MARINE FISH RESOURCES:
Fish Species Biology

Bank Rockfish

History of the Fishery

Most bank rockfish *(Sebastes rufus*) are taken commercially by trawls, although gill nets were also important early in the fishery. Most of the catch occurs off California, although substantial landings are occasionally made off southern Oregon. Until the 1980s, bank rockfish were a relatively minor part of the commercial catch. However, as fishing effort off California expanded into deeper waters, landings of this species sharply increased. From 1981 to 1992, banks ranked among the top 10 rockfish species taken in California, averaging 1,115 tons annually, and ranked among the top three rockfish species landed at Monterey and Morro Bay. In general, catches after 1992, though variable, have remained somewhat steady. Since the 1970s, there has been a decrease in both age and length of individuals in the fishery. In 1998, about 450,000 pounds of bank rockfish were caught in the California commercial fishery; these were valued at about $207,000.

While bank rockfish are rarely caught in the recreational fishery north of Pt. Conception, California, they are a frequent catch of recreational anglers in deep waters off southern California.

Status of Biological Knowledge

Bank rockfish are oval-shaped fish with small head spines. They are dusky red or red-brown, often with a clear pinkish-orange zone along the lateral line and black spotting on the body and spinous portion of the dorsal fin. However, some individuals may not have spots. This species reaches a maximum length of 21.7 inches.

Bank rockfish are found from Queen Charlotte Sound, British Columbia to central Baja California and Isla Guadalupe (off central Baja California). They are abundant from the southern Oregon-northern California area to at least southern California. They live in depths between 100 and 1,500 feet, but most commonly between 300 and 800 feet.

Bank Rockfish, *Sebastes rufus*
Credit: DFG

Juveniles and sub-adults tend to be found in shallower waters than adults are.

Demersal juveniles and adults often are found over high relief boulder fields or steep cliff faces with plenty of crevices and caves. They also are found over cobblestones or on mixed mud-rock bottoms, where they shelter near or beneath the hard substrate. Small numbers have been observed around the bottom of deeper offshore oil platforms. Banks usually are found either alone or in small groups of up to 30 individuals, often hiding in, or very close to, sheltering sites. It is also possible that this species previously formed large schools before it was subjected to intense fishing pressure. In southern California, banks are often found with blackgill rockfish.

Bank rockfish live to at least 53 years. They are among the slowest growing of the rockfishes. Females grow larger than males and, at least among older fish, appear to be larger at a given age. Males reach maximum length at a slightly faster rate than females and mature at a smaller size than females. A few males are mature at 11 inches and 10 years, and all are mature at 14.8 inches and 20 years. Off California, banks release larvae from December to May (peaking in January and February) and from January to April off Oregon. Individual females produce between about 65,000 and 608,000 eggs. Off southern California, females release larvae in several batches per season, although this is not the case further north. Little is known of their food habits, although krill and gelatinous zooplankton have been found in their stomachs.

Status of the Population

In 2000, a partial stock assessment was made on bank rockfish. This assessment implied that there has been a substantial decrease in the bank rockfish population, particularly in the 1990s.

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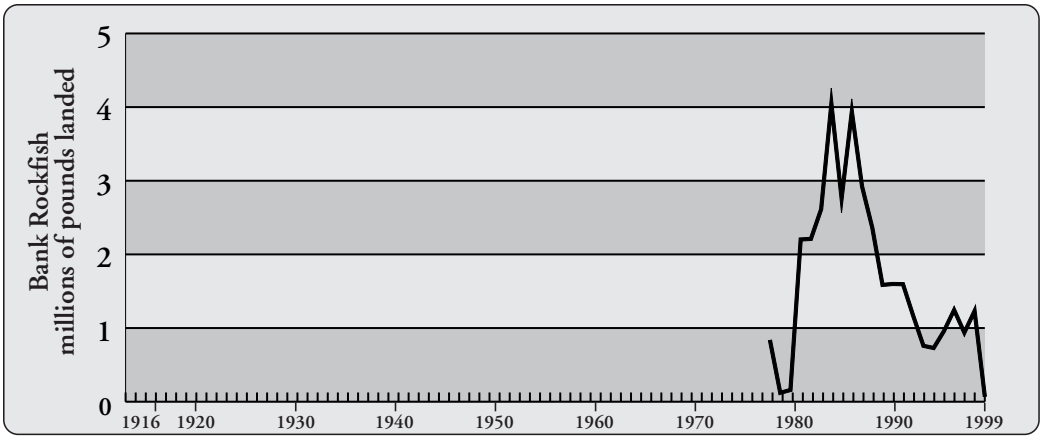

Commercial Landings 1916-1999, Bank Rockfish

Data Source: CalCom, a cooperative survey with input from Pacific Fisheries Information Network (PacFin), National Marine Fishery Service (NMFS), and California Department of Fish and Game (DFG). Data are derived from DFG commercial landing receipts with expansions based on port samples collected by PacFin samplers. Expansion data not available for years prior to 1978.

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Black Rockfish

History of the Fishery

Black rockfish (*Sebastes melanops*), also known as black snapper and black bass, are a minor to moderate component of nearshore commercial and recreational fisheries, with increasing importance from the San Francisco area northward. The Eureka area accounts for 80 percent to 90 percent of all commercial landings in the "black rockfish" market category (which may contain other species, most commonly blue rockfish). Annual statewide landings in the 1990s ranged from 189,000 to 277,000 pounds, except in 1993 when only 86,000 pounds were landed. Landings from port areas south of San Francisco have never comprised more than 10 percent of total landings in the market category. In the San Francisco port area, "black rockfish" landings increased fifteen-fold from 1989 to 1992. The majority of black rockfish in commercial fisheries are landed dead but a small portion are now landed live in the recently expanded live fish fishery, primarily from Morro Bay north to Fort Bragg. They are also taken incidentally in the commercial salmon troll fishery. Black rockfish also comprise minor to significant proportions of other market categories, in particular "blue rockfish," "small rockfish," and "unspecified rockfish."

Black rockfish are an important recreational species, particularly in northern California. Long-term monitoring of the recreational skiff fishery in the Eureka/Crescent City area showed them as the most frequently taken species every year in the 1990s; in 1997, for example, black rockfish comprised 58 percent of the observed catch. During the period from 1981 through 1986, the Marine Recreational Fisheries Statistical Survey (MRFSS) showed that in Humboldt and Del Norte Counties (northern California), black rockfish comprised from 15 to 31 percent annually of the estimated total marine recreational catch for all fishing modes combined. South of the Eureka area, black rockfish gradually decrease in importance in the recreational catch and are infrequently observed south of Santa Cruz. They are often among the top 10 species observed annually in commercial passenger fishing vessel (CPFV) catches from Fort Bragg south to the San Francisco/Princeton area. Black rockfish also are important to divers. In a 1972 survey in northern and central California, black rockfish comprised approximately eight percent of all fish taken by divers, and were primarily taken in northern California.

Black Rockfish, *Sebastes melanops*
Credit: DFG

A six- to seven-fold increase in estimated annual landings of black rockfish in the recreational fishery occurred between 1957 through 1961 and 1979 through 1986, which reflects a substantial increase in fishing effort between the two periods. Since then, estimated total recreational catch has been variable and has not continued to increase steadily. During the 1990s, the annual estimated take of black rockfish in the recreational fishery was fairly similar to that of the commercial fishery.

In 1992, DFG initiated a voluntary catch-and-release program in recreational and commercial fisheries for black rockfish less than 14 inches in total length in response to concerns over the lack of larger fish in sampled recreational catches, particularly in the San Francisco/Half Moon Bay area. The program was unsuccessful in the primary target area (Bodega Bay to Santa Cruz) and was not continued due to two factors: 1) increased recruitment of sub-adult fish to the fishery (*i.e.*, recreational anglers were unwilling to return a substantial portion of their catch to the water); and 2) perceived competition for the same resource from non-cooperative fishermen.

Status of Biological Knowledge

Black rockfish range from Amchitka Island, Alaska to Santa Monica Bay in southern California, but are uncommon south of Santa Cruz. They frequently occur in loose schools ten to twenty feet above shallow (to 120 feet) rocky reefs, but may also be observed as individuals resting on rocky bottom, or schooling in midwater over deeper (to 240 feet) reefs. They may attain a maximum length of 25.5 inches in California, although individuals over 20 inches are rarely observed today. Average size observed in commercial and recreational fisheries now is 14 to 15 inches in northern California and 11 to 13 inches in central California.

Black rockfish have a relatively fast growth rate. First year growth is usually 3.5 to 4.0 inches. Most individuals become available to the fishery by the time they have reached three to four years of age and are approximately 10 to 11.5 inches. They are larger at equal age then blue rockfish; four-to-seven-year old black rockfish may average from 11.5 to 13.8 inches, while blue rockfish range from 10 to 12 inches within that age range. By age five, growth rate of female black rockfish surpasses that of males, and

by age 15, female black rockfish may average 2.4 inches longer than males.

At six years, or about 14 inches, half of all males are sexually mature. At seven to eight years, or about 16 inches, half of all females are sexually mature.

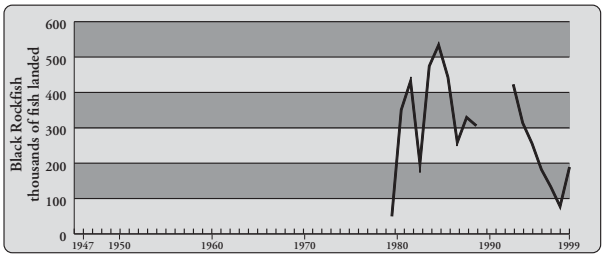
As with all members of the genus *Sebastes*, fertilization and development of embryos takes place within the female's body. Black rockfish mating generally occurs between September and November. Females store the sperm until their eggs mature in December or January, at which time the eggs are fertilized by the stored sperm. The larvae develop within thirty days, at which time black eyespots become visible to the naked eye. The eyed larvae are released into the water from late January to May, peaking in February off of California.

Larvae may remain in the ocean's surface waters for three to six months where they are dispersed by currents, advection, and upwelling. They begin to reappear as young-of-the-year (YOY) in shallow, nearshore waters by May, but the major recruitment event usually occurs from July to August. YOY black rockfish generally recruit to the shallower portions of kelp beds (15- to 40-foot depth) as well as semi-protected sandy areas of the coast. As newly settled YOY (approximately 1.5 inches) they most closely resemble yellowtail rockfish YOY. As they grow, YOY black rockfish more closely resemble YOY blue rockfish in pigmentation but lack the mottling on the sides, which are a uniform tan to light brown. As juveniles and adults, black rockfish are frequently mistaken for blue rockfish. The best characteristics that separate black from blue rockfish are a wide, unmottled, light blue-gray area along the lateral line, a relatively large mouth, the shape of the anal fin, and black speckling in the dorsal fin.

