate that this population is stable at moderate biomass levels.

Pacific Sardine (*Sardinops sagax*)

Sardine fisheries have been an important marine resource within California since the early 1900s (Fig. 113). During the peak harvest periods in the 1930s and 1940s, sardine were used for fishmeal, soap oil, paint mixer, vitamins, glycerin, and shortening. The decline in stock biomass caused many of the canneries to close by the 1960s. In 1974, a moratorium limited the take to incidental catch totaling no more than 110,000 lb/yr. These regulations remained in place through 1981 to allow the population to recover. Catches between 1975–86 remained less than

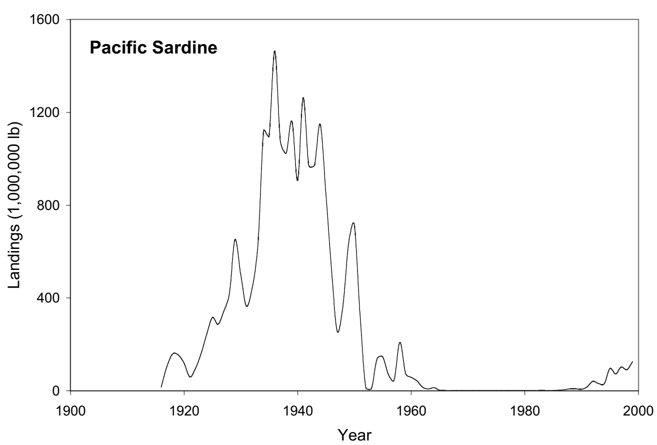


Figure 113. Reported commercial landings of Pacific sardine in California from 1916–1999.

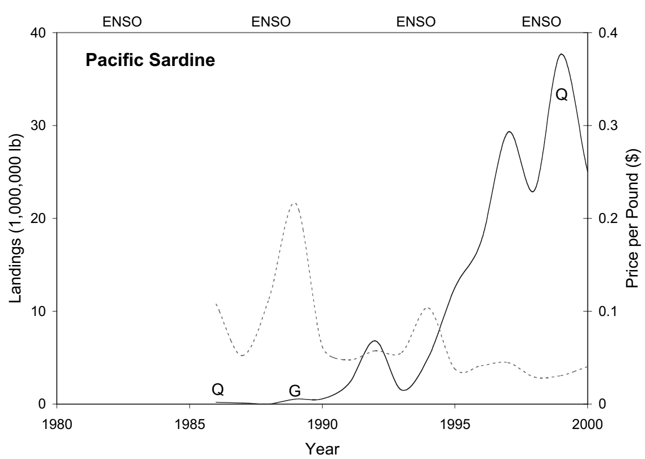


Figure 114. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Pacific sardine within open water habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

5,000 lb/yr. In 1986, CDFG allowed the first targeted sardine fishery since the 1974 closure, and landings at ports near the MBNMS began to increase. Landings gradually rose from 1986 to a total of over 37 million lb in 1999 (Fig. 114). A new canning line developed in 1994, allowing fishers to target smaller sardine and was one of the reasons landings peaked in 1999. Landings of Pacific sardine comprise 14% of the total landings of all species from 1981–2000 in the MBNMS. In 1999, Pacific sardine was added to the Coastal Pelagic Species FMP, which implemented harvest limits based on stock assessments and established a limited entry fishery. Ex-vessel price per pound has remained consistently low throughout recent years due to the increasing trend in sardine landings.

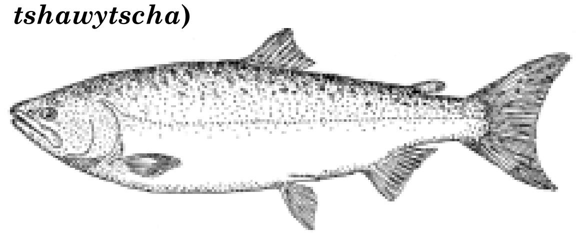
The Pacific sardine has long been considered a boom-and-bust species. Fluctuations in population size are apparent as far back as 200 AD. Twelve main occurrences, separated by 20–200 yr, have been documented, with the highest population existing 1,000 years ago. This fluctuation in population size suggests that species interactions and environmental factors play a large role in the pattern seen in the fishery.

Prior to 1967, Pacific sardine were managed by seasonal closures and catch limits of whole fish for reduction. From 1967–85, the fishery was limited to incidental catch. Small, directed fisheries have been allowed since 1986 with specific catch quotas. At this time, a joint research effort exists with the United States and Mexico to assess spawning biomass. In 1999, Pacific sardine biomass in United States waters was estimated to be about 3.5 billion lb and total Pacific sardine landings for the directed fisheries off California and Baja California reached more than 253 million lb, the highest level in recent history. Stock biomass and recruitment is estimated to be high in the 2001 stock assessment conducted by PFMC, and current harvest is less than the quota.

Currently, the Pacific sardine is managed by the PFMC under the Coastal Pelagic Species FMP. Pacific sardine is designated "actively managed species," meaning harvest limits are based on current assessments of stock biomass. Under the plan, a limited entry program was established. The 2001 harvest limit for the Pacific sardine was set at 297 million lb based on a biomass estimate of 2.6 billion lb. This species has increased in abundance since the 1980s; the age-1 plus population was estimated at 3.8 billion lb in 1998 and 1999 in California waters. Although the population of Pacific sardine has rapidly expanded in the past twenty years, it is still well below biomass estimates from the 1930s.

Coastal Migrants

Chinook Salmon (*Oncorhynchus tshawytscha*)



Most of the Chinook salmon caught in the Monterey Bay region originated in the Sacramento River or its tributaries. In the Sacramento River system, there are four distinct runs of Chinook salmon that are named after the time they enter fresh water: fall, late-fall, winter, and spring. The Sacramento River fall and late fall runs are more robust than the other two runs, which are listed under the Endangered Species Act (ESA). Sacramento River winter run Chinook salmon abundance dropped from more than 100,000 fish in 1979 to a historic low of 191 fish in 1991, and that run received federal protection under the ESA in 1994. The Red Bluff dam and irrigation districts that diverted water from this run altered essential spawning habitat, and played a major role in this run's decline. Since 1996, when the spawning population was estimated to be 800 individuals, the size of the winter run has dramatically increased, reaching around 11,000 individuals by 2001. Much of this increase is due to improved river flow conditions in the watershed. Spring run Chinook salmon were once the most abundant salmon in California prior to state and federal dam systems, with up to 1 million fish returning to spawn in each of the Central Valley and Klamath/Trinity watersheds. Today, the number of spring run Chinook returning to these river systems has declined relative to historic abundances. Population estimates of spring run Chinook in 1999 were low enough to cause them to be listed as threatened under the ESA. It is these weaker salmon runs that greatly affect fishery management and water policy throughout the state of California.

Chinook salmon is the most commonly caught anadromous species in the MBNMS, and accounted for 11% of all landings from open water habitats from 1981–2000 (Table 12). The ocean troll fishery for salmon started in the 1880s in Monterey Bay. Originally, sailboats were used to fish for salmon, but by 1910 almost all trollers were using powered boats. In the 1960s and 1970s, the salmon fishing fleet grew extensively as fishers who had other jobs during the rest of the year joined the summer fishery. In 1980, a moratorium was placed on the issuance of permits to new participants in the ocean commercial salmon fishery in order to increase individual profits and reduce overall fishery impacts. A limited-entry program was implemented in 1983. Despite these regulations, the overall landings of Chinook increased from 1980–88. However, a dramatic decrease in landings was seen from 1988 to the early 1990s, due in large part to the drought conditions in California. Since this time there has been a sharp increase and subsequent decrease in landings. In 2000, more than 3.3 million lb of salmon were landed at ports near the MBNMS (Fig. 115). Overall, the trend in Chinook salmon landings is variable and is directly related to stock size and available seasons and quotas. Recent landings of Chinook salmon have been high, largely attributed to the relatively robust fall run of the Sacramento River, rather than populations of winter and spring run Chinook salmon which are severely depressed. Alteration or loss of spawning grounds of several runs through water diversion has dramatically affected population abundance and contributed significantly to the current declines.

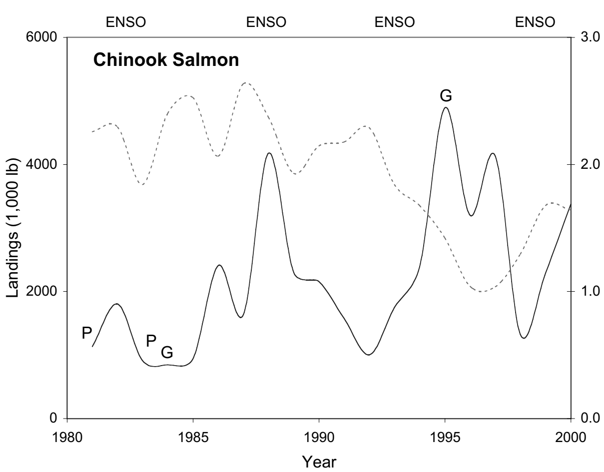


Figure 115. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Chinook salmon within open water habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

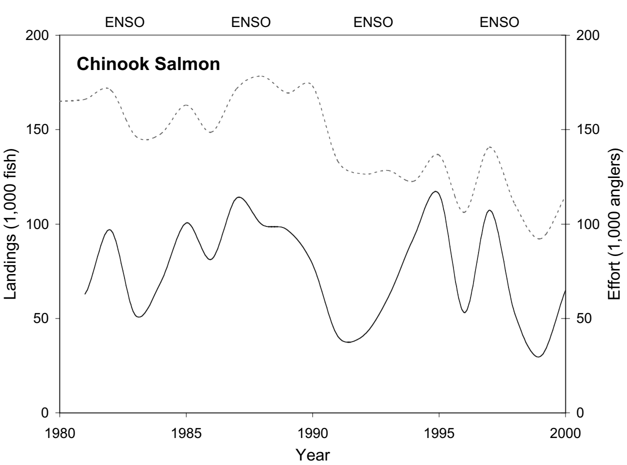


Figure 116. Reported CPFV landings (solid line) and effort (dotted line) from 1981–2000 of Chinook salmon within open water habitats at the five major ports associated with the MBNMS.

Chinook salmon is currently a federally managed species. Regulations are set regarding gear types for commercial and sport fisheries as well as bag limits, size limits, and seasons for sport fishers. Commercial fisheries south of San Francisco usually are open May through September. Those races of Chinook salmon that can be legally harvested are caught using trolling gear with specific regulations on the type of hooks and amount of weight allowed per line. The recreational CPFV landings at ports associated with the MBNMS have been highly variable over the past twenty years, but have decreased since the early 1980s (Fig. 116). Trends in landings are similar to those seen in the commercial fishery and are most likely related to degradation of freshwater and estuarine habitat. For additional information see Leet et al. *California's Living Marine Resources: A Status Report* (2001).

Coho Salmon (*Oncorhynchus kisutch*)
Coho salmon are smaller than Chinook salmon and spawn more frequently in coastal streams and rivers. In contrast to the many Chinook runs, there is now only one race of Coho salmon in California. The abundance of Coho salmon between the Oregon border and Monterey Bay was once estimated at over 500,000 fish. Today, this population has declined to less than 15,000 wild fish. Because of this drastic decline, Southern Oregon and Northern and Central California Coho salmon stocks have been listed as "threatened" under the ESA.

Coho salmon wild fish populations have steadily declined since the 1950s and 1960s. These declines are due primarily to habitat destruction, water diversion, the effects of hatchery practices, and fishing. The limited evidence available indicates that these low numbers of natural populations are not self-sustaining and Coho populations are in danger of extinction. Landings of Coho salmon reflect the current severe fishery restrictions for this species. Excluding the anomalously high catches in 1991, Coho landings at ports near the MBNMS averaged less than 20,000 lb/yr from 1980–92 (Fig. 117). The PFMC regulates Coho fisheries. The retention of Coho salmon in the commercial and sport fishery has been prohibited since 1994. For additional information see Leet et al. *California's Living Marine Resources: A Status Report* (2001).

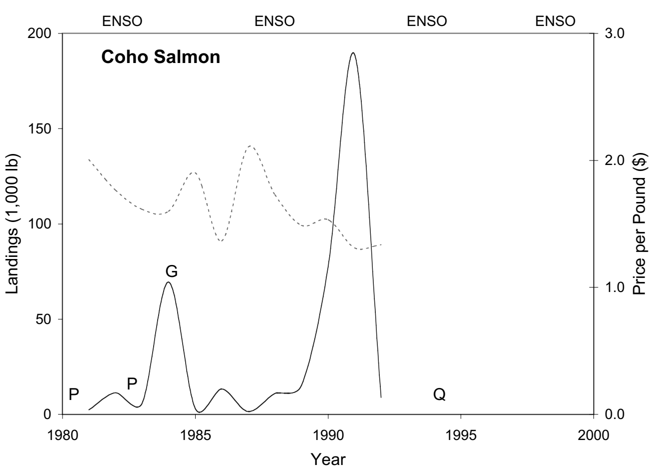
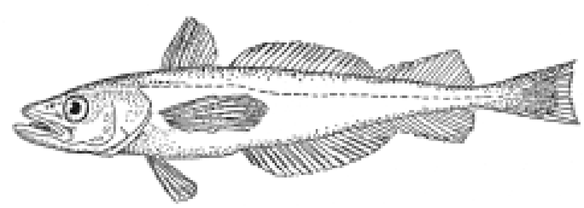


Figure 117. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Coho salmon within open water habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Pacific Hake (*Merluccius productus*)



Pacific hake is one of the most abundant groundfish populations in the California current system. This species is caught almost exclusively in midwater trawls, in water depths of 100–500 m. Historically, foreign vessels dominated the Pacific hake fishery off the West Coast of the United States. The fishery was started in 1966 by Soviet trawlers, which caught more than 302 million lb. By 1976, more than 523 million lb were harvested by vessels from several foreign nations. After

1976, the FCMA limited the ability of foreign vessels to fish in United States waters. Because Pacific hake meat deteriorates and softens quickly after the fish is caught, most domestic vessels were not equipped to properly handle or process hake. This instigated several joint venture efforts in which domestic fishers would catch the fish and transfer them at sea to foreign processing vessels. Joint venture fisheries disappeared as improved processing techniques for hake were developed for United States based processors.

In recent years, catches of Pacific hake have been largely influenced by annual recruitment. Higher catches occur 3–4 years following strong recruitment years. Very large year-classes of Pacific hake were produced in 1980 and 1984, leading to high catches in Central California throughout most of the 1980s. Most of the landings were delivered into San Francisco ports, however, and are not reflected in the landings for ports near the MBNMS (Fig. 118). Coastwide recruitment was average or low between 1987 and 1992, but a strong 1994 year-class is indicated from high bycatch of juveniles in recent years. Landings within the MBNMS have fluctuated over the past twenty years, declining from a high of over 9,000 lb in 1984 and followed by years with increasing trends and years with little to no commercial landing of Pacific hake.