Although black rockfish may occur with blue rockfish, particularly in central and northern California, they are not considered to be competitors because their diets share little in common. Juvenile and adult black rockfish primarily consume crab megalopae, amphipods, isopods, and other fishes, including YOY rockfishes,.

Major predation occurs on all rockfishes from the moment of larval release throughout the first year by a variety of fishes and invertebrates, as well as marine birds. Larger black rockfish are preyed upon by lingcod and marine mammals such as sea lions.

Black rockfish are commonly associated with other nearshore fish species, particularly other rockfishes. A statistical technique, cluster analysis, was used to partition CPFV catch data from 1987 to 1992 in the Monterey area based on the frequency of occurrence of species in the sampled catch. Interestingly, no other schooling rockfish was closely associated statistically with black rockfish, but three benthic species (gopher, China, and brown rockfishes) showed an affinity to the same habitat and depth range as black rockfish. It is commonly known among fishermen that black rockfish in central California are characterized by localized areas of relatively high abundance in the nearshore area.



Recreational Catch 1947-1999, Black Rockfish

Data Source: RecFin data base for all gear types; data not available for 1990-1992

The DFG has conducted limited tagging studies on juvenile and adult black rockfishes. Between 1978 and 1985, 89 black rockfish were tagged in central California. Four tags were returned from fish which had been at liberty from 18 to 552 days; all fish were recaptured in the same areas where they were released.

Status of the Population

Although no fishery-independent population estimates have ever been made of black rockfish stocks in California, substantial information exists on relative abundance and length frequency from fishery-dependent surveys. Data from the 1981-1986 MRFSS survey showed a 23 percent decline in the average weight of black rockfish taken compared with fish harvested from 1958 through 1961.

Onboard observations from CPFVs in the San Francisco area documented a significant change in the length frequency of the sampled catch from 1989 to 1990. During that period, the occurrence of larger adult black rockfish (greater than 15 inches) declined precipitously. This occurred during a time when nearshore commercial hook-and-line fishing effort and landings were expanding, as mentioned previously. Mean length in the sampled catch from the San Francisco area declined from 14.3 inches in 1988-1989 to 12.1 inches in 1990-1991, and has ranged from 11.4 to 12.6 inches annually from 1993 to 1998. This is well below the average length at 50 percent sexual maturity. Since 1993, all other CPFV port areas from Fort Bragg south to Morro Bay have yielded similar low mean lengths.

Results from commercial fishery sampling are consistent with the above. For example, 296 black rockfish sampled from the Morro Bay area commercial nearshore fishery from 1993 to 1997 averaged 12.2 inches. Coincident with

Blue Rockfish

History of the Fishery

The blue rockfish (*Sebastes mystinus*), also known as bluefish, blue perch, blue bass, priestfish, and reef bass, is most commonly caught from the northern Channel Islands (in the Southern California Bight) to the Oregon border. Although only a small portion of blue rockfish landings is from the commercial fishery, those landings have increased in the past decade. During the 1987-1989 period, landings in the "blue rockfish" market category (which may include other morphologically similar rockfishes) averaged 25,670 pounds; in 1998 landings were approximately 92,000 pounds. Based on market sampling in the Morro Bay area, total landings of the species blue rockfish are significantly greater than those of the market category "blue rockfish." For example, in 1998 in this port area, estimated total landings for the species were 19,300 pounds, yet total reported landings for the market category were only 2,100 pounds. The former estimate is based on the percentage of blue rockfish in various sampled market categories and the total landed weight of all market categories. Blue rockfish are often landed as "unspecified rockfish" or "group small rockfish," both frequently used market categories.

Blue rockfish have become a minor component of the live fish fishery, which developed during the 1990s in California. For example, in the Morro Bay area during the 1996-1998 period, less than one percent of the live fish landings were blue rockfish, and about four times as many blue rockfish were landed dead than alive. In 1998, the ex-vessel value of all fish landed statewide in the "blue rockfish" market category was $57,700.

The blue rockfish is one of the most important recreational species in California. It is usually the most frequently caught rockfish north of Point Conception for anglers fishing from skiffs and Commercial Passenger Fishing Vessels (CPFVs). It is also an important species for skin and scuba divers using spears, and is occasionally caught by shore anglers fishing in rocky subtidal areas. In a 1981-1986 survey of sport fish taken between the southern boundary of San Luis Obispo County and Oregon, an estimated 800,000 blue rockfish were harvested annually - more than any other species. This represents a doubling of the estimated annual harvest from a similar survey conducted in 1957-1961.

In every complete year sampled by the department, from 1988 through 1998, blue rockfish has been among the three most frequently observed species caught on CPFVs in every major port area from Morro Bay to Fort Bragg. Based on the Department of Fish and Game's (DFG) onboard observations and log book summaries, estimated annual take of blue rockfish by CPFV anglers ranged from 199,000 to 546,000 fish for the period 1988 to 1995 and averaged 335,000 fish. This species truly has been the bread and butter of the nearshore recreational angler in northern and central California.

In a survey of divers conducted in 1972 in northern and central California, blue rockfish ranked second in importance to lingcod with 10.5 percent of all fish landed and was the most common rockfish taken, comprising 29.6 percent of all rockfishes. Preliminary data from a 1999 survey of Monterey Bay area divers revealed that blue rockfish was the fourth most abundant species harvested, after California halibut, kelp rockfish, and lingcod.

For more than 25 years, the recreational harvest of rockfish was limited to 15 fish per day, with 15 blue rockfish allowed within that limit. Effective January 1, 2000, the bag limit was reduced to 10 rockfish overall, with 10 blue rockfish allowed within that limit. The National Marine Fisheries Service considers the blue rockfish a "nearshore species." Effective January 1, 2000, very restrictive limits on the commercial harvest of nearshore rockfishes have been imposed by the National Marine Fisheries Service upon recommendation of the Pacific Fishery Management Council. In addition, the DFG now requires a special permit for the commercial harvest of nearshore fishes, and it is likely that a restricted access program will be developed for the nearshore commercial finfish fishery in California.

Status of Biological Knowledge

Blue rockfish range from the Bering Sea to Punta Baja, Baja California, and from surface waters to a maximum depth of 300 feet. They are less common south of the northern Channel Islands and north of Eureka, California. They are a medium-sized species among all rockfishes; the largest known specimen was 21 inches, although individuals exceeding 15 inches are uncommon in central and southern California. Average size in California recreational fisheries today is 11 to 13 inches. In central and southern California, larger blue rockfish are now common only in areas distant from fishing ports or in larger kelp beds which are practical to fish only from the edges.

Blue Rockfish, *Sebastes mystinus*
Credit: DFG

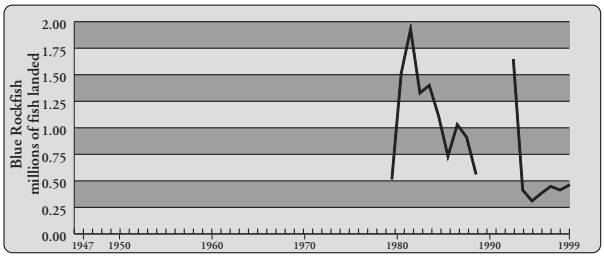
Rockfishes in general are considered to be slow-growing fishes. However, blue rockfish are among the faster growing rockfishes. First year growth may vary from 3.0 to 4.5 inches (central California average about 4.25 inches), and after two years blues may reach six inches. An occasional two- or three-year old blue rockfish may be caught by anglers, but most do not recruit to the sport and commercial fisheries until four to seven years of age when they range from eight to 10 inches. Females grow at a slightly faster rate than males. Maximum age is about 24 years.

Age at first spawning is protracted for both sexes. Only about 10 percent spawn for the first time at three years of age. At five years, or about 10 to 10.5 inches, half of all males are sexually mature. At six years, or about 11 inches, half of all females have spawned.

In males, the gonads increase in size from May to July, but in females the eggs begin maturing from July to October. Males transfer sperm to the females in October, but the embryos do not begin to develop until December when the eggs are fertilized by the stored sperm. Embryos develop within the female and hatch immediately upon being released into the water; larval release usually peaks in mid-January. Larvae live in the surface waters for four to five months, where they may be carried many miles by ocean currents. Young-of-the-year (YOY) blue rockfish begin to appear in the kelp canopy and shallow rocky areas by late April or early May when they are about 1.2 to 1.4 inches in length. However, they are not considered fully recruited each year until July due to the variability in the planktonic period. As YOY, they are mottled reddish-blue in color upon settlement and may appear in massive swarms in certain years in inshore areas, especially in kelp beds.

After more than two decades of estimating relative abundance of blue rockfish in central California, DFG biologists have shown a positive statistical correlation with blue rockfish recruitment and annual upwelling index. Continuing research is directed towards the mechanisms by which YOY rockfish recruit to nearshore areas, and the relationship between spawning areas and recruitment areas, as influenced by current patterns and oceanographic events.

Feeding habits vary considerably depending upon life history stage, depth, and locality. Larval and YOY blue rockfish consume primarily planktonic crustacea. Adult fishes in deeper water feed almost entirely on macroplankton consisting of tunicates (salps), scyphozoids (gonadal material of jellyfish), and crustaceans. In shallow areas and kelp beds, blue rockfish feed on the same types of macroplankton as those in deeper water, but they also feed on algae, small fishes, hydroids, and crustaceans, including amphipods and crab larvae.



Recreational Catch 1947-1999, Blue Rockfish

Data Source: RecFin data base for all gear types; data not available for 1990-1992

During their first few months on nearshore reefs, larval and YOY blue rockfish are preyed upon by most large piscivorous fishes. As adults, their predators include lingcod, harbor seals, sea lions, and, occasionally, larger rockfishes, especially bocaccio.

Adult blue rockfish are common in kelp beds, where food is plentiful and the kelp provides protection from predators, but they also occur on deeper rocky reefs between 100 and 300 feet deep. In kelp beds they form loose to compact aggregations. Under dense kelp canopies, they will sometimes form columns at least 30 wide and 80 feet deep and may be extremely compact. In deeper waters, they form aggregations that may extend from the surface to the bottom, but they are usually at or below mid-depth.

Blue rockfish are commonly associated with other nearshore fish species, particularly other rockfishes. A statistical technique, cluster analysis, was used to partition CPFV catch data from 1987 to 1992 in the Monterey area based on the frequency of occurrence of species in the sampled catch. In a broad area along the entire Monterey Peninsula extending out to 240 feet deep, blue rockfish were the predominant species and were in close association with olive, yellowtail, starry, and rosy rockfishes. This statistical relationship has been supported with observations using scuba and submersibles.

The DFG has conducted marking studies on all size ranges of blue rockfish from 1.8 to 18 inches. A population study using freeze branding as a marking technique resulted in more than 80,000 recently-settled blue rockfish being marked in a five-week period. These fish showed very little movement from an isolated reef 100 x 150 feet and, in fact, showed very little movement from one part of the reef to another.

Tagging studies of adult blue rockfish indicate they do not migrate laterally along the coast. Between 1978 and 1985, over 1500 blue rockfish were tagged and released in central California waters by DFG biologists. Eighteen tags were subsequently returned, with the fish being at liberty from 11 to 502 days; all were recaptured in the same locations where they were tagged. The longest recorded movement of a blue rockfish from any tagging study was 15 miles. While these studies show adult blue rockfish

populations are more or less discrete at each fishing port, it is not known how much larval drift occurs between fishing areas.

Status of the Population

Although no fishery-independent population estimates have ever been made of blue rockfish stocks, it appears that they have withstood considerable fishing pressure over the last four decades and continue to be healthy, at least north of Point Conception. There is evidence of a decline in blue rockfish stocks off southern California since the 1970s. There is a well-documented difference in the population structure between northern and central California stocks. Northern stocks are generally characterized by a wider size range of adults, a higher proportion of adults greater than 15 inches and a correspondingly greater mean length, less variability in annual recruitment, and most likely a higher growth rate. These attributes are likely a result of a combination of greater fishing pressure and a greater influence of anomalous oceanic conditions such as El Niño events in central California. Greater variability in annual recruitment results in occasional strong year classes which cause strong length-frequency modes in the sampled catch; this occurred four times in recreational fishery samples obtained from 1959 to 1983 in central California. It is believed that the last exceptionally strong year class of blue rockfish in central California occurred in 1988, which is cause for concern. However, a relatively strong year class also was observed in 1999. In 1993, when the majority of the 1988 year class had become available to recreational anglers, mean lengths in the sampled catch declined substantially in central California. For example, mean length of blue rockfish sampled from Monterey area CPFVs declined from 11.9 inches in 1992 to 11.0 inches in 1993. In heavily fished and well-sampled populations of rockfishes, changes in annual mean length from one year to the next are commonly less than 0.5 inches.

The total number of blue rockfish caught in recreational fisheries increased substantially from the late 1950s to the mid-1980s, concurrent with increased effort. However in the past 15 years recreational fishing effort has been variable but has not shown a consistent increase; the recreational catch of blue rockfish has shown the same pattern. However, increased commercial fishing in the nearshore area during the same period has put additional stress on blue rockfish populations. Fishery managers have increased monitoring efforts for this keystone species of nearshore ecosystems.

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References

See black rockfish reference list.

Bocaccio

History of the Fishery

Bocaccio (*Sebastes paucispinis*), sometimes called red snapper, rockcod, grouper, salmon grouper, or tomcod (as juveniles), was the dominant rockfish in California's early longline fishery. It was the most abundant rockfish in the bottom trawl fishery from Morro Bay to Fort Bragg until the mid-1980s. In the late 1980s, two-thirds of the bocaccio landed were taken by trawl, with the remainder being taken by set net, longline, and the recreational fishery. Before 1970, estimated landings by all fisheries averaged approximately six million pounds per year. Following 1970, combined landings increased, peaking in 1983 at over 15 million pounds. Landings have declined steadily since then, and fell below 0.5 million pounds in 1998. In 1978, nearly 40 percent of the sampled trawl landings contained half or more bocaccio by weight, but this value has declined to a very small percentage of landings in recent years.

Recreational catches of bocaccio are generally made on rocky reefs by party boat fishermen at depths of 250 to 750 feet. In some years, however, juveniles concentrate in shallow sandy areas near piers off central and southern California, where they are easily taken on small baited hooks. Estimated catches for the recreational fishery are available from 1980 onward and averaged 15 percent of the total landings in recent years. Recreational catches since 1984 have shown the same decline as the trawl fishery.

Status of Biological Knowledge

Bocaccio range from central Baja California to Kodiak Island, Alaska, and are common from northern Baja California to the Washington-British Columbia border. Genetic studies indicate partial separation between the bocaccio population off the Pacific Northwest and that off California.

Among rockfishes, bocaccio are noted for their relatively rapid growth, large adult size, and high variation in year-class strength. They are known to attain a length of 36 inches, a weight of 15 pounds, and a maximum age of about 50 years. Some fast growing individuals are caught with trawl gear at age one, and substantial numbers are landed by age two at lengths of about 16 inches.

Bocaccio are live-bearing fish. At extrusion (release), larvae are about 0.25 inch in length and absorb yolk from the egg stage during the first eight to 12 days. They grow rapidly to about seven inches by the end of their first year. A few mature when they are three years old, about 14 inches long and one pound. Fifty percent are mature at 16.5 inches and four years. Males mature at a slightly smaller size than females. By the time they are 10 years old, they average over 24 inches and weigh five pounds. The number of developing eggs increases from 20,000 in a 15-inch fish to about 2.3 million in a fish 30.5 inches long.

Off central and northern California, larval release occurs from January through May, peaking in February. In southern California spawning takes place from October through July, peaking in January. In central California, most larvae that survive to the juvenile stage are born in January and February, but months of successful reproduction can shift substantially from year to year. In southern California, some females produce as many as three broods in a season, but multiple brooding is uncommon farther north.

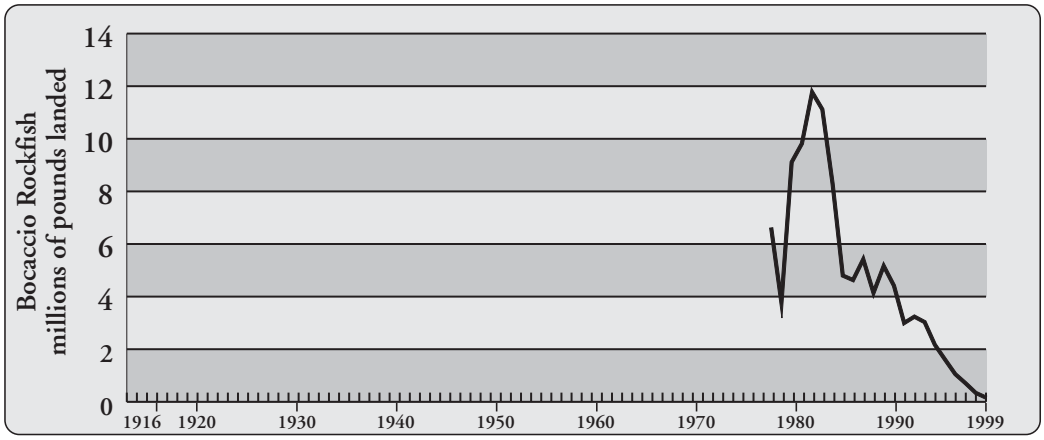
Larval bocaccio are initially pelagic and are most common within 100 feet of the sea surface, where they feed on plankton. Larval bocaccio have been captured in plankton nets as far as 300 miles from shore. By late May or early June, they settle to the bottom at lengths of 1.5 to 2.5 inches, often in kelp beds. Before completing their first year of life, these fast growing young-of-the-year start eating the young of other rockfishes, surfperch, jack mackerel, and various small inshore fishes. Adults are found from depths of 60 to 1550 feet. They feed on smaller rockfishes, sablefish, anchovies, lanternfish, and squid.

Status of the Population

During the past two decades bocaccio landings have been dominated by the 1977, 1984, and 1986 year classes. A long string of recruitment failures occurred from 1989 to 1998, which under intense fishing led to a severely depleted population. By 1999, abundance had fallen to about three percent of the level seen in 1969, and the Pacific Fishery Management Council declared the population as "overfished." Evidence from entrainment of young fish at the San Onofre Nuclear Generating Station indicates that the 1999 year class is large.

Bocaccio, *Sebastes paucispinis*
Credit: DFG

Commercial Landings 1916-1999, Bocaccio Rockfish
Data Source: CalCom, a cooperative survey with input from Pacific Fisheries Information Network (PacFin), National Marine Fishery Service (NMFS), and California Department of Fish and Game (DFG). Data are derived from DFG commercial landing receipts with expansions based on port samples collected by PacFin samplers. Expansion data not available for years prior to 1978.



Management Considerations

See the Management Considerations Appendix A for further information.

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Historic photo of a catch of boccaccio and chilipepper being unloaded from a trawler. Credit: DFG

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these observed declines in mean length were increased harvest rates (catch per angler hour) observed in the CPFV fishery in central California, particularly from 1994 to 1997. Thus, the observed decline in mean length is partially related to stronger recruitment, and, in spite of increased fishing effort on black rockfish in recent decades, localized populations of adults still must be present in California to provide this recruitment.

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Brown Rockfish

History of the Fishery

Brown rockfish (*Sebastes auriculatus)*, commonly referred to as bolina by fishermen and markets, have long been an important component of the marine recreational fishery and a relatively minor but important component of the nearshore commercial fishery in California, especially north of Point Conception. In the commercial fishery freshly caught whole brown rockfish are sold either dead or alive in the fresh fish markets. Brown rockfish have not been reported separately from other rockfishes in catch statistics, but comprise the majority of the market grouping called bolina, which also includes other similar-looking rockfish species, such as copper or quillback rockfish, that are sold at the same price. In samples obtained from 1999 landings, brown rockfish comprised 70 percent by weight of the bolina category. Brown rockfish are also mixed into other market categories, such as the red rockfish group (19 percent by weight in 1999 landings).

Commercial catches were made in the past with hook-and-line gear and, to a lesser extent, gillnets until gillnets were excluded from state waters in 1991. Today, brown rockfish are primarily taken with hook-and-line gear, which includes mainly rod-and-reel and horizontal longline gear, along with some vertical longline (stick) and troll longline gear. In most port areas of the state, the majority of bolina group catch is made by rod-and-reel, although, in the San Francisco area, the longline fleet accounts for over 70 percent of bolina taken. The species is targeted directly in both nearshore and offshore ocean environments. In the San Francisco area, the brown rockfish was estimated to be the third most common rockfish species landed by weight in the hook-and-line commercial fishery through the 1990s. The 1999 and 2000 catch estimates suggest that they are now equal to line-caught landings of chilipepper and the two are the most common species in nearshore catches. Since the early 1990s, the brown rockfish has been the most common rockfish species sold live in San Francisco markets and comprised nearly 50 percent of the live rockfish catch in 1999.