The fishery is managed using quotas, geographic and seasonal restrictions, mesh size, and incidental catch levels. The effectiveness of management plans has been limited because there is currently no agreement between the United States and Canada on how to divide the predicted ABC between the two countries. In 1997, the PFMC set a United States harvest guideline of 80% of the predicted ABC for the stock. Since the end of joint venture fishing in 1989, the total United States and Canadian reported catch has met or exceeded the ABC by 10–15% each year. The 2000 stock assessment for Pacific hake revealed that the stock is at moderate abundance, with mature female biomass at 37% of the unfished stock.

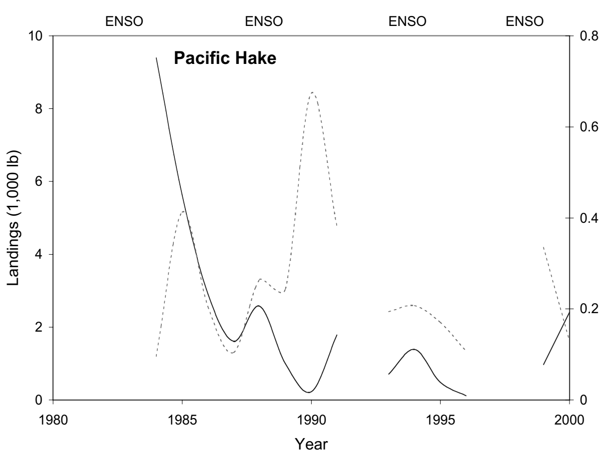


Figure 118. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of Pacific hake within open water habitats at the five major ports associated with the MBNMS.

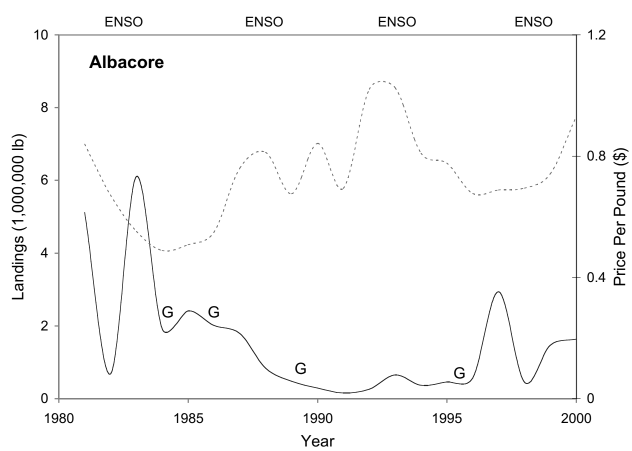


Figure 119. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of albacore within open water habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

Pelagic Migrants

Albacore (*Thunnus alalunga*)

Albacore make large transoceanic migrations. They spawn in subtropical waters and pass by our coast as young fish from June to January. Albacore were first reported in the sport fishery off Santa Catalina Island at the turn of the century. As the size, speed, and technology of boats has increased, so have albacore landings. Fishing gear, however, has changed very little. Because juvenile albacore travel in loose knit schools at the surface, commercial harvesting is most effectively accomplished by trolling with lures or baited hook-and-line. Commercial vessels landing albacore in the MBNMS only fish seasonally and switch gears or target species to participate in other fisheries, such as the salmon fishery. At ports near the MBNMS, there has been a decline in total landings and fishing effort since the mid-1980s (Fig. 119). A series of gear restrictions, lower ex-vessel prices in this area, and a shift in albacore distribution to areas far from MBNMS ports is responsible for this decline in landings. Albacore fishing is now also popular in the recreational CPFV and private skiff fishery (Fig. 120), with significant landing increases occurring in the late 1990s.

Historically, there has been a tremendous fluctuation in albacore landings due to changes in nearshore distribution and availability (Fig. 121). This variability is caused by environmental factors such as winds, location of cool sea surface temperatures, and intense storms that displace albacore offshore. During El Niño years, albacore may appear off Oregon and Washington without ever entering California waters. Albacore catch is greatest when surface temperatures are 18.3–19.7° C.

Albacore exhibit substantial yearly fluctuations in year class strength. This fact, coupled with the highly migratory lifestyle of the species, makes albacore stock status difficult to determine. Stock assessments based on catch rates from fisheries showed a slight decreasing trend in abundance between 1980 and 1990. In more recent years, however, abundance estimates have increased, possibly due to the strong year-class of 1989 and cessation of high seas drift gill net fishery by foreign vessels.

Albacore has been designated as a highly migratory species and will be managed under the PFMCs Highly Migratory Species fishery management plan, which is currently under development. To date there is no limit on sport catch of albacore. Current information sug-

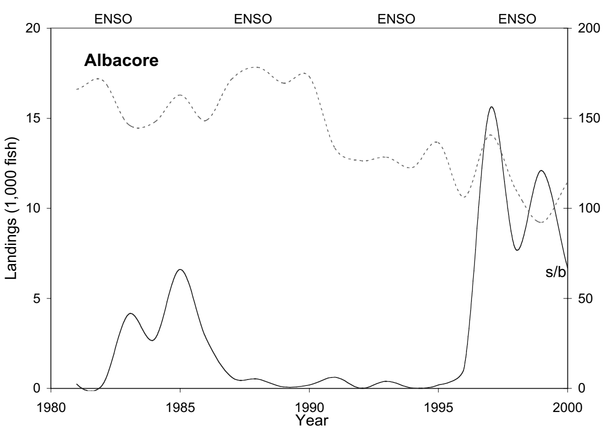


Figure 120. Reported CPFV landings (solid line) and effort (dotted line) from 1981–2000 of albacore within open water habitats at the five major ports associated with the MBNMS. See Appendix G for specific yearly meanings of each regulatory symbol.

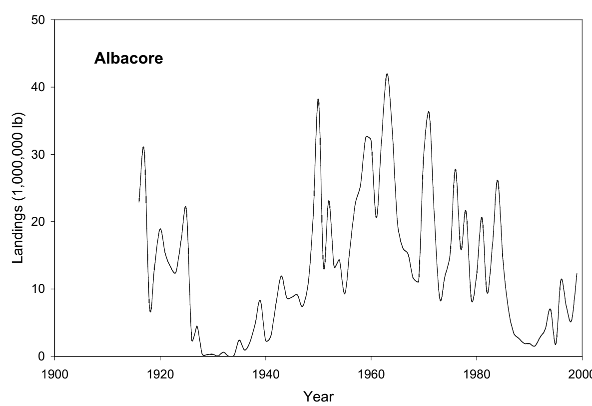
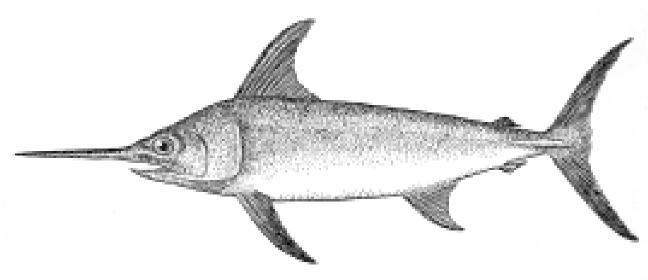


Figure 121. Reported commercial landings of albacore in California from 1916–1999.

gests that north Pacific stock of albacore is healthy and sustainable at current exploitation rates.

Swordfish (*Xiphias gladius*)



The swordfish is a cosmopolitan species highly valued for its meat. Major swordfish fisheries exist in all the world's oceans, but it is unclear how these stocks are related to each other. Currently, there is a belief that the swordfish comprises one worldwide stock, though there could be three or more. Regardless, the Pacific swordfish stock seems healthy off California and provides for a substantial fishery within the MBNMS. Swordfish landings at ports near the MBNMS averaged 741,000 lb/yr from 1981–2000, with a 1984 peak of 1.6 million lb (Fig. 122). Decreased landings since then are due to the 1985 limitations imposed on the use of driftnet gear, a gear that provided a more cost efficient and successful method to catch swordfish and other large pelagic fishes. Harpoon, hook-and-line, and limited driftnet fisheries still exist for the swordfish, but effort, and therefore catch, are substantially reduced. In recent years, concerns about possible bycatch in this fishery have led to regulations that shifted fishing effort to areas outside of the MBNMS.

Pelagic Sharks

Shark fisheries first boomed in the 1930–40s during World War II because of the high demand for liver oil. Populations quickly declined in the early 1950s and the fisheries collapsed. An increased demand for shark meat as a food item began in the late 1970s and early 1980s, leading to targeting of species of pelagic sharks, such as the common thresher shark. This species was heavily targeted for about ten years, until declines in population became evident from the reduced harvest. This decline prompted the commercial fishery to switch to targeting of another pelagic species, the shortfin mako. The devel-

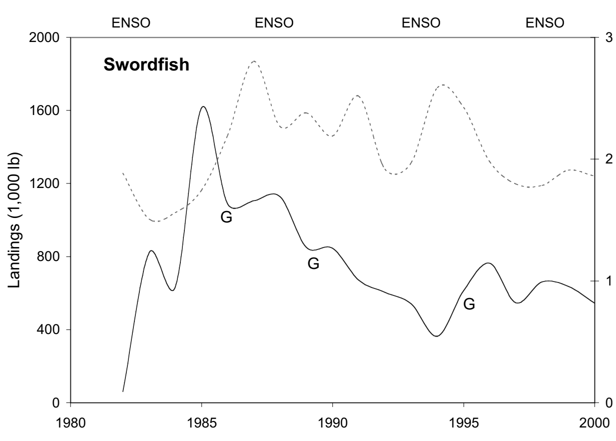


Figure 122. Reported commercial landings (solid line) and ex-vessel prices (dotted line) from 1981–2000 of swordfish within open water habitats at the five major ports associated with the MBNMS. See Appendix F for specific yearly meanings of each regulatory symbol.

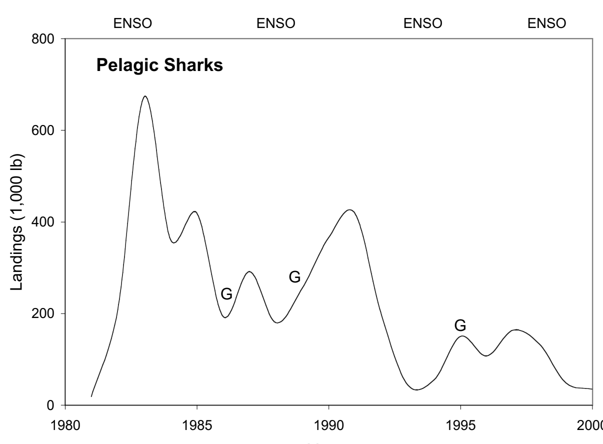


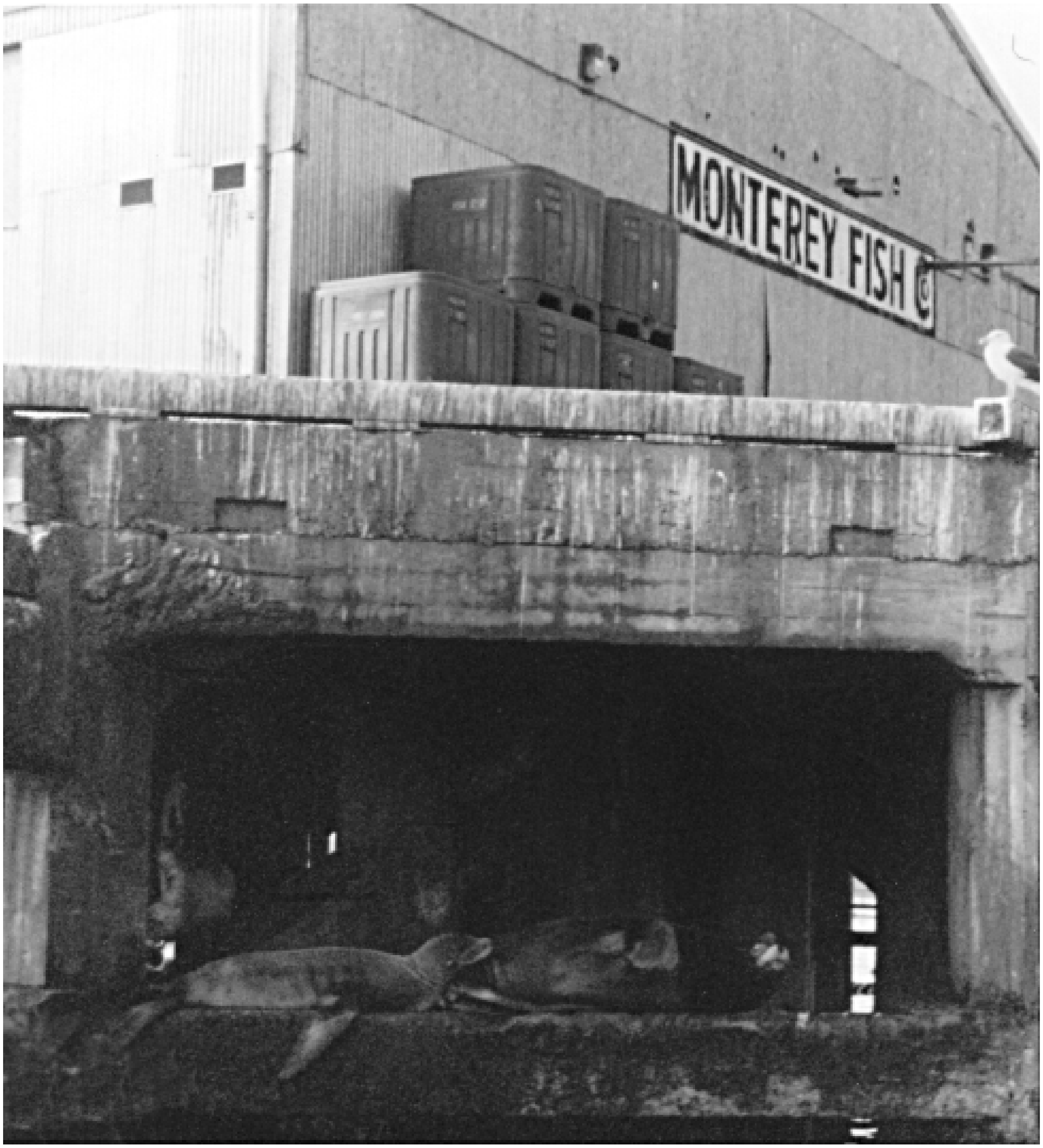
Figure 123. Reported commercial landings from 1981–2000 of pelagic sharks within open water habitats at the five major ports associated with the MBNMS.

opment of the drift longline fishery enabled the successful targeting of this species.

Landings of pelagic sharks at ports associated with the MBNMS have declined since a high of nearly 700,000 lb in 1983 (Fig. 123). This decline is associated with the implementation of gear regulations that affected the shark fishery. The main gear types used to catch sharks include gill net, hook-and-line gear, set line, and trawl gear, all of which have individual regulations. The gill net ban in the early 1990s considerably lowered fishing effort on many shark species in California. In addition, additional time restrictions and the banning of the drift gill net fishery within 12 nautical miles of the coast north of Point Arguello virtually eliminated the thresher shark fishery and diminished fishing effort for other pelagic sharks.