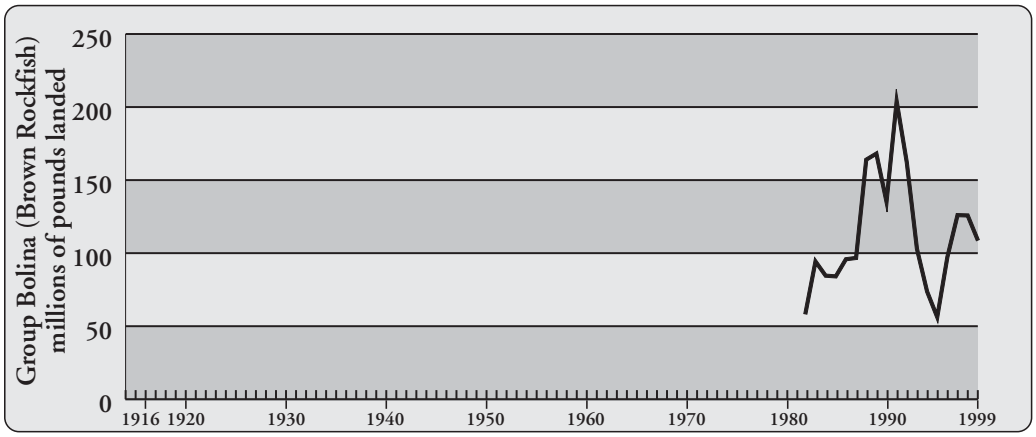
Brown Rockfish, *Sebastes auriculatus*
Credit: DFG

The number of vessels landing brown rockfish peaked in the early 1990s, when over 250 hook-and-line vessels made an average of over 1,300 landings per year statewide, usually ranging from 60 to just over 100 pounds per landing. Total landings of brown rockfish peaked in 1991, decreased through the mid-1990s, and increased again during the late 1990s coincident with an increasingly active nearshore premium and live fish fishery. Though landings have fluctuated over the last two decades, the value of the catch has continued to increase, particularly during the last decade, as rockfish quotas have been reduced and demand has continued to remain high. Markets in areas such as San Francisco (especially those in Chinatown) sell their brown rockfish whole and preferably live. Dead-landed fish obtain an ex-vessel price of $1 to $2 per pound, whereas live brown rockfish have demanded an ex-vessel price from $2 to $4 per pound. With the recent management-related reductions in supply, prices have increased to over $6 to $8 per pound at times in 1999 and 2000.

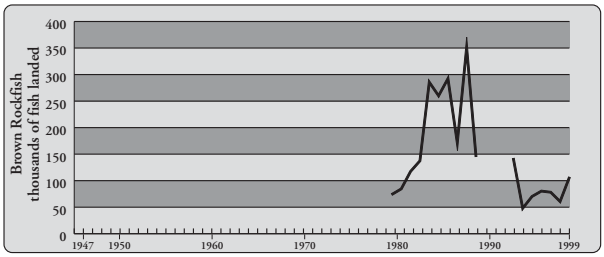
Sport anglers regularly catch brown rockfish with rod-and-reel either from the shore, commercial passenger fishing vessels (CPFVs), or private/rental boats (PRBs), especially in nearshore reef habitats (depths of less than 175 feet). Brown rockfish are most common in sport catches near San Francisco. In a sport fish survey conducted from 1980 through 1986, brown rockfish were among the top five species of rockfish caught and composed up to 6.6 percent of the estimated sport catch. Inside San Francisco Bay, they are the most common sport-caught rockfish species. Although catches south of Point Conception are lower, brown rockfish have comprised up to one percent of rockfish take and have remained among the top 15 species of rockfish caught during the last 20 years. These represent a seven-fold increase by number in statewide take relative to a 1958 to 1961 survey of recreational fishing. Substantial increases in take have occurred in all modes of fishing, especially by shore fishing, pier fishing, and PRBs.

Status of Biological Knowledge

Brown rockfish are found along the Pacific Coast of North America from the northern Gulf of Alaska to central Baja California. They live in shallow subtidal waters and bays, and have been found at depths of just over 400 feet, although they most commonly reside above 175 feet. Brown rockfish are typically found associated with sand-rock interfaces and rocky bottoms of artificial and natural reefs. In shallow waters, they may be found in small aggregations associated with rocky areas and kelp



Commercial Landings 1916-1999, Brown Rockfish
Group Bolina (Brown) rockfish landings were aggregated as rockfish prior to 1979. DFG market sampling indicates that 75 percent of the Group Bolina rockfish market category is made up of brown rockfish, the remaining 25 percent consists primarily of widow rockfish. Data Source: DFG Catch Bulletins and commercial landing receipts.



Recreational Catch 1947-1999, Brown Rockfish
Data Source: RecFin data base for all gear types; data not available for 1990-1992

beds, whereas they stay near the rocky bottom when in deeper waters. The sub-adults migrate into both high and low relief reefs and are strongly residential to their home sites.

Distinguishing characteristics of brown rockfish include orange-brown or dark brown mottling, especially on the back, and a prominent dark brown blotch on the gill cover. Little sexual dimorphism is evident between male and female brown rockfish in relation to growth or maturity rates. Recent studies found maturity as early as three years, and 100 percent maturity at six years, or roughly 12.2 inches total length (TL). Half of the population was mature at 3.9 and 4.2 years of age, measuring 9.8 and 10.4 inches TL in males and females, respectively. Brown rockfish grow to a maximum size of 22 inches, and live less than 25 years. This is a relatively short life span compared with most offshore rockfish species, though many nearshore rockfish species have a similar or shorter lifespan.

As with all members of the genus *Sebastes*, brown rockfish are ovoviviparous. A 12-inch TL female may produce approximately 42,500 eggs, while an 18-inch TL female may produce as many as 266,000 eggs. Peaks in larval release occur in the pelagic environment in both December-January and May-June. Larvae live in the upper zooplankton layer for approximately a month before metamorphosing into pelagic juveniles as part of the plankton and micronekton, and subsequently settling out into shallow nearshore waters. Although brown rockfish reproduce on the open coast, young-of-the-year fish commonly migrate into bays and estuaries for use as nursery habitat, which is an uncommon practice for rockfish species. They may remain in the bay around rubble, piers and other structures in areas of higher salinity for one to two years before returning to the open coast.

Brown rockfish feed on increasingly larger prey as they grow. They shift from small crustaceans, amphipods, and copepods as juveniles, to an adult diet of crabs and fish. Little is known about predation on brown rockfish, but it is thought to be similar to that of other nearshore rockfish species: Most predation on the brown rockfish presumably occurs during the larval and juvenile stages, with less predation occurring on the adults.

Status of the Population

While there have been studies of local abundance in certain coastal areas and within bays, the population size and structure of this species has not been comprehensively assessed. Evidence of stress on brown rockfish stocks in California exists, however, and some relative changes in the population have been identified. Commercial and recreational catches have steadily increased during the last 40 years, while the average length and weight of brown rockfish in landings have declined. When recreational statistics collected during the last 20 years were compared to results from a 1958 through 1961 recreational survey, brown rockfish showed a 49 percent decrease in average weight per fish over 30 years. Mean length of brown rockfish obtained from CPFVs and PRBs in northern California declined by 18 percent and 21 percent respectively over 40 years. In southern California, mean

length in the CPFV catches declined by 31 percent during the same period. In relation to the length at which 50 percent of males and females are mature, recreational landings data indicate that from 1958 to 1961, most brown rockfish taken had reached sexual maturity. By the 1980s, however, few fish taken from shore or from the bays, and about half taken from PRBs were sexually mature. Lengths of brown rockfish sampled from commercial landings during the last decade also reflect that half of the fish were at or below the size at which 50 percent of the population is sexually mature, and few larger adult fish are being landed compared to historic values. The decline in size of fish in these fisheries does not seem to be associated with incoming year classes, but instead with a depletion of larger adults due to fishing pressure. Although nearly half of the fish landed statewide are adults that can replenish the population, there are now few large adults above the length of the median-sized fish recorded in the 1958 through 1961 survey. The brown rockfish has been identified as a species vulnerable to severe localized depletions in other geographic areas; in Washington state, the Puget Sound stock of brown rockfish was recommended for listing as a threatened species in 1999.

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Canary Rockfish

History of the Fishery

Prior to 1944, the primary gear used for the capture of rockfish was the hook-and-line (primarily vertical longline). Soon after World War II, the "balloon" trawl became the dominant gear used to capture rockfish. Canary rockfish (*Sebastes pinniger*) became the largest component in the trawl fishery landings in northern California. From the 1940s to the late 1960s, rockfish landings began to increase steadily, due in part to Asian market demands. Estimated canary rockfish landings for this time period indicate annual catches of 550 to 2,200 tons, the majority being landed in northern California with trawl gear. The exact amounts harvested during this time period are not known since rockfish landings were not recorded separately until 1981. During the 1970s, total landings of canary rockfish in California decreased slightly to between 440 and 990 tons. Trawl gear continued to dominate the total catch (60-70 percent), with recreational catches (15-30 percent) and commercial hook-and-line (5-15 percent) accounting for the rest.

In 1982, the trawl catch of canary rockfish in California accounted for 77 percent of the total canary rockfish catch (1,200 tons), with most of the fish being landed in Eureka and Fort Bragg. Recreational and commercial hook-and-line catches accounted for 21 percent and 2 percent of the total in 1982. During the 1980s, a new gear, the setnet or gillnet entered the fishery. Gillnet catches began to replace hook-and-line catches for a few years, but accounted for less landings compared to the recreational and trawl catches. The trawl remains the dominant gear type for harvesting canary rockfish to this day, but has experienced declines to levels nearly matching the hook-and-line catches. Since 1982, the total harvest of canary rockfish in California has declined dramatically to 250 tons in 1998. The trawl, commercial hook-and-line, recreational, and setnet catches account for 50 percent, 42 percent, 8 percent, and less than 1 percent of the total canary rockfish landings in 1998. Canary rockfish are currently being managed through bi-monthly trip limits.

Canary rockfish is an important component of the commercial passenger fishing vessel (CPFV) recreational catch from central and northern California. This species was consistently one of the top ten species landed by CPFV anglers fishing in the San Francisco area north to the Eureka area. Average length of canary rockfish caught by CPFV anglers is small and usually involves immature fish (less than 50 percent maturity).

Status of Biological Knowledge

Canary rockfish, referred to as orange rockfish in older reports, occur from Baja California to southeast Alaska. Their center of distribution is the Washington-British Columbia area, and in California they have commercial importance only as far south as Bodega Bay. Electrophoretic differences indicate that canary rockfish may have two separate subpopulations: one north, the other south of central Oregon. A recent assessment of these two portions of the canary rockfish resource suggests the southern area may be receiving population enhancements from the northern spawned fish. Canary rockfish have been caught at depths below 1,000 feet, but are taken in abundance only to 500 feet.

Canary rockfish grow rapidly until they reach maturity at about 17 inches, then more slowly to a maximum age of 70 years and a maximum length of 24.5 inches for females and 21 inches for males. For example, at one year, females average 5.4 inches and males 4.3 inches; at four years both females and males average about 11.7 inches; by age 12, females average 20.2 inches and males 19.1 inches. By age 50 they have added little length (females, 24.4 inches; males, 20.9 inches). Most populations have few individuals older than 20 years.

Females begin to mature sexually at 10.6 inches, reaching 50 percent maturity at 17.3 inches, and 100 percent maturity at 21.2 inches. Males begin to mature at 11 inches, reaching 50 percent maturity at 15.7 inches, and 100 percent maturity at 17.7 inches. A 10.6-inch female carries about 69,000 eggs; a 17.3-inch female about 489,000 eggs; and a 21.2-inch female about 1,113,000 eggs.

Canary rockfish are viviparous, meaning that the females bear free-living young and contribute some energy to their young while they are inside the mother. Males fertilize the females around December, and the females hold their young until December to March. Pelagic juveniles occur in the upper 100 feet of the surface waters from April to June. It is assumed that the juveniles descend to

Canary Rockfish, *Sebastes pinniger*
Credit: DFG

benthic habitats after mid-June. Juvenile canary rockfish, like most rockfishes, tend to settle in the shallower depths of their range and move to deeper waters as they grow older.

Adult canary rockfish feed primarily on euphausiids. Next in importance as prey are fish, mainly myctophids and adult shortbelly rockfish which are most abundant in the fall and winter diet. Gelatinous zooplanktors and associated hyperiid amphipods are common prey but are a minor part of the diet. Pelagic juvenile canary rockfish feed on copepods and euphausiid eggs and larvae.

Predation on canary rockfish is most severe during the pelagic larval and juvenile stages. Juveniles (one to three inches) are commonly found in the stomach contents of chinook salmon. Undoubtedly, other predators of juvenile fish (other fishes, mammals and birds, including the common murre) prey on juvenile canary rockfish. After the juveniles descend to the benthos and become adults they are much less vulnerable to predators.

Status of the Population

The canary rockfish population has declined since the early 1970s, particularly in the waters north of California. The population size of age three and older canary rockfish for California was estimated to be approximately 4,700 tons in 1973 and had decreased nearly 60 percent to 1,900 tons in 1998. The mean length of canary rockfish has declined 13 percent since 1980 in the trawl fishery, indicating the removal of larger, older fish from the population. Off the coast of Washington and Oregon age two and older fish were estimated at 73,700 tons in 1967; in 1999 the estimate was 12,100 tons. The spawning population of canary rockfish has seen even more dramatic declines, with estimates of 1999 spawning population sizes of 6-23 percent of historically unfished levels. In 1999, the canary rockfish resource off the entire U.S. West Coast was declared overfished. Recent predictions of population trends indicate the population may take many decades to recover to fishable levels. Attempts to decrease fishing pressure on canary rockfish are resulting in severe restrictions for many other West Coast fisheries.

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Chilipepper

History of the Fishery

The chilipepper (*Sebastes goodei*) is one of California's most important rockfish species; it is a major contributor to commercial and sport landings. In fact, from 1996 through 1998 chilipepper was ranked first in statewide commercial rockfish landings, with an annual average of over 3.8 million pounds. Important ports of landing are throughout central and much of northern California, including Fort Bragg, Bodega Bay, San Francisco, Princeton, Monterey, Moss Landing, and Morro Bay. Chilipepper also contribute to southern California rockfish landings, although not so heavily.

In the late 1800s, chilipepper and most other rockfish were caught by Portuguese longline fishermen who fished Monterey Bay from small two or three-person vessels. Longlines provided most, if not all, rockfish landings until the mid-1940s. Improvements in otter trawl technology subsequently led to trawl gear replacing longlines as the primary gear used to catch rockfish. Trawl gear enabled fishermen to make much larger landings with larger vessels. Trawlers have since accounted for the great majority of chilipepper landings, followed by set gill net and hook-and-line gears. During the 1990s, gill net landings have declined to very low levels, whereas hook-and-line gears have comprised a relatively higher portion of the catch.

Historically, chilipepper was not considered an important component of the party boat angler's catch in central and northern California due to its deep offshore distribution. In the early 1980s, Monterey and Santa Cruz party boat skippers began fishing chilipepper schools in the vicinity of the Monterey underwater canyon in late spring through summer. In contrast, southern California chilipepper partyboat landings peak during the winter months. Chilipepper was ranked third among rockfishes taken off central and northern California in 1989-1990, but its relative importance in the recreational fishery has dwindled throughout the 1990s. Since 1995, sport landings have comprised less than two percent of the total chilipepper catch.

Chilipepper, *Sebastes goodei*
Credit: DFG

Status of Biological Knowledge

Chilipepper range from Queen Charlotte Sound, British Columbia to Magdalena Bay, Baja California. Adults are found on deep rocky reefs, as well as on sand and mud bottoms, from 150 to 1,400 feet; juveniles school and are frequently found in shallow nearshore waters, particularly in kelp beds. Spawning occurs from September to April with a peak occurring in December and January. About 50 percent of female chilipepper are sexually mature at four years when they are between 11 and 12 inches, while males mature at two years and between eight and nine inches. Chilipepper attain a maximum age of 35 years and a size of up to 23 inches, with females growing substantially larger than males.

Adults feed on krill and other small crustaceans, squid, and a variety of small fishes. Probable predators of chilipepper include marine birds and mammals, king salmon, lingcod, Pacific hake, sablefish, and other rockfish.

Status of the Population

The last stock assessment of chilipepper, conducted in 1998, indicated that unlike most other rockfish populations, the stock was in quite good condition. At that time, the population size was determined to be 35,000 tons, which is about 50 percent of the unexploited level. The healthy status of the chilipepper stock has been due to a very strong 1984 year-class that supported the fishery throughout the 1990s, although recent recruitments have been lower and the stock is slowly but steadily declining. Based on the assessment, the Pacific Fishery Management Council set the acceptable biological catch at 4,100 tons, although the Council lowered the total allowable catch (TAC) to 2,000 tons out of concern for bocaccio bycatch in chilipepper fisheries. Even with the lower TAC, the various fisheries have not been catching the quota.

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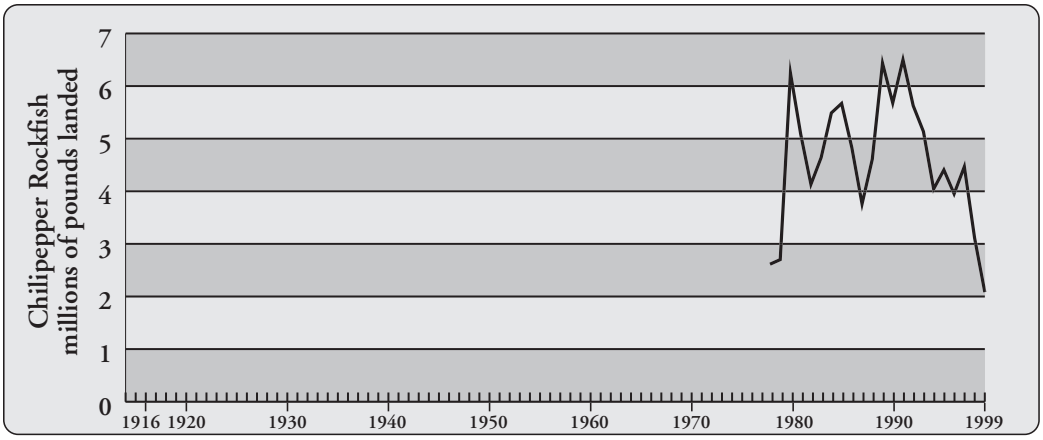
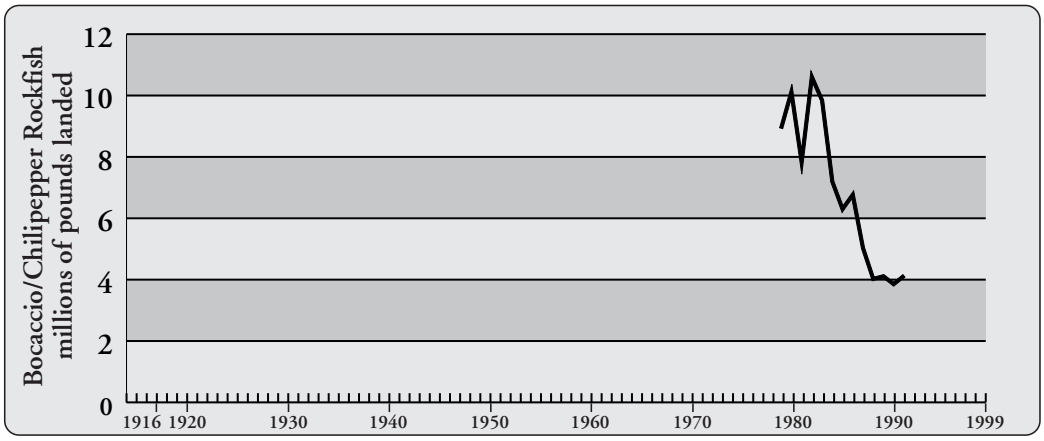


Commercial Landings 1916-1999, Chilipepper Rockfish
Data Source: CalCom Database utilizing DFG commercial landing receipts. Expansions of port samples are conducted by Pacific States Fishery Management Council with input from DFG.



Commercial Landings 1916-1999, Bocaccio/Chilipepper Rockfish
Data Source: DFG Catch Bulletins and commercial landing receipts. The market category Bocaccio/Chilipeper Rockfish were aggregated within the market category Rockfish prior to 1979.

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Copper Rockfish

History of the Fishery

The copper rockfish (*Sebastes caurinus*) is a highly variable species in terms of coloration, and due to this characteristic it has been known by several names, depending to some degree upon locality. These include copper rockfish, whitebelly rockfish, gopher, white gopher, and bolina (this name is most commonly applied to the brown rockfish). Copper rockfish is most widely used and is the recommended vernacular name. Historically, copper rockfish was considered a common nearshore species.