In 2001, the PFMC proposed the federal management of pelagic sharks, including the blue shark, common thresher, pelagic and bigeye thresher, and shortfin mako, as part of a highly migratory species group. However, a Highly Migratory Species Fisheries Management Plan has not been adopted to date and current take of selected pelagic sharks by commercial and sport fishers is regulated under the general provisions of the California Fish and Game Code. Unfortunately, estimates of the commercial catch of sharks are confounded by unknown quantities that are landed under the market category shark/unspecified. Despite this uncertainty, scientists believe the pelagic thresher shark populations may be rebuilding from overfishing in the 1980s.

Pelagic sharks are also popular game fish. Current recreational take of thresher and mako shark is limited to two per day; there is no size limit for the mako shark. Unfortunately, because the recreational fishery usually occurs in areas believed to be shark nursery grounds, pelagic sharks targeted in this fishery are often juveniles. The present status of the mako shark stock is unknown, but is of concern to managers. A stock assessment of the thresher shark is currently underway and populations appear to be rebuilding.


MONTEREY FISH Co

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GLOSSARY

ABC	Acceptable (sometimes Allowable) Biological Catch. A seasonally determined catch or range of catches based on the best scientific estimates of current stock conditions.
Age at 50%	Age at which 50% of the population is estimated to be reproductively mature.
CDFG	California Department of Fish and Game.
CPFV	Commercial Passenger Fishing Vessel.
CPUE	Catch per Unit Effort. The total number or weight of fish harvested by a defined unit of fishing effort. Measures of "unit of effort" are variable and defined separately within each fishery (e.g., angler day, hours fished, trips, vessel days, number of hooks, etc.)
EEZ	Exclusive Economic Zone. The zone out to 200 miles in which the United States claims control over natural resources.
EFP	Experimental Fishery Permit.
ESA	Endangered Species Act.
Fecundity	The potential net reproductive output of a female (e.g., the number of eggs present in the ovaries).
FCMA	Fishery Conservation and Management Act, or "Magnuson Act." The Fishery Conservation and Management Act was created in 1976 and was renamed the "Magnuson Act" in 1980. The MFCMA established the 200-mile EEZ and the regional fishery management council system. Reauthorized as the Sustainable Fisheries Act (SFA) or the Magnuson-Stevens Fishery Conservation and Management Act in 1996.
FMP	Fishery Management Plan. The Magnuson Fishery Conservation and Management Act provides that each Council shall prepare a FMP with respect to each fishery within its geographical area of authority. Among the necessary components of such FMPs are the conservation and management measures (1) applicable to foreign and domestic fishing, (2) necessary and appropriate for the conservation and management of the fishery, and (3) consistent with the seven national standards, the other provisions of the FCMA, and any other applicable law. California's Marine Life Management Act also requires that fishery managers create fishery management plans that foster sustainable fisheries.
IFQ	Individual Fishery Quotas. IFQs are certificates or licenses given to individual fishers which represent the right to catch and sell a certain share of the Total Allowable Catch. When these certificates are transferable between fishers they are referred to as Individual Transferable Quotas (ITQs).
IFS	Individual Fishery Shares. IFSs are under consideration for the nearshore fishery in California and are in use in a few fisheries around the world. IFSs represent an individual's share of the total allowable commercial catch.
MBNMS	Monterey Bay National Marine Sanctuary.

MLMA	California Marine Life Management Act
MLPA	California Marine Life Protection Act
Monterey Management Area	The area from 36° N latitude to 40° 30' N latitude off Central California that is designated as a fishery management area by the International North Pacific Fisheries Commission (INPFC) and used by the Pacific Fishery Management Council.
NMFS	National Marine Fisheries Service.
NOAA	National Oceanic and Atmospheric Administration.
OY	Optimum Yield. The term "optimum," with respect to the yield from a fishery, means the amount of fish (1) that will provide the greatest overall benefit to the nation, with particular reference to food production and recreational opportunities, and (2) that is prescribed as such on the basis of the maximum sustainable yield from such fishery, as modified by any relevant economic, social, or ecological factors.
PFMC	Pacific Fishery Management Council.
PSMFC	Pacific States Marine Fisheries Commission.
Recruitment	The process or time at which young individuals of a species are first harvested by a fishery.
Sebastes Complex	A rockfish management group that includes bocaccio, canary, chilipepper, yellowtail and a remaining rockfish group. The remaining rockfish group includes all rockfishes harvested, but not individually addressed with stock assessments.
SFA	Sustainable Fisheries Act. In 1996, Congress reauthorized and amended the Magnuson-Stevens Fishery Conservation and Management Act of 1976 with the Sustainable Fisheries Act.
Stock	A segment of a fish population that is selected to be harvested and managed.
TAC	Total Allowable Catch. The total amount in weight of fishes that can be harvested from a particular fishery over a predetermined length of time.

Appendices

Appendix A. Common and scientific names of species commonly caught and sold in the commercial fishery (C), commercial live-fish fishery (C/L), and recreational fishery (R) within the MBNMS.

Common Name	**Scientific Name**	**C**	**C/L**	**R**
Invertebrates				
Abalone, red	*Haliotis rufescens*	X	X	X
Abalone, black	*Haliotis cracherodii*	X		X
California spiny lobster	*Panulirus interruptus*	X	X	
Clam, California jackknife	*Tagelus californians*			X
Clam, common littleneck	*Protothaca staminea*	X		X
Clam, common Washington	*Saxidomus nuttalli*	X		X
Clam, gaper	*Tresus nuttalli*	X		X
Clam, northern quahog	*Mercenaria mercenaria*			X
Clam, northern razor	*Siliqua patula*			X
Clam, Pismo	*Tivela stultorum*	X		X
Clam, purple	*Nuttallia nuttallia*			X
Clam, rosy razor	*Solen rosaceus*			X
Clam, softshell	*Mya arenaria*			X
Crab, box	Family: Lithodidae	X	X	
Crab, Dungeness	*Cancer magister*	X	X	X
Crab, rock	*Cancer* spp.	X	X	X
Crab, shore	*Pachygrapsus* spp.			X
Crab, shore	*Hemigrapsus* spp.			X
Crab, spider	*Loxorhynchus grandis*	X	X	X
Limpet, owl	*Lottia gigantea*	X		X
Mussel, California	*Mytilus californianus*	X		X
Mussel, bay	*Mytilus edulis*	X		X
Octopus	*Octopus* spp.	X	X	X
Prawn, ridgeback	*Sicyonia ingentis*	X	X	
Prawn, spot	*Pandalus platyceros*	X	X	
Scallop, rock	*Hinnites multirugosus*			X
Sea cucumber	*Parastichopus* spp.	X	X	X
Sea snail	Subclass: Prosobranchia	X	X	X
Sea star	Class: Asteroidea	X		X
Shrimp, bay	*Crangon stylirostris*	X		X
Shrimp, Pacific ocean (Pink)	*Pandalus jordani*	X	X	
Squid, market	*Loligo opalescens*	X		
Urchin, purple sea	*Strongylocentrotus purpuratus*	X	X	X
Urchin, red sea	*Strongylocentrotus franciscanus*	X	X	X
Whelk, Kellet's	*Kelletia kelletii*	X	X	
Fishes				
Albacore	*Thunnus alalunga*	X	X	X
Anchovy, northern	*Engraulis mordax*	X	X	X
Barracuda, California	*Sphyraena argentea*	X		X
Bass, kelp	*Paralabrax clathratus*	X		X
Bass, striped	*Morone saxatilis*	X		X
Blacksmith	*Chromis punctipinnis*			X
Blenny, bay	*Hypsoblennius gentilis*			X
Bonito, Pacific	*Sarda chiliensis*	X		X
Butterfish, Pacific	*Peprilus simillimus*	X		X
Cabezon	*Scorpaenichthys marmoratus*	X	X	X
Cabrilla, spotted	*Epinephelus analogus*	X	X	X
Cod, Pacific	*Gadus microcephalus*	X		

Appendix A. *(continued)* Common and scientific names of species commonly caught and sold in the commercial fishery (C), commercial live-fish fishery (C/L), and recreational fishery (R) within the MBNMS.

Common Name	Scientific Name	C	C/L	R
Croaker, white	*Genyonemus lineatus*	X	X	X
Dolphinfish	*Corypahaena hippurus*			X
Eel, California moray	*Gymnothorax mordax*	X	X	
Flounder, arrowtooth	*Atheresthes stomias*	X		X
Flounder, starry	*Platichthys stellatus*	X	X	X
Fringehead, onespot	*Neoclinus uninotatus*			X
Fringehead, sarcastic	*Neoclinus blanchardi*			X
Goby, bay	*Lepidogobius lepidus*			X
Goby, yellowfin	*Acanthogobius flavimanus*			X
Goby, zebra	*Lythrypnus zebra*	X	X	
Greenling, kelp	*Hexagrammos decagrammus*	X	X	X
Greenling, painted	*Oxylebius pictus*			X
Greenling, rock	*Hexagrammos lagocephalus*	X	X	X
Grenadier, Pacific	*Coryphaenoides acrolepis*	X		
Grouper, broomtail	*Mycteroperca xenarcha*			X
Grouper, gulf	*Mycteroperca jordani*			X
Guitarfish, shovelnose	*Rhinobatus productus*	X		X
Hagfish, Pacific	*Eptatretus stoutii*	X		
Hagfish, black	*Eptatretus deani*	X		
Hake, Pacific	*Meluccius productus*	X		X
Halfmoon	*Medialuna californiensis*	X	X	X
Halibut, California	*Paralichthys californicus*	X	X	X
Halibut, Pacific	*Hippoglossus stenolepis*	X		X
Herring Pacific	*Clupea pallasii*	X		X
Irish lord, brown	*Hemilepidotus spinosus*			X
Irish lord, red	*Hemilepidotus hemilepidotus*			X
Jacksmelt	*Atherinops californiensis*	X		X
Kelpfish, giant	*Heterostichus rostratus*	X	X	X
Kelpfish, striped	*Gibbonsia metzi*	X	X	X
Lancetfish, longnose	*Alepisaurus ferox*			X
Lingcod	*Ophiodon elongatus*	X	X	X
Lizardfish, California	*Synodus lucioceps*	X		X
Louvar	*Luvarus imperialis*	X		
Mackerel, Pacific	*Scomber japonicus*	X	X	X
Mackerel, jack	*Trachurus symmetricus*	X		X
Midshipman, plainfin	*Porichthys notatus*			X
Opaleye	*Girella nigricans*	X	X	X
Prickleback, monkeyface	*Cebidichthys violaceus*	X	X	X
Prickleback, rock	*Xiphister mucosus*			X
Queenfish	*Seriphus politus*	X		X
Ratfish, spotted	*Hydrolagus colliei*	X		X
Ray, bat	*Myliobatis californica*	X	X	X
Ray, Pacific electric	*Torpedo californica*			X
Rockfish, aurora	*Sebastes aurora*	X		X
Rockfish, bank	*Sebastes rufus*	X		X
Rockfish, black	*Sebastes melanops*	X	X	X
Rockfish, black-and-yellow	*Sebastes chrysomelas*	X	X	X
Rockfish, blackgill	*Sebastes melanostomus*	X	X	X
Rockfish, blue	*Sebastes mystinus*	X	X	X
Rockfish, bocaccio	*Sebates paucispinis*	X	X	X

Appendix A. *(continued)* Common and scientific names of species commonly caught and sold in the commercial fishery (C), commercial live-fish fishery (C/L), and recreational fishery (R) within the MBNMS.

Common Name	Scientific Name	C	C/L	R
Rockfish, bronzespotted	*Sebastes gilli*	X	X	X
Rockfish, brown	*Sebastes auriculatus*	X	X	X
Rockfish, calico	*Sebastes dalli*			X
Rockfish, canary	*Sebastes pinniger*	X	X	X
Rockfish, chameleon	*Sebastes phillipsi*	X		
Rockfish, chilipepper	*Sebastes goodei*	X	X	X
Rockfish, China	*Sebastes nebulosus*	X	X	X
Rockfish, copper (whitebelly)	*Sebastes caurinus (vexillaris)*	X	X	X
Rockfish, cowcod	*Sebastes levis*	X	X	X
Rockfish, darkblotched	*Sebastes crameri*	X	X	X
Rockfish, dusky	*Sebastes ciliatus*			X
Rockfish, flag	*Sebastes rubrivinctus*	X	X	X
Rockfish, freckled	*Sebastes lentiginosus*			X
Rockfish, gopher	*Sebastes carnatus*	X	X	X
Rockfish, grass	*Sebastes rastrelliger*	X	X	X
Rockfish, greenblotched	*Sebastes rosenblatti*	X		X
Rockfish, greenspotted	*Sebastes chlorostictus*	X		X
Rockfish, greenstriped	*Sebastes elongatus*	X	X	X
Rockfish, halfbanded	*Sebastes semicinctus*			X
Rockfish, honeycomb	*Sebastes unbrosus*	X		X
Rockfish, kelp	*Sebastes atrovirens*	X	X	X
Rockfish, Mexican	*Sebastes mcdonaldi*	X		
Rockfish, olive	*Sebastes serranoides*	X	X	X
Rockfish, Pacific Ocean Perch	*Sebastes alutus*	X		X
Rockfish, pink	*Sebastes eos*	X	X	
Rockfish, quillback	*Sebastes maliger*	X	X	X
Rockfish, redbanded	*Sebastes babcocki*	X		X
Rockfish, redstripe	*Sebastes proriger*			X
Rockfish, rosethorn	*Sebastes helvomaculatus*	X	X	X
Rockfish, rosy	*Sebastes rosaceus*	X		X
Rockfish, rougheye	*Sebastes aleutianus*			X
Rockfish, sharpchin	*Sebastes zacentrus*			X
Rockfish, shortbelly	*Sebastes jordani*	X		X
Rockfish, silvergray	*Sebastes brevispinis*			X
Rockfish, speckled	*Sebastes ovalis*	X		X
Rockfish, splitnose	*Sebastes diploproa*	X	X	X
Rockfish, squarespot	*Sebastes hopkinsi*	X		X
Rockfish, starry	*Sebastes constellatus*	X	X	X
Rockfish, stripetail	*Sebastes saxicola*	X		X
Rockfish, swordspine	*Sebastes ensifer*	X	X	X
Rockfish, tiger	*Sebastes nirgocinctus*	X		X
Rockfish, treefish	*Sebastes serriceps*	X	X	X
Rockfish, vermilion	*Sebastes miniatus*	X	X	X
Rockfish, widow	*Sebastes entomelas*	X	X	X
Rockfish, yelloweye	*Sebastes ruberrimus*	X	X	X
Rockfish, yellowtail	*Sebastes flavidus*	X	X	X
Sablefish	*Anoplopoma fimbria*	X	X	X
Salmon, chinook	*Oncorhynchus tshawytscha*	X	X	X
Salmon, chum	*Oncorhynchus keta*			X
Salmon, coho	*Oncorhynchus kisutch*	X		

Appendix A. *(continued)* Common and scientific names of species commonly caught and sold in the commercial fishery (C), commercial live-fish fishery (C/L), and recreational fishery (R) within the MBNMS.