Over the past 20 years, copper rockfish have become a less frequent component of the nearshore environment. Commercially, copper rockfish are landed in a number of market categories including copper rockfish as well as red, bolina, and gopher rockfish groups. It is sold as fillets by the market names rockfish or red rockfish and often whole as red rockcod; it is considered an excellent food fish. Copper rockfish is one of the species taken in the live-fish fishery. They have been an important component of the recreational catch in both skiff and commercial passenger fishing vessel fisheries, especially off central and northern California. Due to its relatively large size, known to reach 22.9 inches in length, copper rockfish has been considered one of the premium species in the recreational angler's catch and a prime target for the sport diver.

Status of Biological Knowledge

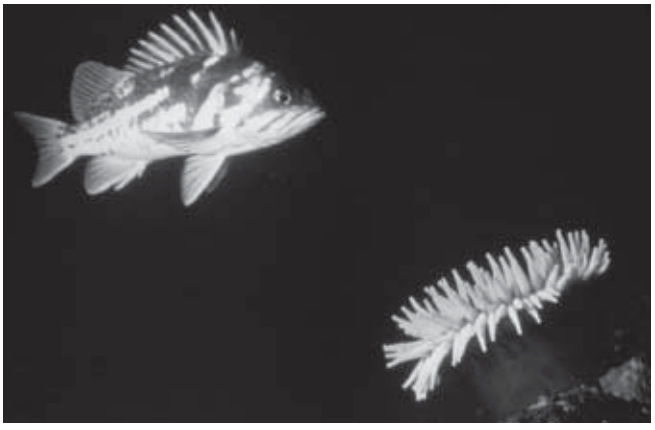
The copper rockfish was one of the first species of rockfishes to be described from the Pacific Coast, having been scientifically named in 1845 by John Richardson from Sitka, Alaska. For many years, the copper and whitebelly rockfish were considered as separate species but morphological and biochemical analyses in the 1980s have shown these two nominal forms to be conspecific, a highly variable-colored but genetically unique species. The copper rockfish is broadly distributed geographically, known from the Gulf of Alaska to off central Baja California, Mexico. It also has a broad bathymetric distribution, known to occur from the shallow subtidal to 600 feet.

As with all rockfishes, coppers are viviparous and highly fecund. A 13.4-inch female is capable of producing 215,000 ova and an 18.5-inch fish of producing 640,000 ova. The largest individuals may well produce over one million larvae. The larvae are released during winter months (Jan.-March). Young-of-the-year copper rockfish are pelagic and recruit into the nearshore environment at about 0.8 to 1.0 inch during April and May off central California. The newly recruited copper rockfish initially associate with canopy-forming kelps such as *Macrocystis*, *Cystoseira*, and *Nereocystis*. After several months, and at about 1.6 inches, the juveniles settle to the bottom on rocky reef as well as sandy areas and are referred to as benthic juveniles. Copper rockfish in the early juvenile stage are morphologically similar to two closely related species, gopher rockfish and black-and-yellow rockfish, and the three species at this life stage are extremely difficult to distinguish. Upon settling, color patterns and morphological characteristics develop and the three species become separable.

Copper rockfish are an important component of the nearshore rocky reef system and are frequently encountered by scuba divers in this environment. Submersible observations of the biotic community off the Big Sur coast revealed copper rockfish between depths of 70 and 325 feet. The majority of sightings were of individual (solitary) fish occurring over rocky reef or boulder fields and most frequently in areas of high relief. Occasionally, an individual was observed over sand. Coppers are considered epibenthic, normally occurring slightly above the substrate.

Tagging studies indicate that copper rockfish, for the most part, show little movement once they have settled to the bottom. Movement of up to one mile has been noted but the majority of tagged and recaptured copper rockfish are from the locality where they were originally taken. This life history characteristic makes species with high site fidelity susceptible to local depletion. In areas close to fishing ports and higher rates of utilization, fewer and smaller copper rockfish are caught.

Copper rockfish reach sexual maturity at about 11.6 inches total length (TL) for females and 14.6 inches TL for males. This is at about five years of age for females and seven years for males. Size and age for copper rockfish from off central California for the first five years are as follows: age zero, 3.6 inches TL; age one, 3.7 to 5.9 inches TL; age two, 4.2 to 9.4 inches TL; age three, 7.0 to 11.5 inches TL, and age four, 8.9 to 13.2 inches TL. There appears to be no significant difference in the growth rates between sexes.



Copper Rockfish, (*Sebastes caurinus*) and a sea anemone
Credit: CA Sea Grant Extension Program

Off central California, copper rockfish have been aged to 28 years for a 22.1-inch individual. Copper rockfish from Puget Sound have been aged to 34 years.

Copper rockfish feed on a wide variety of prey items. Crustaceans form a major part of their diet; these include *Cancer* crabs, kelp crabs, and shrimps. Squid of the genus *Loligo* and octopuses are also important food items. Fishes, which include young-of-the-year rockfishes, cusk-eels, eelpouts, and sculpins are important forage for larger individuals. Juvenile copper rockfish feed primarily on planktonic crustaceans.

Hybridization of copper rockfish with brown rockfish has been suspected in Puget Sound, but this has not been noted from anywhere else within their range.

Status of the Population

There has been no stock assessment of this species in California. However, there is compelling evidence that copper rockfish populations have severely declined in many areas and large individuals are noticeably less common than in past decades. Due to their solitary nature, high habitat specificity, and the size they can enter the fishery (as juveniles), the copper rockfish is a prime candidate for local depletion.

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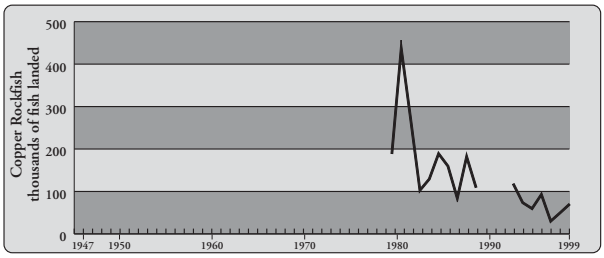

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Cowcod

History of the Fishery

Cowcod (*Sebastes levis*) are important to commercial and recreational fisheries in California. Estimated total catch peaked in 1976 at 213 tons, and then trended downward to 14 tons in 1999. Recreational catch of cowcod exceeded commercial landings between 1959 and 1980 but commercial catch has been larger since. Recreational landings peaked in 1976 at 154 tons, and then declined to less than two tons from 1997 through 1999. Commercial landings reached a record 155 tons in 1984. Fishing grounds nearest to major ports have been progressively exploited. Most of the remaining productive cowcod fishing grounds in the Southern California Bight are found well offshore, out-of-range for many private skiffs.

Cowcod reach the largest size of any rockfish in central and southern California, and are a highly prized trophy in the recreational fishery. The official California record for sport caught cowcod is 21 pounds 14 ounces, but the recreational fishery has produced confirmed specimens as large as 34 pounds in recent years.

Cowcod are caught along with other species of rockfish by the recreational fishery. Recreational effort is directed at cowcod from private fishing boats and commercial passenger fishing vessels (CPFVs). CPFVs include both charter boats (carrying a prearranged or closed group of anglers), and party boats (generally open to the general public, without prior reservation). The CPFV industry began in southern California around 1919, and by 1939 the fleet consisted of over 200 boats. CPFV operators targeted numerous species prior to 1950, such as tuna, giant sea bass, marlin, swordfish, mackerel, California halibut, kelp and sand bass, bonito, barracuda, and yellowtail. However, early reports do not list rockfish as a CPFV target group during the first half of the century.

Following World War II, there was a notable expansion of the CPFV fleet, and in 1953 it totaled about 590 boats. By 1963, the statewide CPFV fleet had declined to 476 vessels, 450 of which operated out of central and southern California ports. The majority of the 1963 CPFV fleet (256 vessels) was based in the Southern California Bight. Species of preference for the southern California CPFV fleet in 1963 did not include *Sebastes*, although rockfish were listed as an important part of the catch. As recently as 1969, there were reports that "some [CPFV] fishermen would rather fish for yellowtail, and catch little or nothing, than to take home a sack of rockfish. Those who prefer rockfish to yellowtail are in a minority." However, by 1974 attitudes of the typical CPFV fisherman had changed, and there was increased effort directed toward rockfish. With the decline in availability of "traditional" sportfish in the 1960-1970s, less lively "food" fish such as *Sebastes* were sought in order to maintain angler satisfaction.

Although highly sought in recent decades, cowcod have consistently composed a very small fraction of the recreational rockfish catch. Cowcod were estimated to comprise greater than one percent of the CPFV rockfish catch in 1961, 0.4 percent of total rockfish during the 1970s, and only 0.3 percent from 1985 through 1987. Cowcod seasonal catch in the sport fishery tends to peak in late autumn through early spring, which is the time of year when southern California CPFVs normally target bottom fishes.

Historically, commercial landings were highest in the Southern California Bight but landings in the Monterey area have been larger during most recent years. Hook-and-line and set net gear fished in deep water on rocky bottom accounts for the bulk of historical landings in the commercial fishery. Set net catches declined after 1989, but hook-and-line has remained important. Trawling accounts for most cowcod landings in northern areas. Trawls tend to take cowcod that are smaller and more often immature than fish taken by hook-and-line. Prior to 2000, discard of cowcod in commercial and recreational fisheries was probably insignificant. Beginning in 2000, new regulations limited commercial landings to one fish per trip, which may have resulted in increased discards.

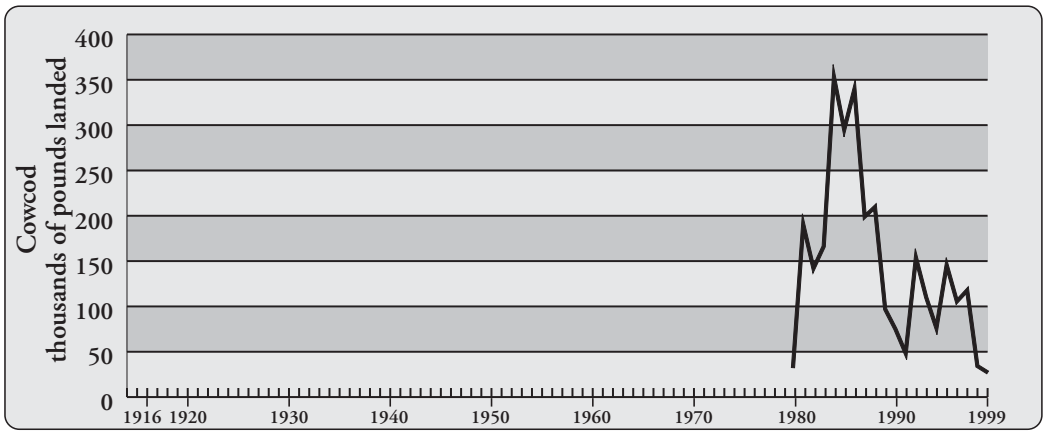
Fourteen species of rockfish have been landed in the cowcod market category; of these, the bronzespotted rockfish is the most common. Species associated with cowcod vary by gear type. In the trawl fishery, which is primarily in the Monterey management area, the main species taken with cowcod are chilipepper, bocaccio, and widow rockfish. In the hook-and-line and set net fishery, which is primarily in the Conception management area, bronzespotted rockfish, bocaccio, and vermilion rockfish are most important.

Cowcod are valuable in the commercial fishery. Fishermen received $1.37 per pound for cowcod in 1998, more than

Cowcod, *Sebastes levis*
Credit: DFG

Commercial Landings 1916-1999, Cowcod

Data Source: CalCom, a cooperative survey with input from Pacific Fisheries Information Network (PacFin), National Marine Fishery Service (NMFS), and California Department of Fish and Game (DFG). Data are derived from DFG commercial landing receipts with expansions based on port samples collected by PacFin samplers. Cowcod landings expansion data not available for 1979 and years prior to 1978.



cowcod landed by hook-and-line command higher prices than those landed by set net or by trawl.

Prior to 2000, the Pacific Fishery Management Council managed cowcod under regulations established annually for commercial groundfish, the *Sebastes* complex and remaining rockfish. Remaining rockfish were managed as a group without specific allowable biological catch or optimum yield levels for individual species. During those years, *Sebastes* complex cumulative trip limits were high relative to landings of cowcod, and it is unlikely that the regulations had affected commercial fishing for cowcod. Specific regulations to limit the commercial and recreational take of cowcod were first established in 2000. In order to achieve an optimum yield of 5.5 tons for recreational and commercial landings combined, the recreational bag limit in 2000 was reduced to one cowcod (with a maximum of two cowcod per boat), and commercial regulations allowed only one cowcod to be landed per fishing trip.

Status of Biological Knowledge

Cowcod range from central Oregon to central Baja California, and offshore to Guadalupe Island. The geographic center of distribution is the southern California Bight. They are uncommon off Oregon and northern California. Adult cowcod habitat is primarily rocky reefs from 165 to 1,000 feet, most of which are found in the vicinity of offshore banks and islands in the Southern California Bight. Smaller fish generally occur at the shallower end of the depth range.

As with other species of *Sebastes*, fertilization is internal and females give birth to first-feeding stage planktonic larvae during the winter. Gonad-somatic indices of females are highest from November through April. Peak abundance of cowcod larvae is January through April, with some larvae present from November through August. Larvae spend about 100 days in the plankton and settle to the bottom as juveniles at about two to 2.4 inches in length. In Monterey Bay, juveniles recruit to fine sand and clay sediments at depths of 130 to 330 feet during the months of March through September. Adults are found at depths of 300 to 1,680 feet usually on high relief rocky bottom. Cowcod reach 37 inches FL and 33 pounds.

Cowcod have been aged by counting annuli in sectioned and polished otoliths. Although age determinations have not been validated, there was good agreement among independent readers. Based on a sample of 259 specimens collected in the 1970s and 1980s, the youngest fish in the landings was age seven, and the oldest was age 55. Cowcod are thought to become fully recruited to recreational and commercial fisheries at age 17, which is similar to the age at which all females become mature.

The approximate length (inches) and age of first, 50 percent and 100 percent maturity is as follows:

	Male		Female	
Maturity	**Length (in)**	**Age**	**Length (in)**	**Age**
First	13.5	8	16.5	11
50%	17.5	12	17	11
100%	19	14	20	16

Status of the Population

Cowcod were reported to be abundant off southern California in the 1890s. However, the first formal stock assessment of cowcod was in 1999. Results of the assessment suggest that spawning biomass in 1916 was near the

virgin level and it remained stable through a rather long historical period (1916-1950). Biomass began to decline slowly in the 1950s and accelerated through the 1970s. Recruitment declined dramatically and biomass continued to decline after the early 1980s. The best estimate of cowcod spawning biomass in the Southern California Bight during 1998 is 262 tons, which is about seven percent of the estimated unfished stock size.

Based on the results of the 1999 stock assessment, cowcod were formally declared overfished by the National Marine Fisheries Service in 2000. A rebuilding plan will be adopted to provide assurance that abundance will be restored to 40 percent of the unfished stock size in a minimal length of time. However, due to the unproductive nature of the stock, it is likely that rebuilding will require many decades.

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Other Nearshore Rockfishes

History of the Fishery

Historically, many of the nearshore rockfishes have been taken primarily by recreational anglers fishing from boats, the shore, or by diving. Kelp rockfish (*Sebastes atrovirens*), gopher rockfish (*Sebastes carnatus*), black-and-yellow rockfish (*Sebastes chrysomelas*), China rockfish (*Sebastes nebulosus*), grass rockfish *(Sebastes rastrelliger*), and treefish (*Sebastes serriceps*) have been minor components of recreational and commercial fisheries. Gopher rockfish is the only species of these six that comprised a significant proportion of recreational landings and was common enough in commercial landings to have a market category prior to 1994. Gopher rockfish have comprised up to 13 percent annually of commercial passenger fishing vessel (CPFV) observed landings from the Morro Bay area. A review of the marine recreational fishery statistics survey (MRFSS) catch data from 1980 to 1999 indicated recreational catches of grass rockfish, China rockfish, gopher rockfish and kelp rockfish have declined since the late 1980s and landings of treefish were higher from 1993 to 1999 than 1980 to 1989. While the MRFSS provides catch information for shore and vessel-based angling, divers are not represented. The "private/rental boat" method contributed the highest proportion of the gopher rockfish recreational catch for all of California. China rockfish have accounted for up to three percent of CPFV observed catches from San Francisco north. Both China rockfish and gopher rockfish are most frequently observed in CPFV and private boat catches. Grass rockfish, kelp rockfish, black-and-yellow rockfish and treefish are more frequently caught by anglers fishing from private boats than by anglers fishing from CPFVs or from shore.

Development of the live/premium fishery in the late 1980s resulted in increasing commercial catches of many species occupying the nearshore environment in and around kelp beds, including these six rockfishes. Live fish are taken primarily by line gear and pot and trap gear, but other gear types are used. The fishery serves mainly Asian American markets that demand top quality (live) fish. Fishermen receive premium prices for their catches ranging from $2 to $10 per pound, compared to $1.50 per pound or less previously. Grass rockfish command the highest prices up to $4.84 average price per pound in 1998. With the exception of treefish, these nearshore rockfish species are caught primarily north of Point Conception.

Historically, commercial landings have been recorded by both specific (gopher rockfish) or nonspecific (gopher group) market categories and until 1994 there were no specific market categories for any of these nearshore species except gopher rockfish. Annual total landings by species are difficult to determine due to the inexact nature of recording landings. Market categories are often comprised of multiple species; for example, sampled market categories from the Morro Bay area from 1993 to 1998 revealed a wide range of placement of the six species in both group and single species categories. Gopher and grass rockfish appeared most frequently in nine other market categories than their own. The most common classification error seemed to occur between gopher and black-and-yellow rockfishes with 34.4 percent of the black-and-yellow market category being made up of gopher rockfish. The gopher group contained up to 61 percent gopher rockfish. While species misidentification does occur, fish are often grouped by price rather than by species complicating specific landing estimates. Based on DFG CMASTER summaries of reported landings, landings of gopher and grass rockfishes and the gopher group peaked at 31,255 pounds ($35,740 value) in 1994, 109,003 pounds ($506,670) in 1995, and 221,018 pounds ($521,163) in 1996, respectively.

The live fish market demand is mainly for fish in the one to two pound size range, and up to four pounds for grass rockfish. For gopher, black-and-yellow, grass, and China rockfishes, this size range is above the size of sexual maturity, although in the development of the fishery all fish were kept regardless of size. Due to concerns over the harvest of immature fish, legislation passed in late 1998, the Marine Life Management Act, implemented minimum commercial size limits on grass, gopher, kelp, black-and-yellow, and China rockfishes. The new size limits are 12 inches for grass and China rockfishes, and 10 inches for gopher, kelp, and black-and-yellow rockfishes. The shallow, nearshore nature of this fishery renders it very weather dependent. Poor weather, combined with lower overall allowable catches, implementation of minimum size limits, and a lack of a market north of Bodega Bay resulted in reduced catches from 1997 to 1999.

Several of these species are also important in non-consumptive uses. Colorful, accessible, or both, treefish and

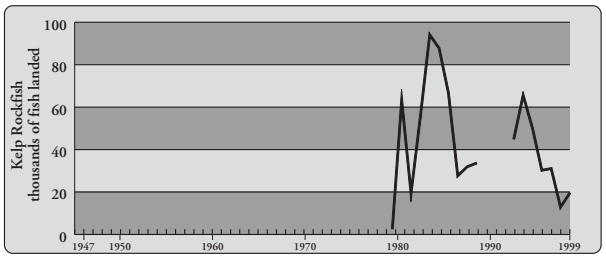
Gopher Rockfish, *Sebastes carnatus*
Credit: DFG

kelp, black-and-yellow, gopher, and China rockfishes are frequently observed and photographed by divers. In addition, individuals are taken for the aquarium trade.

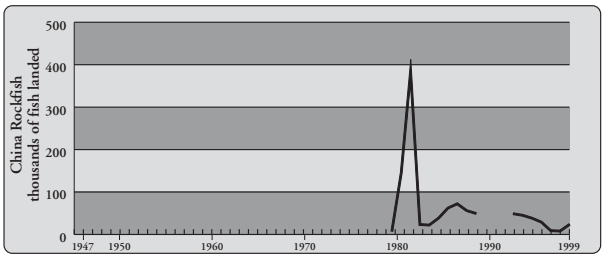
Status of Biological Knowledge

Kelp, black-and-yellow, gopher, and grass rockfishes are relatively well studied, while treefish and China rockfish are, to differing degrees, less well-known. Most of these species occupy restricted ranges of geography or habitat. The treefish is most common in depths of less than 100 feet or so on rocky reefs, and is restricted largely to the region south of Point Conception. Kelp, black-and-yellow, and gopher rockfishes are not abundant north of Sonoma County (or farther south, for kelp rockfish), and range south to the region of Point Eugenia, Baja California. Each has a restricted habitat, with kelp rockfish occurring almost exclusively in kelp forests, black-and-yellow rockfish occurring in high-relief rocky bottom at depths shallower than about 60 feet, and gopher rockfish occurring on rocky reefs from 40 feet to perhaps 150 feet. The geographical range of the grass rockfish extends throughout California and into southern Oregon, but its habitat is restricted to rocky areas shallower than about 20 feet.