Common Name	Scientific Name	C	C/L	R
Salmon, pink	*Oncorhynchus gorbuscha*	X		X
Sand bass, barred	*Paralabrax nebulifer*			X
Sand lance, Pacific	*Ammodytes hexapterus*			X
Sanddab, longfin	*Citharichthys xanthostigma*	X		X
Sanddab, Pacific	*Citharichthys sordidus*	X	X	X
Sanddab, speckled	*Citharichthys stigmaeus*	X		X
Sandfish, Pacific	*Trichodon trichodon*			X
Sardine, Pacific	*Sardinops sagax*	X		X
Saury, Pacific	*Cololabis saira*			X
Sculpin, Pacific staghorn	*Leptocottus armatus*	X	X	X
Sculpin, sharpnose	*Clinocottus acuticeps*			X
Seabass, white	*Atractoscion nobilis*	X	X	X
Senorita	*Oxyjulis californica*			X
Shad, American	*Alosa sapidissima*			X
Shark, bigeye thresher	*Alopias superciliosus*	X		X
Shark, blue	*Prionace glauca*	X		X
Shark, common thresher	*Alopias vulpinus*	X		X
Shark, leopard	*Triakis semifasciata*	X	X	X
Shark, Pacific angel	*Squatina californica*	X	X	X
Shark, seven gill	*Notorynchus cepedianus*			X
Shark, shortfin mako	*Isurus oxyrinchus*	X		X
Shark, six gill	*Hexanchus griseus*	X		X
Shark, soupfin	*Galeorhinus galeus*	X	X	X
Shark, spiny dogfish	*Squalus acanthias*	X	X	X
Sheephead, California	*Semicossyphus pulcher*	X	X	X
Sierra, gulf	*Scomberomorus concolor*			X
Skate, big	*Raja binoculata*	X		X
Skate, California	*Raja inornata*	X		X
Skate, longnose	*Raja rhina*	X		X
Smelt, night	*Spirinchus starksi*	X	X	X
Smelt, surf	*Hypomesus pretiosus*	X		X
Smelt, whitebait	*Allosmerus elongatus*			X
Smoothhound, brown	*Mustelus henlei*	X		X
Smoothhound, gray	*Mustelus californicus*	X		X
Sole, bigmouth	*Hippoglossina stomata*	X		X
Sole, butter	*Isopsetta isolepis*	X		X
Sole, Dover	*Microstomus pacificus*	X	X	X
Sole, English	*Parophrys vetulus*	X		X
Sole, fantail	*Xystreurys liolepis*	X		X
Sole, petrale	*Eopsetta jordani*	X	X	X
Sole, rex	*Errex zachirus*	X	X	X
Sole, rock	*Lepidopsetta bilineata*	X	X	X
Sole, sand	*Psettichthys melanostictus*	X	X	X
Stingray, diamond	*Dasyatis brevis*			X
Stingray, round	*Urolophus halleri*			X
Sturgeon, green	*Acipenser medirostris*			X
Sturgeon, white	*Acipenser transmontanus*			X
Sunfish, ocean	*Mola mola*			X
Surfperch, barred	*Amphistichus argenteus*	X	X	X
Surfperch, black	*Embiotoca jacksoni*	X	X	X

Appendix A. *(continued)* Common and scientific names of species commonly caught and sold in the commercial fishery (C), commercial live-fish fishery (C/L), and recreational fishery (R) within the MBNMS.

Common Name	**Scientific Name**	**C**	**C/L**	**R**
Surfperch, calico	*Amphistichus koelzi*	X	X	X
Surfperch, dwarf	*Micrometrus minimus*			X
Surfperch, kelp	*Brachyistius frenatus*			X
Surfperch, pile	*Damalichthys vacca*	X	X	X
Surfperch, rainbow	*Hypsurus caryi*	X	X	X
Surfperch, redtail	*Amphistichus rhodoterus*	X	X	X
Surfperch, rubberlip	*Rhacochilus toxotes*	X	X	X
Surfperch, sharpnose	*Phanerodon atripes*			X
Surfperch, shiner	*Cymatogaster aggregata*	X	X	X
Surfperch, silver	*Hyperprosopon ellipticum*			X
Surfperch, spotfin	*Hyperprosopon anale*			X
Surfperch, striped	*Embiotoca lateralis*	X	X	X
Surfperch, walleye	*Hyperprosopon argenteum*	X		X
Surfperch, white	*Phanerodon furcatus*	X	X	X
Thornyhead, longspine	*Sebastolobus altivelis*	X	X	X
Thornyhead, shortspine	*Sebastolobus alascanus*	X	X	X
Tomcod, Pacific	*Microgadus proximus*			X
Topsmelt	*Atherinops affinis*	X		X
Trout, steelhead	*Oncorynchus mykiss*			X
Tuna, bigeye	*Thunnus obesus*	X		X
Tuna, bluefin	*Thunnus thynnus*	X		X
Tuna, skipjack	*Euthynnus pelamis*	X	X	X
Tuna, yellowfin	*Thunnus albacares*	X	X	X
Turbot, C-O	*Pleuronichthys coenosus*	X		X
Turbot, Curlfin	*Pleuronichthys decurrens*	X		X
Turbot, Diamond	*Hypsopsetta guttulata*	X		X
Whitefish, ocean	*Caulolatilus princeps*	X	X	X
Wolf eel	*Anarrhichthys ocellatus*	X	X	X
Yellowtail	*Seriola lalandi*	X		X
Zebraperch	*Hermosilla azurea*			X

Appendix B. Reported commercial landings (1,000 lb) of major species at the five major ports associated with the MBNMS from 1981–2000. Species listed in order of decreasing average annual landings.

Species	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Market squid	28,209.87	23,314.21	2,064.50	930.82	8,516.49	13,799.65	13,095.68	11,430.98	15,757.81	17,612.52	17,539.96
Pacific sardine	0.00	0.00	0.00	0.73	0.00	185.79	104.63	6.51	523.60	546.06	2,169.07
Total rockfish	7,043.85	11,338.49	9,601.53	9,395.03	7,494.43	9,992.31	8,113.75	7,880.44	9,526.64	8,415.13	6,226.35
Northern anchovy	10,195.75	5,751.24	705.65	4,168.41	2,507.23	1,778.74	1,487.93	1,534.74	2,076.98	4,689.17	5,558.81
Dover sole	1,312.43	2,005.74	3,256.11	5,393.83	8,065.35	4,509.87	7,508.20	4,349.66	3,405.62	2,514.18	2,947.43
Chinook salmon	1,128.49	1,802.42	909.94	843.83	937.73	2,407.42	1,637.35	4,176.74	2,298.30	2,153.80	1,573.84
Pacific mackerel	2,983.05	4,115.39	5,916.04	7,087.59	988.75	2,082.23	707.17	51.74	31.64	4,653.33	296.10
Sablefish	1,999.34	2,325.05	1,950.15	1,581.12	2,241.76	2,118.14	1,860.87	1,775.80	2,013.18	1,688.15	1,381.80
Albacore	5,115.90	676.13	6,098.84	1,923.22	2,407.15	2,013.33	1,787.06	832.44	474.03	291.04	152.81
Jack mackerel	465.37	617.10	5,405.80	12,057.41	501.82	420.55	461.58	267.89	85.65	461.87	95.96
Unspecified mackerel	8.12	406.19	1,682.82	8,652.38	4,973.47	2,313.17	1,408.90	83.36	116.25	867.88	362.45
Swordfish	0.00	60.54	820.53	633.16	1,613.90	1,087.86	1,104.58	1,127.54	850.04	845.37	669.77
Sanddabs	202.47	272.93	130.97	173.82	236.46	471.92	394.55	576.16	794.00	917.49	918.26
English sole	662.77	617.85	346.48	329.98	435.53	658.24	652.89	642.14	750.02	986.08	829.58
Dungeness crab	129.14	116.58	259.36	233.62	126.98	344.48	682.55	915.86	355.19	255.77	343.84
Petrale sole	445.17	412.17	263.10	255.99	534.40	746.77	487.10	525.71	597.76	731.79	575.37
Lingcod	575.83	746.70	487.45	351.63	177.56	246.66	495.00	545.80	811.27	566.15	340.36
Rex sole	210.69	229.83	314.01	178.75	580.60	438.15	506.18	646.54	470.29	351.10	368.30
White croaker	623.66	739.29	320.06	262.59	564.50	680.86	519.22	646.91	588.90	377.10	426.27
Pink shrimp	871.46	482.75	760.06	126.54	0.46	799.72	472.16	312.60	0.00	0.00	0.00
Unspecified grenadier	0.46	0.46	0.46	0.46	0.46	0.46	0.00	0.00	0.62	22.04	0.00
California halibut	199.83	229.13	196.79	197.32	176.07	178.27	236.54	260.88	279.86	134.86	159.13
Rock crab	36.98	43.21	67.01	143.11	283.21	266.02	143.09	145.11	304.22	295.88	314.45
Common thresher shark	18.33	199.12	541.71	320.03	345.99	165.22	229.00	145.93	192.21	273.04	318.82
Pacific herring	276.21	550.48	285.38	208.87	134.77	309.72	136.75	28.47	27.39	280.54	243.47
Unspecified skate	168.08	165.95	203.48	86.97	54.47	57.93	47.70	58.74	106.35	99.81	81.64
Red sea urchin	22.09	12.43	22.86	9.90	1.78	10.98	16.61	260.99	727.58	190.89	164.14
Spot prawn	64.02	90.11	44.68	26.27	28.51	15.03	17.01	22.09	11.35	11.00	18.72
Other species	148.87	163.66	304.33	77.77	100.83	160.38	37.47	241.05	19.34	10.87	110.22
Red abalone	59.22	65.78	40.74	52.29	106.44	63.89	104.10	109.10	129.43	104.46	75.90
Cabezon	27.41	34.54	14.08	12.47	19.01	10.27	4.49	7.57	10.27	4.20	3.83
Miscellaneous fish	26.36	22.42	64.33	72.03	77.18	58.23	34.58	32.01	60.50	45.69	39.84
Unspecified hagfish	0.46	0.46	0.46	0.46	0.46	0.46	0.00	0.00	0.00	867.99	0.00
Sand sole	52.21	70.29	63.82	75.53	68.57	91.74	50.67	31.17	24.53	16.83	31.26
Unspecified flatfish	89.91	74.27	44.46	59.53	98.78	91.43	48.33	43.41	56.80	23.32	16.76
Shortfin mako	0.46	9.28	58.30	26.18	26.38	19.07	50.82	23.96	48.71	80.94	60.63
Pacific bonito	1.98	16.10	146.19	10.21	5.26	3.96	450.58	2.07	0.44	28.64	0.00
Bluefin tuna	0.46	0.00	0.13	0.64	1.17	0.00	0.70	1.36	1.50	13.16	2.79
Unspecified clam	0.46	0.46	0.46	0.46	0.46	47.81	112.46	105.86	99.84	61.40	11.00
Surfperch	20.77	36.54	28.36	13.93	14.08	24.24	44.57	41.05	32.25	30.87	28.25
Starry flounder	5.76	1.45	13.79	42.66	79.90	59.80	38.08	64.70	22.13	9.61	19.23
Pacific angel shark	36.28	28.09	24.44	45.78	40.55	34.10	67.54	47.78	48.38	23.28	12.10
Soupfin shark	23.80	30.87	36.23	35.93	40.46	27.13	29.77	16.32	20.99	25.41	19.56
Coho salmon	2.31	11.33	5.68	69.43	2.97	13.27	1.36	10.87	15.03	77.31	188.78
Unspecified shark	48.91	45.74	39.16	46.20	65.14	32.05	20.42	27.63	13.71	6.84	4.33

Appendix B. *(continued)* Reported commercial landings (1,000 lb) of major species at the five major ports associated with the MBNMS from 1981–2000. Species listed in order of decreasing average annual landings.

Species	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Total**	**Mean**
Market squid	18,566.33	19,712.00	35,730.73	7,066.42	11,199.98	18,672.08	0.00	636.15	15,352.66	279,208.84	13,960.44
Pacific sardine	6,805.02	1,487.46	5,036.99	12,495.27	17,573.31	29,279.36	23,019.19	37,682.94	25,043.61	161,959.56	8,097.98
Total rockfish	6,087.69	5,412.00	4,334.70	4,994.77	4,698.47	4,100.27	4,323.22	650.32	355.22	129,984.63	6,499.23
Northern anchovy	1,338.11	2,827.00	2,506.50	2,646.14	7,828.33	8,580.42	1,983.52	3,329.59	14,464.67	85,958.91	4,297.95
Dover sole	4,470.49	3,418.58	2,829.20	4,042.50	4,029.85	3,538.94	1,769.04	1,844.72	1,414.31	72,626.07	3,631.30
Chinook salmon	1,001.07	1,745.68	2,386.36	4,888.60	3,199.44	4,128.56	1,320.53	2,287.82	3,370.95	44,198.86	2,209.94
Pacific mackerel	843.13	85.29	87.23	1,014.42	1,550.01	7,059.01	3,207.40	6.18	86.81	42,852.50	2,142.63
Sablefish	1,494.88	911.57	738.32	1,533.71	2,151.14	1,807.37	724.22	900.39	827.13	32,024.06	1,601.20
Albacore	254.80	648.82	368.94	455.25	567.78	2,934.73	451.97	1,467.00	1,632.73	30,553.97	1,527.70
Jack mackerel	244.57	759.88	421.34	240.50	201.50	720.39	73.24	53.20	110.46	23,666.08	1,183.30
Unspecified mackerel	3.48	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	20,879.65	1,043.98
Swordfish	602.98	541.27	363.37	613.05	763.14	546.44	660.64	636.70	545.20	14,086.07	704.30
Sanddabs	416.61	504.77	892.39	865.28	1,056.20	1,200.08	1,233.65	1,280.77	868.30	13,407.06	670.35
English sole	486.33	331.45	319.62	326.99	381.11	379.39	245.74	209.11	150.96	9,742.26	487.11
Dungeness crab	371.98	275.77	825.31	996.07	541.46	971.37	719.99	246.47	375.47	9,087.25	454.36
Petrale sole	325.97	277.73	323.31	401.02	509.32	447.72	278.74	251.66	182.27	8,573.07	428.65
Lingcod	403.99	552.51	410.59	248.25	259.42	206.05	82.83	62.44	13.35	7,583.84	379.19
Rex sole	319.40	339.77	476.72	620.03	455.33	254.74	181.32	125.40	66.09	7,133.24	356.66
White croaker	124.89	195.32	84.90	75.11	132.68	67.65	32.56	21.89	12.58	6,496.93	324.85
Pink shrimp	2.57	0.00	366.41	746.59	257.93	386.54	313.02	228.07	339.13	6,465.56	323.30
Unspecified grenadier	7.92	8.76	60.21	476.32	1,991.48	932.40	520.43	331.50	227.39	4,579.08	229.09
California halibut	190.30	141.61	108.09	155.89	212.92	443.85	344.32	419.12	158.14	4,422.90	221.15
Rock crab	431.00	338.34	205.57	204.89	114.03	83.40	88.46	73.48	49.65	3,631.10	181.56
Common thresher shark	144.19	17.25	27.63	108.44	75.15	106.44	94.89	28.25	22.02	3,373.66	168.68
Pacific herring	0.00	0.00	0.00	7.35	546.94	0.00	0.00	0.00	56.30	3,092.65	154.63
Unspecified skate	73.66	53.81	55.42	77.77	115.10	244.75	177.03	158.07	103.64	2,190.36	109.52
Red sea urchin	151.89	126.21	42.57	7.63	27.41	23.32	0.00	15.38	8.65	1,843.31	92.17
Spot prawn	22.04	61.51	129.78	199.43	186.14	231.51	372.04	209.77	166.19	1,927.20	96.36
Other species	28.73	12.94	10.69	62.26	7.17	10.69	71.92	53.17	15.62	1,647.98	82.40
Red abalone	122.34	79.31	67.54	75.90	65.27	38.52	0.00	0.00	0.00	1,360.24	68.01
Cabezon	9.22	8.69	42.57	124.39	161.94	159.35	219.52	136.75	85.47	1,096.04	54.80
Miscellaneous fish	54.52	48.00	41.58	48.20	66.44	75.59	54.52	23.28	10.98	956.27	47.81
Unspecified hagfish	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	868.45	43.56
Sand sole	52.84	44.84	16.46	20.31	32.25	26.53	19.01	24.90	28.03	841.79	42.09
Unspecified flatfish	34.06	19.71	10.12	6.07	8.56	12.67	24.29	24.88	5.43	792.81	39.64
Shortfin mako	47.39	24.42	22.46	30.93	27.98	53.72	38.06	20.28	12.87	682.40	34.14
Pacific bonito	1.89	2.07	0.20	0.00	0.00	0.24	3.04	0.44	0.84	674.15	33.71
Bluefin tuna	9.35	39.97	15.16	21.49	58.63	58.87	37.51	249.13	44.79	556.36	27.84
Unspecified clam	51.70	24.46	6.67	0.00	0.86	0.00	0.00	0.00	0.00	522.06	26.22
Surfperch	34.43	26.58	22.88	26.47	20.81	25.67	34.45	8.23	7.50	521.93	26.10
Starry flounder	18.19	9.66	5.26	8.34	15.40	24.95	30.38	28.27	18.63	516.21	25.81
Pacific angel shark	10.34	10.69	6.38	6.18	5.96	5.30	4.25	8.34	4.42	470.18	23.51
Soupfin shark	13.68	24.46	19.87	18.28	12.54	15.11	23.10	15.00	7.77	456.28	22.81
Coho salmon	8.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	408.41	20.42
Unspecified shark	3.89	4.14	5.52	5.57	2.82	1.65	3.04	13.86	10.67	401.28	20.06

Appendix B. *(continued)* Reported commercial landings (1,000 lb) of major species at the five major ports associated with the MBNMS from 1981–2000. Species listed in order of decreasing average annual landings.

Species	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Bigeye thresher shark	0.46	0.46	72.53	15.25	46.97	9.37	11.42	10.12	14.67	11.70	39.31
Unspecified smelt	17.71	35.55	23.56	4.69	12.10	13.99	6.07	7.72	7.57	12.45	6.42
Unspecified squid	0.46	0.46	0.46	0.46	0.46	0.46	0.00	0.00	0.00	0.00	0.00
Leopard shark	6.42	18.19	6.71	10.65	16.63	17.47	12.98	7.72	12.98	5.83	2.77
Rock sole	5.48	9.59	4.75	8.84	11.79	5.83	5.02	2.84	9.20	3.85	3.50
White seabass	2.38	1.41	4.38	2.51	2.18	2.86	0.81	1.21	1.10	6.89	0.88
Unspecified octopus	7.13	18.13	6.05	1.47	0.42	0.42	1.61	2.11	19.87	6.64	2.84
Yellowtail	1.06	12.63	10.41	50.03	0.13	0.35	0.46	0.46	0.13	0.00	0.00
Unspecified salmon	18.33	12.21	7.77	12.47	16.13	0.46	0.00	0.00	0.00	0.00	0.00
Unspecified tuna	0.46	0.40	2.44	0.59	1.58	1.32	1.50	4.05	1.19	2.20	2.95
Yellowfin tuna	0.46	0.81	9.92	0.64	4.03	2.20	2.24	3.96	0.37	5.50	1.52
Kelp greenling	0.13	0.55	0.46	0.46	0.46	0.55	0.53	2.20	3.83	0.22	1.58
Unspecified ocean shrimp	2.99	0.46	8.98	18.90	4.60	2.62	0.90	1.89	0.00	0.00	0.00
Other tuna	0.46	0.46	2.71	0.46	1.21	1.28	3.01	8.36	0.00	0.57	3.81
Skipjack tuna	0.46	0.46	11.35	1.30	0.46	0.46	0.00	0.00	0.53	0.24	4.11
Pacific hake	0.46	0.77	0.46	9.39	5.63	2.90	1.61	2.57	0.99	0.22	1.78
Butter sole	0.46	0.46	0.46	0.46	0.46	23.28	0.00	7.85	0.00	0.00	0.00
Spiny dogfish	1.32	0.46	0.46	13.49	0.46	0.46	0.31	0.62	0.15	0.00	0.00
Other sea urchins	0.46	0.46	0.46	0.46	0.46	0.46	0.00	0.00	0.00	0.00	28.78
California sheephead	0.00	0.00	0.00	0.92	0.00	0.00	0.15	0.46	0.04	0.18	0.46
Pelagic thresher shark	0.46	0.46	0.46	0.46	0.46	0.46	0.00	0.00	0.00	0.00	0.00
Total	56,539.16	46,709.15	34,114.45	46,974.20	37,310.13	38,932.67	37,344.87	32,241.40	34,326.71	43,304.23	38,575.55
Taxonomic Groups											
Invertebrates	29,404.30	24,145.04	3,275.62	1,544.31	9,070.27	15,351.53	14,646.17	13,306.59	17,405.28	18,538.56	18,499.62
Anadromous fishes	1,149.13	1,825.96	923.38	925.74	956.82	2,421.14	1,638.71	4,187.61	2,313.32	2,231.11	1,762.62
Flatfishes	3,187.18	3,923.72	4,634.74	6,716.71	10,287.93	7,275.29	9,927.57	7,151.06	6,410.23	5,689.11	5,868.81
Pelagic Fishes	19,067.91	12,244.25	21,122.24	34,809.70	13,158.66	10,217.86	7,664.78	3,963.26	4,198.28	12,698.25	9,571.83
Nearshore	13,947.71	11,489.35	14,030.13	32,239.48	9,123.91	7,107.45	4,315.10	1,983.48	2,870.19	11,511.52	8,734.07
Offshore	5,120.19	754.91	7,092.12	2,570.22	4,034.76	3,110.40	3,349.68	1,979.78	1,328.10	1,186.72	837.76
Roundfishes	3,229.67	3,848.46	2,777.50	2,212.63	3,006.39	3,060.27	2,881.08	2,979.94	3,429.21	3,532.91	2,155.19
Rockfishes	7,043.85	11,338.49	9,601.53	9,395.03	7,494.43	9,992.31	8,113.75	7,880.44	9,526.64	8,415.13	6,226.35
Sharks and Rays	304.52	498.63	983.49	600.93	637.52	363.26	469.94	338.82	458.15	526.86	539.18
Surfperches	20.77	36.54	28.36	13.93	14.08	24.24	44.57	41.05	32.25	30.87	28.25

Appendix B. *(continued)* Reported commercial landings (1,000 lb) of major species at the five major ports associated with the MBNMS from 1981–2000. Species listed in order of decreasing average annual landings.

Species	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Total**	**Mean**
Bigeye thresher shark	5.90	2.57	5.10	10.43	4.29	3.23	0.00	0.00	0.00	262.88	13.19
Unspecified smelt	3.94	2.62	14.19	3.61	30.14	10.54	1.69	1.17	10.23	225.96	11.30
Unspecified squid	0.00	0.00	0.00	0.00	0.00	0.70	190.32	0.00	0.00	191.03	9.69
Leopard shark	4.95	5.41	9.22	4.64	2.18	2.88	2.99	2.64	1.25	154.53	7.73
Rock sole	3.43	7.30	3.63	10.38	3.28	4.11	9.92	3.30	3.28	119.33	5.97
White seabass	1.65	5.87	9.72	2.13	1.12	9.61	4.16	5.32	25.94	92.14	4.61
Unspecified octopus	4.38	4.93	1.50	0.15	0.59	3.04	3.17	2.66	1.50	88.59	4.43
Yellowtail	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.46	3.82
Unspecified salmon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.90	3.37
Unspecified tuna	11.73	14.41	3.41	1.03	0.00	0.00	0.00	0.00	0.00	48.80	2.46
Yellowfin tuna	1.43	2.11		0.53	0.46	2.90	3.67	2.31	0.57	44.73	2.40
Kelp greenling	4.14	0.57	2.02	1.17	2.00	3.70	4.44	7.26	10.52	45.41	2.34
Unspecified ocean shrimp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.88	2.07
Other tuna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.69	0.00	38.63	2.00
Skipjack tuna	0.29	0.00	0.13	2.93	0.18	2.07	4.69	0.00	9.22	37.03	1.94
Pacific hake		0.70	1.39	0.48	0.11	0.46	0.46	0.97	2.40	31.92	1.78
Butter sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.13	1.67
Spiny dogfish	0.20	0.00	0.00	0.00	0.00	0.46	1.25	0.00	12.89	30.69	1.63
Other sea urchins	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.78	1.58
California sheephead	1.50	0.46	3.32	5.90	4.11	2.35	2.51	2.82	1.28	25.54	1.32
Pelagic thresher shark	0.00	0.00	0.00	0.00	0.00	9.68	0.00	8.45	0.86	18.99	1.09
Total	39,646.42	35,792.59	55,158.00	41,040.41	56,487.42	83,838.61	38,696.81	53,173.16	65,983.48	916,153.39	
Taxonomic Groups											
Invertebrates	19,724.23	20,622.54	37,376.06	9,297.09	12,393.68	20,410.48	1,687.00	1,411.98	16,293.24	304,394.84	15,225.03
Anadromous fishes	1,009.89	1,745.68	2,386.36	4,888.60	3,199.44	4,128.56	1,320.53	2,287.82	3,372.20	44,674.17	2,233.73
Flatfishes	6,317.63	5,095.42	4,984.78	6,456.80	6,704.21	6,332.99	4,136.42	4,212.14	2,895.44	118,205.87	5,910.41
Pelagic Fishes	10,121.43	6,411.61	8,818.85	17,502.06	29,120.52	49,196.62	29,447.02	43,447.32	42,007.83	384,782.42	19,279.88
Nearshore	9,238.97	5,162.96	8,067.64	16,407.78	27,730.34	45,651.36	28,285.51	41,074.04	39,774.48	338,742.69	16,937.36
Offshore	882.46	1,248.65	751.21	1,094.28	1,390.18	3,545.26	1,161.51	2,373.27	2,233.35	46,039.73	2,342.52
Roundfishes	2,048.18	1,684.21	1,351.66	2,466.97	4,703.91	3,188.48	1,590.67	1,468.37	1,203.66	52,811.48	2,653.02
Rockfishes	6,087.69	5,412.00	4,334.70	4,994.77	4,698.47	4,100.27	4,323.22	650.32	355.22	129,984.63	6,499.23
Sharks and Rays	304.19	142.76	151.60	262.24	246.03	443.23	344.61	254.89	176.40	8,041.24	402.36
Surfperches	34.43	26.58	22.88	26.47	20.81	25.67	34.45	8.23	7.50	521.93	26.10

Note: Species with mean landings less than 1000 lb/yr are not included. Data were collected by CDFG and provided by NMFS.

Appendix C. Estimated commercial landings (lb) of rockfishes and thornyheads at the five major ports, plus San Francisco, associated with the MBNMS from 1978–2000. Determined from an expansion of species composition sampling conducted by CDFG. Species are listed in order of decreasing average annual landings.

Species	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Chilipepper	1,363,359	501,869	4,199,228	3,343,406	3,036,042	2,247,748	3,549,686	4,186,536	3,920,844	2,501,774	2,637,777	3,605,117
Bocaccio	3,309,375	3,176,662	7,214,520	4,184,258	6,434,226	4,994,637	4,027,813	2,515,652	2,856,430	3,431,133	2,261,291	3,353,817
Widow rockfish	285,019	5,169	815,057	1,948,033	7,222,981	1,029,648	984,179	1,600,870	1,212,778	1,480,255	744,442	1,743,254
Bank rockfish	763,511	0	31,073	1,089,325	1,605,314	964,551	1,015,065	1,190,902	2,723,304	1,788,681	1,872,397	1,438,460
Shortspine thornyhead	394,162	648,523	7,333	472,942	676,515	842,098	1,473,751	1,987,593	1,113,320	217,556	1,331,126	1,798,682
Longspine thornyhead	192,243	85,295	0	9,150	48,187	40,071	9,630	13,638	151,402	104,611	800	990,605
Splitnose rockfish	355,213	180,682	293,269	304,748	442,346	846,709	840,034	943,765	784,561	58,021	542,108	536,025
Yellowtail rockfish	185,851	542,251	461,917	350,916	593,244	1,280,176	871,430	959,536	929,070	522,412	286,203	875,936
Blackgill rockfish	228,307	0	64,171	173,258	526,284	258,232	96,853	161,492	470,591	50,954	1,028,696	452,468
Vermilion rockfish	2,810	88	158,414	23,968	1,257	121,306	62,134	102,797	65,224	197,719	107,556	79,503
Unspecified thornyhead	3,727	17,267	361,531	4,492	2,068	2,209	770	7,372	14,077	1,702,347	12,149	29,897
Brown rockfish	794,251	124,940	383,942	113,036	126,888	46,400	20,144	12,720	84,996	9,174	8,423	19,463
Yelloweye rockfish	574,790	726,660	28,179	299,978	29,866	1,920	21,643	2,392	11,881	8,515	34,685	17,630
Canary rockfish	48,954	44	88,229	74,434	46,521	48,683	61,287	190,438	1,985	11,663	43,380	197,493
Darkblotched rockfish	11,869	0	24,353	6,990	60,032	133,730	325,234	176,536	177,993	55,941	75,247	94,524
Aurora rockfish	0	0	5,257	0	7,110	60,002	5,237	57,830	65,281	0	116,418	188,589
Greenspotted rockfish	8,368	55,403	19,480	58,848	110,931	22,080	30,961	43,772	10,858	8,342	40,273	43,180
Blue rockfish	57,236	78,954	113,233	142,012	81,473	55,660	29,326	263,293	35,774	18,200	17,149	55,945
Gopher rockfish	95,731	74,995	140,528	115,493	85,557	54,794	19,633	773	249	0	13	28
Cowcod	22,227	0	19,038	16,072	26,813	18,973	50,039	20,033	12,418	18,078	19,511	60,185
Speckled rockfish	4,283	59,121	0	30,369	27,293	89,013	58,822	0	108,524	0	0	50,507
Black rockfish	139,620	136,418	26,514	11,886	9,663	12,103	14,826	22,540	25,452	14,334	731	7,852
Copper rockfish	1,641	1,606	34,652	3,874	10,345	27,830	5,355	1,329	2,176	2,273	6,771	2,107
Olive rockfish	25,355	0	25,194	1,660	5,229	38,807	44	1	3,576	26,634	12,763	763
China rockfish	8,106	22,808	52,665	42,448	32,533	15,731	21,947	6,664	5,002	12,769	16,332	1,010
Grass rockfish	0	0	0	134	34	0	115	0	41	3,371	0	0
Starry rockfish	266	22	464	268	4,930	575	205	5,333	463	0	7,013	27,490
Greenstriped rockfish	2,049	0	40,317	580	12,847	10,779	8,031	21,249	8,964	4,888	17,776	33,083
Black-and-Yellow rockfish	0	515	0	0	0	0	0	0	0	66,671	0	13
Redbanded rockfish	2,783	0	0	2,654	7,079	1,716	63,353	45,174	9,207	43	8,823	4,554
Stripetail rockfish	3,484	22,223	37,492	54,854	28,283	521	1,453	10,762	6,119	666	1,988	1,128
Shortbelly rockfish	6,771	0	6,398	609	1,219	7,654	4,892	62,284	6,882	736	567	1,297
Greenblotched rockfish	0	0	4,068	8,019	3,384	0	8,515	0	299	0	230	202
Rosy rockfish	0	1,064	0	0	0	5,391	0	278	0	0	218	760
Quillback rockfish	0	0	0	0	0	0	0	0	0	0	0	0
Sharpchin rockfish	0	0	0	0	0	1,375	3,044	10,742	1,834	80	0	0
Flag rockfish	30	1,029	331	0	20,234	4	0	424	5,042	7,587	1,913	935
Kelp rockfish	0	0	68	25	0	2	0	205	0	12,151	40	0
Tiger rockfish	0	0	0	14,311	0	0	0	0	0	0	0	0
Rosethorn rockfish	0	0	0	0	0	8	0	1,897	317	0	2,334	5,807
Bronzespotted rockfish	0	0	0	0	0	436	833	0	0	1,642	627	0
Total	8,891,391	6,463,608	14,656,915	12,903,050	21,326,728	13,281,572	13,686,284	14,626,822	14,826,934	12,339,221	11,257,770	15,718,309

Appendix C. *(continued)* Estimated commercial landings (lb) of rockfishes and thornyheads at the five major ports, plus San Francisco, associated with the MBNMS from 1978–2000. Determined from an expansion of species composition sampling conducted by CDFG. Species are listed in order of decreasing average annual landings.

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Total**	**Mean**
Chilipepper	3,573,137	3,924,882	3,739,511	2,844,178	2,476,053	2,684,696	2,572,620	2,506,189	2,787,198	910,154	349,979	63,461,983	2,759,217
Bocaccio	2,976,039	1,908,281	2,090,076	1,603,232	1,379,472	1,026,518	699,326	393,619	198,927	71,168	26,448	60,132,920	2,614,475
Widow rockfish	1,689,812	981,617	681,574	468,059	321,554	1,059,249	891,474	717,909	435,612	337,044	263,857	26,919,446	1,170,411
Bank rockfish	1,056,712	925,194	844,089	387,880	320,217	591,315	872,051	459,360	765,069	32,593	95,090	20,832,153	905,746
Shortspine thornyhead	1,783,461	533,701	1,356,411	1,072,269	1,306,560	960,526	712,161	547,241	504,966	357,464	200,635	20,298,996	882,565
Longspine thornyhead	2,035,603	1,006,858	1,923,078	1,503,804	611,175	1,715,163	1,695,917	1,409,444	808,274	693,032	443,122	15,491,102	673,526
Splitnose rockfish	566,371	806,950	492,563	523,977	465,909	513,549	804,945	832,993	2,351,717	331,295	81,393	13,899,143	604,311
Yellowtail rockfish	1,103,840	406,322	619,301	270,170	313,578	256,502	98,102	225,733	118,564	46,922	50,502	11,368,478	494,282
Blackgill rockfish	513,746	211,233	616,315	260,252	310,926	294,556	346,238	294,058	226,366	73,079	38,086	6,696,161	291,137
Vermilion rockfish	251,046	260,260	228,544	386,651	215,858	156,685	151,807	150,479	132,997	66,893	11,465	2,935,461	127,629
Unspecified thornyhead	15,279	27,283	47,674	8,583	20,583	32,436	87,901	82,882	27,305	22,816	23,983	2,554,631	111,071
Brown rockfish	14,722	89,951	76,821	106,963	41,423	19,996	28,682	84,857	83,874	114,020	37,529	2,443,215	106,227
Yelloweye rockfish	58,147	102,684	64,372	70,155	67,920	26,881	46,862	55,478	7,801	15,102	734	2,274,275	98,882
Canary rockfish	144,882	255,129	110,232	147,752	120,219	111,279	298,247	117,476	57,158	18,939	2,442	2,196,866	95,516
Darkblotched rockfish	207,150	30,788	41,045	18,453	8,336	66,660	95,121	288,880	37,058	12,430	16,828	1,965,198	85,443
Aurora rockfish	284,998	3,342	192,489	199,856	143,551	117,837	95,721	45,579	38,688	16,081	23,803	1,667,669	72,507
Greenspotted rockfish	67,060	180,545	149,841	181,136	148,744	165,212	186,408	58,801	20,432	13,135	2,811	1,626,621	70,723
Blue rockfish	46,090	63,427	112,447	140,107	67,713	39,853	13,711	45,407	43,995	36,393	7,162	1,564,560	68,024
Gopher rockfish	91	5	123,444	100,040	76,648	46,596	43,476	18,817	55,201	69,842	37,763	1,159,717	50,422
Cowcod	49,293	30,616	75,267	69,390	46,284	87,733	46,555	69,538	20,959	11,352	496	790,870	34,386
Speckled rockfish	18,282	22,659	31,146	15,193	30,420	28,077	12,231	26,547	6,378	482	43	619,390	26,930
Black rockfish	2,526	10,542	23,393	42,649	26,779	10,318	56,122	33,475	40,577	13,049	2,316	683,685	29,725
Copper rockfish	1,984	48,163	67,438	92,431	26,308	57,269	40,808	25,882	20,096	27,278	5,406	513,022	22,305
Olive rockfish	16,065	166,482	15,660	16,734	45,947	7,914	42,953	2,841	10,526	5,809	1,050	472,007	20,522
China rockfish	2,166	11,038	35,009	9,798	37,228	33,410	12,226	37,567	8,898	1,757	15,563	442,675	19,247
Grass rockfish	0	3,655	12,183	21,266	48,873	75,492	69,371	46,610	68,678	38,389	24,391	412,603	17,939
Starry rockfish	30,067	46,267	74,575	46,288	69,324	22,127	34,261	24,571	7,514	1,100	11	403,134	17,528
Greenstriped rockfish	27,218	18,284	14,963	13,065	22,986	21,146	24,722	41,331	5,701	2,326	538	352,843	15,341
Black-and-Yellow rockfish	0	0	3,396	6,849	14,195	9,189	9,165	5,473	70,188	49,794	29,913	265,361	11,537
Redbanded rockfish	11,641	8,899	10,186	10,842	1,017	18,573	15,006	3,124	10,192	16,492	1,687	253,045	11,002
Stripetail rockfish	437	4,362	258	10,475	6,397	17,375	5,651	11,011	19,388	1,471	0	245,798	10,687
Shortbelly rockfish	4,984	3,476	1,039	1,528	1,969	18,394	66,072	2,627	6,863	0	0	206,261	8,968
Greenblotched rockfish	2,280	770	542	16,270	21,017	23,308	26,799	3,931	51,185	49	9	170,877	7,429
Rosy rockfish	16,434	16,239	13,188	20,850	45,992	6,079	21,578	10,859	7,010	502	100	166,542	7,241
Quillback rockfish	0	3,620	4,296	184	27,772	8,397	12,927	19,034	16,568	6,383	3,743	102,924	4,475
Sharpchin rockfish	3,335	3,463	10,888	1,879	7,174	4,276	8,194	31,649	337	0	0	88,270	3,838
Flag rockfish	600	1,623	7,777	18,037	13,290	1,935	3,584	2,350	116	85	34	86,960	3,781
Kelp rockfish	0	40	2,169	23,961	12,988	10,213	5,132	3,198	9,589	4,519	1,685	85,985	3,738
Tiger rockfish	25,001	0	823	0	191	0	0	176	679	0	0	41,181	1,790
Rosethorn rockfish	8,176	893	3,334	0	5,363	1,819	1,680	2,607	1,090	872	72	36,269	1,577
Bronzespotted rockfish	0	8	13	113	54	0	31,987	378	493	0	37	36,621	1,592
Total	16,608,675	12,119,551	13,917,370	10,731,319	8,928,007	10,348,553	10,287,794	8,739,981	9,084,227	3,420,111	1,800,726	265,964,918	11,563,692

Appendix D. Estimated catch of species in 1,000 fish in Northern and Central California sport fisheries from 1980–2000.

Species	Total	Mean
Surf smelt	37,939	2,232
Blue rockfish	11,166	620
Yellowtail rockfish	5,789	322
Black rockfish	5,365	298
White croaker	4,981	277
Pacific sanddab	4,532	252
Jack smelt	3,854	214
Night smelt	3,622	201
Canary rockfish	2,714	151
Barred surfperch	2,626	146
Lingcod	2,577	143
Brown rockfish	2,418	134
Chilipepper	2,347	130
Pacific mackerel	1,949	108
Striped surfperch	1,541	86
Gopher rockfish	1,520	84
Walleye surfperch	1,478	82
Copper rockfish	1,469	82
Olive rockfish	1,445	80
Bocaccio	1,438	80
Redtail surfperch	1,405	78
Kelp greenling	1,317	73
Pacific herring	1,278	71
Chinook salmon	1,147	64
Shiner surfperch	1,098	61
Rosy rockfish	985	55
Striped bass	945	53
Vermilion rockfish	934	52
Cabezon	883	49
Northern anchovy	829	46
Widow rockfish	824	46
Silver surfperch	813	45
Greenspotted rockfish	791	44
Rockfish genus	757	42
White surfperch	707	39
Pacific sardine	646	36
Pile surfperch	679	38
California halibut	624	35
China rockfish	540	30
Starry rockfish	514	29
Black surfperch	456	25
Starry flounder	441	25
Rubberlip surfperch	391	22
Rock greenling	368	20
Kelp rockfish	366	20
Jack mackerel	356	20
Greenstriped rockfish	355	20
Black and Yellow rockfish	354	20
Yelloweye rockfish	343	19
Leopard shark	305	17

Species	Total	Mean
Albacore	303	17
White sturgeon	281	16
Grass rockfish	277	15
Pacific hake	274	15
Sablefish	266	15
Calico surfperch	235	13
Surfperch family	208	12
Rainbow surfperch	207	11
Pacific staghorn sculpin	207	11
Speckled rockfish	173	10
Brown smoothound	168	9
Rosethorn rockfish	154	9
Quillback rockfish	148	8
Swordspine rockfish	128	7
Speckled sanddab	123	7
Rainbow trout	116	7
Topsmelt	109	6
Sand sole	112	6
Monkeyface prickleback	102	6
Scorpionfish family	99	6
Rougheye rockfish	86	5
Coho salmon	64	4
Sea run trout	76	4
Spiny dogfish	74	4
Flag rockfish	72	4
Cowcod	64	4
Pacific tomcod	63	4
Pacific bonito	60	3
Bat ray	55	3
Buffalo sculpin	54	3
Longfin sanddab	52	3
Sanddab genus	52	3
Rock sole	47	3
Yellowfin goby	46	3
Greenblotched rockfish	41	2
Pacific sandlance	39	2
Shortspine thornyhead	37	2
Kelp bass	33	2
Petrale sole	33	2
Squarespotted rockfish	33	2
Sculpin family	29	2
Salmon genus	28	2
Sea bass family	27	2
Goby family	22	1
Sharpnose surfperch	23	1
Sturgeon	23	1
Total	127,142	

Note: Species with estimate annual catch less than 1,000 fish/yr are not included. Data were provided by PSMFC.

Appendix E. Recreational species landed in the MBNMS grouped by habitat.

HABITAT GROUP	GUILD	COMMON NAME	SCIENTIFIC NAME
Nearshore Rocky Reef/ Kelp			
	Vertebrates		
	Hexagrammids	Kelp greenling	*Hexagrammos decagrammus*
		Lingcod	*Ophiodon elongatus*
		Rock greenling	*Hexagrammos lagocephalus*
	Pricklebacks	Monkeyface prickleback	*Cebidichthys violaceus*
	Scorpaenids	Black rockfish	*Sebastes melanops*
		Black-and-yellow rockfish	*Sebastes chrysomelas*
		Blue rockfish	*Sebastes mystinus*
		Brown rockfish	*Sebastes auriculatus*
		China rockfish	*Sebastes nebulosus*
		Copper (whitebelly) rockfish	*Sebastes caurinus (vexillaris)*
		Gopher rockfish	*Sebastes carnatus*
		Grass rockfish	*Sebastes rastrelliger*
		Kelp rockfish	*Sebastes atrovirens*
		Olive rockfish	*Sebastes serranoides*
		Quillback rockfish	*Sebastes maliger*
		Rosy rockfish	*Sebastes rosaceus*
		Squarespot rockfish	*Sebastes hopkinsi*
		Vermilion rockfish	*Sebastes miniatus*
	Cottids	Buffalo sculpin	*Enophrys bison*
		Cabezon	*Scorpaenichthys marmoratus*
	Surfperches	Black surfperch	*Ebiotoca jacksoni*
		Pile surfperch	*Racochilus vacca*
		Rainbow surfperch	*Hypsurus caryi*
		Rubberlip surfperch	*Rhacochilus toxotes*
		Striped surfperch	*Embiotoca lateralis*
	Other species	Kelp bass	*Paralabrax clathratus*
Nearshore Soft Bottom			
	Vertebrates		
	Sciaenids	White croaker	*Genyonemus lineatus*
	Sculpins	Pacific staghorn sculpin	*Leptocottus armatus*
	Elasmobranchs	Bat ray	*Myliobatis californica*
		Brown smoothhound	*Mustelus henlei*
		Leopard shark	*Triakis semifasciata*
	Surfperch	Barred surfperch	*Amphistichus argenteus*
		Calico surfperch	*Amphistichus koelzi*
		Redtail surfperch	*Amphistichus rhodoterus*
		Sharpnose surfperch	*Phanerodon atripes*
		Shiner surfperch	*Cymatogaster aggregata*
		Silver surfperch	*Hyperprosopon ellipticum*
		Walleye surfperch	*Hyperprosopon argenteum*
		White surfperch	*Phanerodon furcatus*
	Flatfish	California halibut	*Paralichthys californicus*
		Longfin sanddab	*Citharichthys xanthostigma*
		Pacific sanddab	*Citharichthys sordidus*
		Sand sole	*Psettichthys melanostictus*
		Speckled sanddab	*Citharichthys stigmaeus*
		Starry flounder	*Platichthys stellatus*
	Other species	Pacific sand lance	*Ammodytes hexapterus*
		Yellowfin goby	*Acanthogobius flavimanus*

Appendix E. *(continued)* Recreational species landed in the MBNMS grouped by habitat.

HABITAT GROUP	GUILD	COMMON NAME	SCIENTIFIC NAME
Rocky Deep Shelf and Slope			
	Vertebrates		
	Scorpaenids		
	Semi-pelagic	Bocaccio	*Sebates paucispinis*
		Canary rockfish	*Sebastes pinniger*
		Chilipepper rockfish	*Sebastes goodei*
		Widow rockfish	*Sebastes entomelas*
		Yellowtail rockfish	*Sebastes flavidus*
	Demersal	Cowcod	*Sebastes levis*
		Flag rockfish	*Sebastes rubrivinctus*
		Greenblotched rockfish	*Sebastes rosenblatti*
		Greenspotted rockfish	*Sebastes chlorostictus*
		Rosethorn rockfish	*Sebastes helvomaculatus*
		Rougheye rockfish	*Sebastes aleutianus*
		Speckled rockfish	*Sebastes ovalis*
		Starry rockfish	*Sebastes constellatus*
		Swordspine rockfish	*Sebastes ensifer*
		Yelloweye rockfish	*Sebastes ruberrimus*
Soft Bottom Shelf and Slope			
	Vertebrates		
		Sablefish	*Anoplopoma fimbria*
	Scorpaenids	Greenstriped rockfish	*Sebastes elongatus*
		Shortspine thornyhead	*Sebastolobus alascanus*
	Flatfish	Petrale sole	*Eopsetta jordani*
		Rock sole	*Lepidopsetta bilineata*
Open Water			
Small Coastal Pelagics			
	Vertebrates	Pacific mackerel	*Scomber japonicus*
		Jack mackerel	*Trachurus symmetricus*
		Northern anchovy	*Engraulis mordax*
		Pacific sardine	*Sardinops sagax*
Coastal Migrants	Vertebrates		
	Anadromous	Chinook salmon	*Oncorhynchus tshawytscha*
		Coho salmon	*Oncorhynchus kisutch*
		White sturgeon	*Acipenser transmontanus*
		Rainbow trout	*Salmo clarkii*
	Elasmobranchs	Spiny dogfish	*Squalus acanthias*
	Other species	Jacksmelt	*Atherinops californiensis*
		Night smelt	*Spirinchus starksi*
		Pacific bonito	*Sarda chiliensis*
		Pacific hake	*Meluccius productus*
		Pacific herring	*Clupea pallasii*
		Pacific tomcod	*Microgadus proximus*
		Striped bass	*Morone saxatilis*
		Surf smelt	*Hypomesus pretiosus*
		Topsmelt	*Atherinops affinis*
Pelagic Migrants	Vertebrates		
	Scombrids	Albacore	*Thunnus alalunga*

Appendix F. Major commercial regulations affecting species caught within the MBNMS.

G. Gear Regulations

< 1981:	Trawls banned within state waters, except in Southern California halibut trawl grounds (1953).
1981:	Regulations enacted by CDFG restricting fishing season, mesh size, and maximum count of shrimp per pound.
1982:	10 fathom closure to set nets in the Monterey Bay.
1984:	Limit enacted on the number of hooks on a troll line.
1986:	Drift gillnet eliminated within 12 nautical miles off the coast north of Point Arguello and near Gulf of Farallones.
1989:	Fishermen permitted to use all types of roundhaul gear throughout Monterey Bay (CDFG).
1989:	Prohibition of drift gill net fishery within 75 nautical miles from May to July. Effectively eliminates thresher shark fishery in California.
1990:	Ban on use gill and trammel nets within 30 fathoms (55 m) from Waddell Creek to Point Sal in Santa Barbara County
1992:	Ban on use of gill and trammel nets to take rockfishes.
1995:	Commercial set lines, vertical fishing lines, or troll lines are restricted by time closures.
1996:	Restricted on number of hooks for hook and line.
1998:	Prohibition of fin fish traps in waters within 750 ft. of any pier, breakwall, or jetty, along with 50 trap limit from California-Oregon border to Pt. Arguello.

P. Permit Regulations

1980:	Required permit for gill and trammel nets.
1980:	Moratorium in place on new permits into the ocean salmon commercial fishery.
1983:	Limited entry program in ocean salmon commercial fishery enacted.
1985:	Regulation enacted prohibiting issuance of new gill and trammel net permits.
1987:	Moratorium placed on issuance of permits in the red sea urchin fishery (CDFG).
1994:	Commercial groundfish divided into open access and limited entry. Open access limit of 10,000 lb per trip, not to exceed 40,000 lb per month. Limited entry limit of 80,000 lb per month, but increased to 100,000 lb in September.
1994:	Moratorium on new permits in the Pacific ocean shrimp fishery (CDFG).
1996:	Prohibited open access landing of thornyheads north of Pt. Comception.
1996:	Permit required to take finfish in traps.
1997:	Three year moratorium on previously unregulated commercial squid fishery, which restricted the number of vessels in the fishery, established a $2,500 permit fee to fund research, and provided the Fish and Game Commission with regulatory authority over the fishery for the duration of the moratorium.
1999:	Nearshore fishery permit required for 10 nearshore species.

Q. Quota Regulations

<1981:	Various biomass based annual catch quotas (Pacific mackerel, Pacific sardine, and many groundfish)
1982:	First commercial limits imposed on sablefish.
1983:	Coastwide 40,000 lb. trip limit established for the *Sebastes* complex. Nearshore rockfish managed as part of *Sebastes* complex.
1984:	Temporary closure of spot prawn trawl fishery (CDFG).
1986:	CDFG allowed first targeting of sardine fishery since 1974 closure.
1986:	Sablefish allocation first divided between trawl and non-trawl gear.
1989–1990:	Deep-water complex defined as Dover sole, sablefish, arrowtooth flounder, and thornyheads; landing limits imposed and regulated throughout the year.
1991:	Trip limit set at 25,000 lb. for *Sebastes* complex south of Coos Bay.
1991:	No more than 5,000 lb. bocaccio per trip.
1991:	Thornyheads separated from deep-water complex; coastwide weekly limit of thornyheads establishes at 7,500 pounds. Increased to 12,500 lb in July.
1992:	Limit of 50,000 lb. every two weeks for *Sebastes* complex.
1992:	No more than 10,000 lb of bocaccio every two weeks allowed south of Cape Mendocino.

Appendix F. *(continued)* Major commercial regulations affecting species caught within the MBNMS.

Q. Quota Regulations *(continued)*

1992–2000: Thornyhead limits reduced each consecutive year from 25,000 lb every two weeks (1992) to 1,000 to 1,500 lb every 4 weeks (2000, depending on gear type); intra-annual decreasing of limits also occurred each year.

1994: Commercial groundfish divided into open access and limited entry. Open access limit of 10,000 lb per trip, not to exceed 40,000 lb per month. Limited entry limit of 80,000 lb per month, but increased to 100,000 lb in September.

1994: No more than 30,000 lb per month of yellowtail rockfish south of Cape Lookout can be taken in the limited entry fishery.

1994: Retention of Coho salmon prohibited since 1994.

1994: Restriction on season, no commercial harvest of female Dungeness crabs, and minimum size restriction on male crabs.

1994: Establishment of the Big Creek Marine Ecological Reserve. No recreational fishing is allowed within the Reserve.

1995: No limit within the 100,000 lb monthly limit on the amount of yellowtail caught in the limited entry fishery.

1995: No more than 6,000 lb of canary rockfish allowed monthly in the limited entry fishery.

1995: Separate limits for shortspine and longspine thornyheads.

1995: Open access hook-and-line and pot fishery limited to 10,000 lb of rockfish per month.

1997: Two-month cumulative limit in the limited entry fishery dropped to 150,000 lb for the *Sebastes complex.*

1997: Two-month cumulative limit in the limited entry fishery for bocaccio dropped to 12,000 lb. Limit decreased to 5,000 lb per month in October. Open access fishery restricted to 300 lb bocaccio, not to exceed 2,000 lb per month.

1997: All fishing for abalone closed south of San Francisco until populations have sufficiently recovered to support fisheries. (CDFG).

1998: Bocaccio landings for limited entry fishery decreased to 2,000 per two-month period. Open access fishery restricted to 250 lb bocaccio, not to exceed 1,000 lb per month.

1998: Open access *Sebastes* two-month limit set at 40,000 lb. This was decreased to 33,000 lb in July, then to 15,000 per month in October.

1998: Open access widow rockfish limit set at 3,000 per month.

1999: Three-phase cumulative limit imposed on the limited entry fishery for *Sebastes* complex as follows:

Phase 1: 13,000 lb for Janaury 1 through March 31

Phase 2: 6,500 lb for 3 two-month periods of April to May, June to July, and August to September. This limit for June to July and August to September periods was decreased to 3,500 lb in May.

Phase 3: 500 lb per month for October, November, and December.

Open access limit set for *Sebastes* limit at 2,000 lb per month.

1999: Coastwide canary rockfish limits set for each phase as 9,000 lb, 9,000 lb, and 3,000 lb. Phase 2 was decreased to 6,500 in April. This phase was again decreased in May to 3,500 lb.

1999: Bocaccio limit in open access fishery set as 500 lb per month. For setnet and trammel net gear, 1000 lb per month allowed allowed.

1999: Managed under the Coastal Pelagic Species Fishery Management Plan (Pacific sardine, Pacific mackerel, market squid, jack mackerel, and northern anchovy).

2000: Two month closure (March to April) of fishing for all rockfish and lingcod north of Point Conception. From May to June, nearshore fish fishing allowed only in waters <20 fathoms.

S. Size Limit Regulations

1983: Minimum size limit implemented for sablefish.

1988: Minimum size limit established or red sea urchin and reduction in the number of permits issued (CDFG).

1994: Restriction on season, no commercial harvest of female Dungeness crabs, and minimum size restriction on male crabs.

1999: Minimum size limit established for several nearshore fishes by Nearshore Fisheries Management Act.

2000: Size limits for cabezon and sheephead are increased.

Appendix G. Major regulations affecting species caught in recreational fisheries within the MBNMS.

f. Fishing Regulations

1994: Establishment of the Big Creek Marine Ecological Reserve. No recreational fishing is allowed within the Reserve.

2000: Two month closure (March to April) of fishing for all rockfish and lingcod north of Point Conception. From May to June, nearshore fish fishing allowed only in waters <20 fathoms.

2000: Recreational fishery closure from March to June for all non-nearshore rockfish and lingcod.

g. Gear Regulations

1998: "Mouse trap" gear banned as a recreational gear-type.

2000: Restriction placed on number of hooks per line (3 in 2000, decreased to 2 in 2001) while fishing for rockfish.

s/b. Size and Bag Limits

1981: 22 inch size limit established for lingcod.

1982: 12 inch size limit established for cabezon.

1982: Bag limit for lingcod changed from 10 to 5 fish. Size limit of 22 inches.

1982: Limit of ten bonito per trip. Size limit of 24 inches fork length or 5 pounds. Five fish less than 24 inches fork length or weighing less than five pounds may be taken and possessed as part of the 10 fish limit.

1999: Minimum size limit of 14 in. (356 mm) total length established for cabezon; Bag limit of 10 California scorpionfish, with a minimum size of 10 inches (254 mm) total length; Bag limit of 10 each of kelp and rock greenlings, with a minimum size of 12 inches (305 mm) total length; Bag limit of 5 California sheephead, with a minimum size of 12 inches (305 mm) total length.

2000: Daily bag limit of rockfish reduced from 15 to 10 fish.

2000: Bag limit of 10 cabezon, with a minimum size of 14 inches.

Appendix H. Summary of life history parameters for selected species in the MBNMS.

Red abalone

Habitat	intertidal to subtidal rocky reefs
Depth range	intertidal to 165 m
Max. length	NA
Max. age	NA
length @ maturity	Both 7 to 10 cm
age @ maturity	Both 4 to 5 years
Fecundity	a few thousand to 6 million eggs
spawning season	year-round

Albacore

Habitat	pelagic
Depth range	surface to 380 m
Max. length	152 cm
Max. age	13 years
length @ maturity	Both 85 to 101 cm
age @ maturity	Both 3 to 5 years old
Fecundity	up to 2.6 million eggs
spawning season	January to June

Northern anchovy

Habitat	pelagic
Depth range	surface to 310 m
Max. length	24.8 cm
Max. age	7 years
length @ maturity	Both around 5 cm
age @ maturity	Both 2 years
Fecundity	130,000 eggs per season/multiple spawner (every 10 days during spawning season)
spawning season	February to April

Cabezon

Habitat	rocky reefs and kelp beds
Depth range	intertidal to 110 m
Max. length	99 cm
Max. age	17 years
length @ maturity	Both >34 cm
age @ maturity	Both > 2 years
Fecundity	35 per batch/at least two batches per season/multiple spawner
spawning season	October to March

Cowcod

Habitat	hard or rocky bottoms
Depth range	72 to 491 m
Max. length	94 cm
Max. age	55 years
length @ maturity	Both 43 to 44 cm
age @ maturity	NA
Fecundity	181,000 eggs per brood/multiple brooder (3 per season)
spawning season	November to May

Dungeness crab

Habitat	sand and sand/mud bottoms
Depth range	intertidal to 230 m
Max. width	23 cm
Max. age	6 years
width @ maturity	M 140 mm; F 100 mm
age @ maturity	M 3; F 2 years
Fecundity	500,000 to 2 million eggs
spawning season	March to July

Rock crab

Habitat	rocky reefs; sand and mud bottoms; estuaries
Depth range	intertidal to 91 m
Max. width	155 to 190 mm
Max. age	6 yrs.
length @ maturity	3 inches carapace length
age @ maturity	NA
Fecundity	400,000 to 4 million eggs
spawning season	year-round

White croaker

Habitat	neritic; sandy nearshore bottom and midwaters; kelp beds
Depth range	inshore to 236 m
Max. length	41 cm
Max. age	15 years
length @ maturity	M 14; F 15 cm
age @ maturity	Both 1 year
Fecundity	37,200 eggs per batch/multiple spawner
spawning season	July to March

Starry flounder

Habitat	gravel, sand, and mud
Depth range	nearshore to 375 m
Max. length	91 cm
Max. age	24 years
length @ maturity	M 36.8 cm; F 40.6 cm
age @ maturity	M 2 to 3 years; F 3 to 4 years
Fecundity	11 million eggs
spawning season	November to February

Kelp greenling

Habitat	rocky reef and kelp forests
Depth range	intertidal to 158 m
Max length	53 cm
Max. age	18 years
length @ maturity	Both 30 cm
age @ maturity	Both 3 to 4 years
Fecundity	4,000 eggs per egg mass/multiple spawner (at least 3 per season)
spawning season	September to December

Appendix H. *(continued)* Summary of life history parameters for selected species in the MBNMS.

Grenadier	
Habitat	sandy bottom on the continental slope
Depth range	235 to 2,825 m
Max. length	95 cm
Max. age	> 56 years
length @ maturity	M 51 cm; F 66 cm
age @ maturity	Both >10 years
Fecundity	150,000 eggs/possible multiple spawner
spawning season	late winter to early spring

Pacific hake	
Habitat	continental shelf and slope
Depth range	12 to 1327 m
Max. length	91 cm
Max. age	23 years
length @ maturity	M 28; F 37 to 41 cm
age @ maturity	M 3; F 3 to 4 years
Fecundity	496,000 cm
spawning season	October to June

California halibut	
Habitat	benthic, sandy substrate often aggregate near structures
Depth range	nearshore to 183 m
Max. length	152.4 cm
Max. age	30 years
length @ maturity	Both 47 cm
age @ maturity	Both 3 to 4 years
Fecundity	5.5 million eggs per spawning season/ multiple spawner
spawning season	November to April

Lingcod	
Habitat	rocky reef and kelp forest/sandy offshore bottoms
Depth range	3 to 491 m
Max length	152 cm TL
Max. age	25 years
length at 50% maturity	M 50 to 60 cm; F 65 to 75 cm TL
age at 50% maturity	M 3 to 4 yr.; F 4 to 5
fecundity	up to 500,000 eggs
spawning season	November to March

Jack mackerel	
Habitat	pelagic
Depth range	surface to 402 m
Max. length	81 cm
Max. age	35 years
length @ maturity	Both 20 cm
age @ maturity	Both 1 year
Fecundity	multiple spawner
spawning season	July to September

Pacific mackerel	
Habitat	pelagic
Depth range	surface to 300 m
Max. length	64 cm
Max. age	11 years
length @ maturity	Both around 30 cm
age @ maturity	M 1; F 2 years
Fecundity	68,000 eggs/spawning; multiple spawner (up to 8 a season)
spawning season	April to July

Spot prawn	
Habitat	offshore banks; sandy bottoms
Depth range	45 to 400 m
Max. length	NA
Max. age	6 years
length @ maturity	M 1.5 inches carapace length; F 1.75 inches
age @ maturity	F 3 years; Individuals are protandrous
Fecundity	1,400 to 5,000 eggs
spawning season	September

Bank rockfish	
Habitat	deep rocky walls and canyons
Depth range	31–454 m
Max length	55.2 cm
Max. age	53 years
length @ maturity	M 31 cm; F 36 cm
age @ maturity	NA
fecundity	up to 600,700 eggs
spawning season	December to May

Black rockfish	
Habitat	high-relief rocky reefs; in and around kelp beds; boulder fields; midwater; pelagic
Depth range	<1 to 366 m
Max. length	91 cm
Max. age	M 48; F 35
length @ maturity	46 cm
age @ maturity	9 to 13 years
Max. fecundity	1.2 million eggs
spawning season	January to May

Black-and-yellow rockfish	
Habitat	shallow rocky reefs and kelp beds
Depth range	<1 to 37
Max. length	39 cm
Max. age	24 years
length @ maturity	Both 16 cm
age @ maturity	Both 3 to 4 years
Max. fecundity	110,000 eggs
spawning season	January to May

Appendix H. *(continued)* Summary of life history parameters for selected species in the MBNMS.

Blackgill rockfish

Habitat	deep rocky and hard bottoms
Depth range	87 to 768 m
Max length	64 cm
Max. age	~90 years
length @ maturity	Both - 34
age @ maturity	7 to 8 or 19 to 20
fecundity	770,000 eggs
spawning season	January to June

Blue rockfish

Habitat	within and around the kelp canopy; high relief rocky and artificial reefs
Depth range	<1 to 549 m
Max length	53 cm
Max. age	40 to 44 years
length @ maturity	M- 27/F- 29
age @ maturity	M- 5/F- 6
Max. fecundity	524,000 eggs
spawning season	October to March

Bocaccio

Habitat	primarily over rocky and hard bottoms, but occasionally found on soft bottoms
Depth range	20 to 475 m
Max. length	91 cm
Max. age	46 years
length @ maturity	36 cm
age @ maturity	M- 4 to 5/F- 4 to 6
Max. fecundity	2.3 million larvae
spawning season	year-round (multiple broods)

Brown rockfish

Habitat	shallow rock/ rocky shelf; often within crevices; estuarine; high relief rock
Depth range	<1 to 135
Max. length	56 cm
Max. age	20 years
length @ maturity	Both- 31 cm
age @ maturity	Both - 5 years
Max. fecundity	340,000 eggs
spawning season	December to July (may be multiple spawner)

Canary rockfish

Habitat	aggegrate around reefs and pinnicles; rocky shelf; larger fish found at deeper depths
Depth range	<1 to 275 m
Max. length	76 cm
Max. age	84 years
length @ maturity	Both - 41 to 43 cm
age @ maturity	Both - 7 to 9 years
Fecundity	1.9 million
spawning season	November to March

Chilipepper rockfish

Habitat	over rocky reefs and along canyon walls
Depth range	<1 to 491 m
Max. length	59 cm
Max. age	27 years
length @ maturity	Both- 30.5 to 33 cm
age @ maturity	Both- 3 to 4 years
Fecundity	538,000 eggs/possible multiple brooder
spawning season	September to April

China rockfish

Habitat	rock and cobble; rocky shelf
Depth range	3 to 128 m
Max. length	43 cm
Max. age	78 years
length @ maturity	Both- 27 to 28 cm
age @ maturity	Both - 4 years
Fecundity	NA
spawning season	January to June

Copper rockfish

Habitat	shallow rock/ high-relief rocky shelf; rock-sand interface; eelgrass beds
Depth range	<1 to 183
Max. length	58 cm
Max. age	55 years
length @ maturity	M- 33 cm/F- 34 cm
age @ maturity	M- 4/F- 6 years
Max. fecundity	654,000 eggs
spawning season	January to April

Darkblotched rockfish

Habitat	on rocky and hard bottoms; mud-rock interface
Depth range	25 to 904 m
Max. length	58 cm
Max. age	66 years
length @ maturity	M- 29.6/F- 36.5 cm
age @ maturity	M- 5/ F- 8 years
Fecundity	500,000 eggs
spawning season	December to March

Gopher rockfish

Habitat	shallow rocky reef bottoms/ rocky shelf; kelp forest bottom
Depth range	<1 to 80
Max. length	34.8 cm
Max. age	30 years
length @ maturity	Both- 17 cm
age @ maturity	Both 4 cm
Max. fecundity	249 eggs/female gram
spawning season	February to July

Appendix H. *(continued)* Summary of life history parameters for selected species in the MBNMS.

Grass rockfish

Habitat	low relief rock, often in crevices; kelp forests
Depth range	<1 to 46
Max. length	56 cm
Max. age	23 years
length @ maturity	Both 24 to 25 cm
age @ maturity	Both 3 to 4 years
Max. fecundity	760,000 eggs
spawning season	November to March

Greenspotted rockfish

Habitat	rocky shelf; hard or mixed bottom; high releif; cobble-mub
Depth range	30 to 273 m
Max. length	50 cm
Max. age	33 years
length @ maturity	Both 28 cm
age @ maturity	Both 6 to 9 years
Fecundity	759,000 eggs
spawning season	April to June

Greenstriped rockfish

Habitat	rocky shelf; mud-rock or sand-mud interface; fine-sediments; high and low relief
Depth range	25 to 495 m
Max. length	43 cm
Max. age	54 years
length @ maturity	Both 23 cm
age @ maturity	Both 7 years
Fecundity	344,000 eggs
spawning season	May to August (possible multiple spawner)

Kelp rockfish

Habitat	shallow rocky reef and kelp canopy; midwater nearshore
Depth range	<1 to 46
Max. length	42.5 cm
Max. age	20 years
length @ maturity	Both 26 cm
age @ maturity	Both 4 to 5 years
Fecundity	172,000 eggs
spawning season	February to July

Olive rockfish

Habitat	rocky shelf; kelp canopy in mid-water column
Depth range	<1 to 172 m
Max. length	61 cm
Max. age	25 years
length @ maturity	Both 33 to 36 cm
age @ maturity	Both 4 to 5 years
Fecundity	490,000 eggs
spawning season	December to March

Quillback rockfish

Habitat	deeper rock/rocky shelf; high relief rock and artificial reefs; boulder fields
Depth range	<1 to 274 m
Max. length	61 cm
Max. age	90 years
length @ maturity	Both 31 to 32 cm
age @ maturity	Both 13 to 14 years
Fecundity	NA
spawning season	April to July

Shortbelly rockfish

Habitat	midwater over soft bottoms
Depth range	91 to 491 m
Max. length	35 cm
Max. age	31 years
length @ maturity	Both 16.5 cm
age @ maturity	Both 3 years
Fecundity	139 eggs/gram body weight
spawning season	January to April

Splitnose rockfish

Habitat	on sand and mud bottoms
Depth range	90 to 795 m
Max. length	46 cm
Max. age	84 years
length @ maturity	Both 21 cm
age @ maturity	Both 5 years
Fecundity	255,000 eggs
spawning season	May to June

Vermilion rockfish

Habitat	rocky shelf and boulder fields; in crevices; continental slope/basin; sandy/soft bottoms; kelp forest bottom
Depth range	<1 to 436 m
Max. length	63 cm
Max. age	60 years
length @ maturity	Both 35.6 cm
age @ maturity	Both 5 to 6 years
Fecundity	2.7 million eggs
spawning season	December to September/possible multiple spawner

Widow rockfish

Habitat	over rocky reefs or other hard bottoms
Depth range	near surface to 549 m
Max. length	59 cm
Max. age	60 years
length @ maturity	Both 25 to 35 cm
age @ maturity	Both 4 to 5 years
Fecundity	915,000 eggs
spawning season	December to February

Appendix H. *(continued)* Summary of life history parameters for selected species in the MBNMS.

Yellowtail rockfish

Habitat	rocky and hard bottoms; sand and mud
Depth range	intertidal to 549 m
Max. length	66 cm
Max. age	64 years
length @ maturity	M 34 to 41; F 37 to 45 cm
age @ maturity	M 5 to 9; F 6 to 10 years
Fecundity	1.15 million
spawning season	February to March

Sablefish

Habitat	benthopelagic on soft bottoms
Depth range	<1 to 740 m
Max. length	114 cm
Max. age	94 years
length @ maturity	M 51; F 61 cm
age @ maturity	M 4 to 6; F 5 to 6
Fecundity	1.3 million eggs
spawning season	October to February

Chinook salmon

Habitat	coastal pelagic
Depth range	surface to 375 m
Max. length	147 cm
Max. age	5 years
length @ maturity	NA
age @ maturity	M 2 to 5 years; F 4 to 5 years
Fecundity	up to 20,000 eggs
spawning season	Fall run: September to December; Late fall run: October to April; Spring run: March to October

Pacific sanddab

Habitat	sand and mud bottoms
Depth range	0 to 549 m
Max. length	41 cm
Max. age	10 years
length @ maturity	Both 19 cm
age @ maturity	Both 2 to 3 years
Fecundity	NA/multiple spawner
spawning season	July to September

Pacific sardine

Habitat	pelagic
Depth range	surface
Max. length	41 cm
Max. age	13 years
length @ maturity	Both 18 to 20 cm
age @ maturity	NA
Fecundity	30,000 to 65,000 eggs
spawning season	April to August

White seabass

Habitat	kelp forest and sandy bottoms
Depth range	inshore to 122 m
Max. length	152 cm
Max. age	20 years
length @ maturity	Both 81 cm
age @ maturity	Both 6 years
Fecundity	NA/multiple spawners
spawning season	January to August

Red sea urchin

Habitat	rocky reef and kelp forests
Depth range	intertidal to 125 m
Max. length	18 cm in diameter
Max. age	> 100 yrs.
length @ maturity	2 inches test diameter
age @ maturity	NA
Fecundity	several million eggs
spawning season	late spring to early summer

Pacific ocean shrimp

Habitat	mud or sand bottoms
Depth range	36 to 357 m
Max. length	30 mm carapace length
Max. age	5 years in north; 3 years in south
length @ maturity	NA
age @ maturity	M at birth; F 2 to 3 years. Individuals are protandrous
Fecundity	800 to 3,900 eggs
spawning season	January to May

Market squid

Habitat	sand bottoms
Depth range	NA
Max. length	190 mm
Max. age	2 years
length @ maturity	NA
age @ maturity	1 to 2 years. Semelparous
Fecundity	3,600 to 9,000 eggs
spawning season	June ot September

Dover sole

Habitat	sand and mud bottoms
Depth range	7 to 1281 m
Max. length	76.2 cm
Max. age	53 years
length @ maturity	F 31 cm
age @ maturity	F 5 to 6 years
Fecundity	>266,000 eggs/multiple spawner
spawning season	November to April

Appendix H. *(continued)* Summary of life history parameters for selected species in the MBNMS.

English sole	
Habitat	shallow sand and mud
Depth range	nearshore to 183 m
Max. length	57 cm
Max. age	22 years
length @ maturity	M 26 cm/F- 30 cm
age @ maturity	Both- 3 years
Fecundity	1.1 million eggs/possible multiple spawner
spawning season	January to June

Petrale sole	
Habitat	sandy and sand-mud bottom
Depth range	<1 to 550 m.
Max. length	70 cm
Max. age	35 years
length @ maturity	M 36 to 37/F- 40 to 44 cm
age @ maturity	M 7/ F- 8 years
Fecundity	NA/multiple spawner
spawning season	November to April

Rex sole	
Habitat	mud and mud boulder
Depth range	<1 to 863 m
Max. length	59 cm
Max. age	24 years
length @ maturity	M 16 /F- 24 cm
age @ maturity	M 3/F- 5 years
Fecundity	238,000 eggs
spawning season	January to June

Pile surfperch	
Habitat	rocky shores; pilings; kelp forest bottoms; surfgrass beds; soft-bottoms
Depth range	1 to 209 m
Max. length	44 cm
Max. age	7 to 10 years
length @ maturity	Both 32.8 cm
age @ maturity	NA
Fecundity	30 to 80 offspring
spawning season	May to June

Rubberlip surfperch	
Habitat	rocky shores and reef bottoms; midwater; kelp beds and forest
Depth range	3 to 47 m
Max. length	47 cm
Max. age	7 to 10 years
length @ maturity	Both 29 cm
age @ maturity	NA
Fecundity	21 offspring
spawning season	April to June

Shiner surfperch	
Habitat	kelp and seagrass beds; estuaries; docks and pilings; sandy/muddy bottoms; deeper water in winter
Depth range	inshore to 209 m
Max. length	19.3 cm
Max. age	9 years
length @ maturity	M 5 cm; F 13 cm
age @ maturity	M at birth; F 1 to 2 years
Fecundity	4 to 17, with an average of about 8 or 9 offspring
spawning season	April to August

Striped surfperch	
Habitat	kelp canopy; pilings and docks; rocky shores and reefs; reefs with foliose red algae; eelgrass
Depth range	1 to 45 m
Max. length	38 cm
Max. age	7 to 10 years
length @ maturity	Both 28.6 cm
age @ maturity	Both 3 years
Fecundity	18 offspring
spawning season	March to June

Longspine thornyhead	
Habitat	soft bottoms of continental slope/ basin
Depth range	20 to 1756 m
Max. length	39 cm
Max. age	45 years
length @ maturity	10 to 18 cm
age @ maturity	14 years
Fecundity	106,000 eggs
spawning season	February to March

Shortspine thornyhead	
Habitat	soft bottoms of continental slope/ basin
Depth range	20 to 1524 m
Max. length	84.6 cm
Max. age	89 years
length @ maturity	21 to 23 cm
age @ maturity	12 or 13 years
Fecundity	450,000 eggs
spawning season	February to March

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Photo credits: Greenspotted rockfish (cover); fishing boats and fishers; coastal scenes; yellowtail and yelloweye rockfishes (p. 41); rosy rockfishes (p. 53); baby squid (p. 68); and canary rockfishes (p. 74) by Richard M. Starr. Yellowtail rockfishes (p. 31) courtesy of Cordell Bank Expeditions, NOAA archives; Monterey Fishing Company (p. 116) by Georgia Ratcliffe.