The China rockfish is abundant into Washington, British Columbia, and southeastern Alaska, declining in abundance south into California. It is quite rare south of Point Conception, and seems to inhabit progressively deeper water in the southern part of its range. The ranges for some of these species have changed in the last 15 to



Recreational Catch 1947-1999, Kelp Rockfish
Data Source: RecFin data base for all gear types; data not available for 1990-1992



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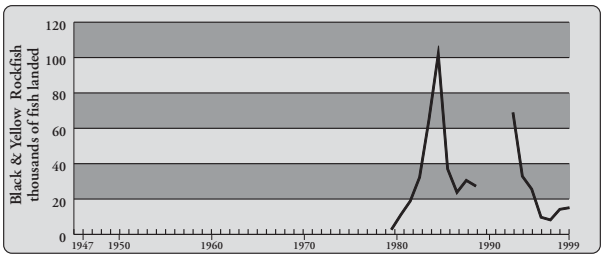
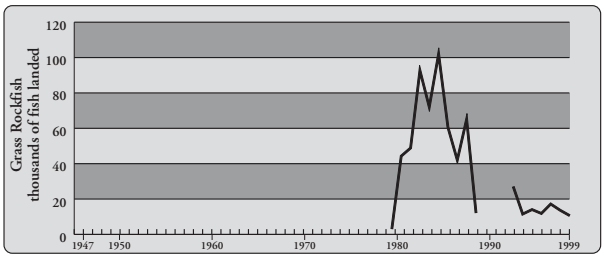


Recreational Catch 1947-1999, Black & Yellow Rockfish
Data Source: RecFin data base for all gear types; data not available for 1990-1992



Recreational Catch 1947-1999, Grass Rockfish
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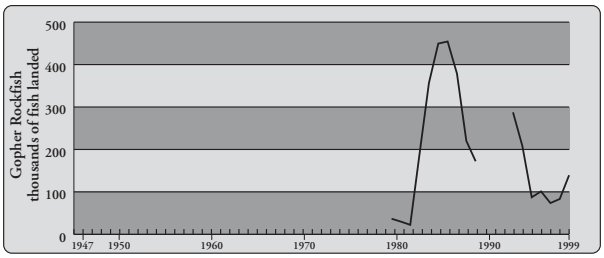

Recreational Catch 1947-1999, Gopher Rockfish
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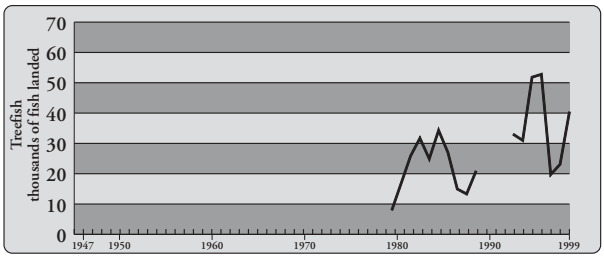

Recreational Catch 1947-1999, Treefish
Data Source: RecFin data base for all gear types; data not available for 1990-1992

20 years. Black-and-yellow rockfish and kelp rockfish abundance have declined since the early 1970s in the northern Channel Islands, and probably throughout the Southern California Bight. Little has been documented on northward range expansion for these species, and nothing has been documented regarding changes in the ranges of gopher, China, and grass rockfishes. The treefish seems to be more abundant now in the Monterey area than in the 1980s. These changes in distribution seem to be related to ocean warming that began in 1977.

Five of the six species are relatively small for rockfish. The grass rockfish, at about 20-22 inches, reaches the largest size of the six species. The largest individuals of the other five species rarely exceed 15-17 inches; among the five, the China rockfish reaches slightly larger sizes than the others, followed in rough order by treefish, kelp rockfish, gopher, and black-and-yellow rockfishes. Treefish have not been aged, but at least one study of age and growth has been conducted on kelp, black-and-yellow, gopher, grass, and China rockfishes. The greatest ages recorded in each of these five species are between 20 and 26 years. However, because the largest individuals observed in each species have typically not been aged and because aging to date has been based largely on readings of whole otoliths, greater maximum ages may be possible. Different studies have produced different estimates of age at first maturity, perhaps because of differences in goals and methodology. In the five species that have been aged, many studies suggest that first maturity occurs in the range of three to four years, although one study indicates later maturity.

Treefish and kelp, black-and-yellow, gopher, and China rockfishes appear to reproduce once per breeding season. Grass rockfish may reproduce only once per season, but some contradictory data exist. There are no data on spawning seasonality in treefish, but the other five species appear to spawn in winter through spring. Grass rockfish seem to reproduce the earliest, giving birth primarily in December through February (except for an observation in August), China rockfish reproduce slightly later, black-and-yellow and gopher rockfishes slightly later still (spawning through early spring), and kelp rockfish the latest, spawning through May and June.

The adult movement of most of these species may be even more restricted than other rockfishes. Individual black-and-yellow, gopher, and kelp rockfishes have been shown to inhabit restricted home ranges, and it is likely grass rockfish, China rockfish, and treefish share this behavior. Aggressive behavior has been observed in all except grass rockfish (for which observations are limited), and gopher rockfish and black-and-yellow rockfish are definitely territorial. However, some evidence from artificial reefs suggests that typically sedentary individuals may occasionally wander indeterminate distances, on the order of tens of meters, from their home ranges.

Available data suggest that diets of juvenile fish of all six species include primarily crustacean zooplanktors such as barnacle cyprids. Overall adult diets are more varied. Crustaceans and small fish are common diet items for adult fish of all six species. Kelp rockfish also eat cephalopods, gastropods, polychaetes, and tunicates. Cephalopods and gastropods are consumed by gopher rockfish as well, along with ophiuroids (brittle stars) and polychaetes. Black-and-yellow rockfish and China rockfish also consume ophiuroids. A variety of mollusks are consumed by China rockfish including cephalopods, gastropods, chitons, and nudibranchs. Small fish consumed by these rockfishes include juvenile rockfish (mainly blue rockfish), sculpins, juvenile surfperch, kelpfishes, and plainfin midshipman. Information on diet of treefish is limited.

Status of the Populations

While there have been several studies of local abundance in some of these species (particularly black-and-yellow, gopher, and kelp rockfishes), there is no comprehensive assessment of their populations. Each species is probably subject to local depression in abundance and average size where diving, skiff fishing, party boat activity, or commercial fishing is concentrated. The low fecundity, restricted habitats, and limited movements of these species make them vulnerable to local fishing pressure. Statewide, the limited geographic ranges and restricted habitats of these species suggest that they have small populations in comparison to more widespread species that have traditionally been the targets of commercial fishing. These species have limited depth distributions so that all of the spawning population is vulnerable to fishing and few natural refugia probably exist. Because good recruitment years are infrequent there is the danger of removing too many spawners even with limited fishing pressure.

Management Considerations

See the Management Considerations Appendix A for further information.

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Olive Rockfish

History of the Fishery

Olive rockfish (*Sebastes serranoides*) form a minor part of the commercial fishery in central and southern California, where they are primarily taken by hook-and-line. A relatively small number find their way into the live fish fishery. Historically, olive rockfish have been common in the recreational fishery as far north as Fort Bragg and were particularly important from central California to the northern Channel Islands. As late as the 1980s, olives were a very important recreational species throughout much of southern California. However, a combination of overfishing and poor juvenile survival brought about by changes in oceanographic conditions led to a steep decline (83 percent) in southern California party vessel catches between 1980 and 1996. In addition, while they were still commonly taken in the central California recreational catch, olive rockfish also declined there in the late 1990s.

Status of Biological Knowledge

Olive rockfish are streamlined fish with almost no head spines. Their body color is dark brown or dark green-brown on the back and light browns or green- brown on sides. There are a series of light blotches on the back. The fins range from olive to bright yellow, and olives are often mistaken for yellowtail rockfish. Olive rockfish are somewhat drabber in appearance, and yellowtail rockfish have red-brown flecking on the scales. They reach a maximum length of two feet.

Olive rockfish occur from southern Oregon to Islas San Benitos (central Baja California) from barely subtidal waters to 570 feet (the latter based on a trawl specimen collected by the Southern California Coastal Water Research Project). They are common from about Cape Mendocino to Santa Barbara and around the Northern Channel Islands from surface waters to about 396 feet. Olives appear to be uncommon off much of both southern California and Baja California.

Olive Rockfish, *Sebastes serranoides*
Credit: DFG

From April to September, young-of-the-year olive rockfish, around 1.2 to 1.6 inches long, settle out of the plankton to kelp beds, oil platforms, surfgrass and other structures at depths as shallow as 10 feet. During the day, young fish aggregate in the water column, occasionally with blue and black rockfish. They spend the night near or on the bottom, sheltering under algae or among rocks. Young olives also are found under drifting kelp mats. Olives about 2.5 inches long become more active at night, but it is not clear whether adult olives are nocturnal. They do feed commonly on octopuses, which are more available at night. Sub-adult and adult olives live over high relief reefs, as well as around the midwaters of oil platforms. In shallow waters, they are found throughout the water column and occasionally rest on the bottom. They form small to moderate-sized schools and a few often are mixed with blue rockfish schools. From tagging studies, most olive rockfish move relatively little; a maximum movement of 20 miles has been reported.

Olive rockfish live at least 25 years. Females grow larger, and, beginning at maturation, tend to be longer at a given age. Males reach maximum length earlier. Throughout California, males mature at a somewhat smaller size and a slightly greater age than females, however the difference is not large. Off central California, a few fish were mature at 10.6 to 11.2 inches (three years), 50 percent were mature at 12.9 to 13.7 inches (five years), and all were mature by 15.2 inches (eight years). Females release larvae once a year from December through March, peaking in January. Females produce between 30,000 to 490,000 eggs per season. Small juveniles are planktivorous, feeding on copepods, gammarid amphipods, cladocerans, euphausiids, other crustaceans and fish larvae. As they grow, their diet shifts to fishes, such as juvenile rockfishes, squids, octopuses, isopods, polychaete worms and krill.

Status of the Population

There has been no stock assessment of this species. However, there is clear evidence that olive rockfish have declined in abundance south of Pt. Conception.

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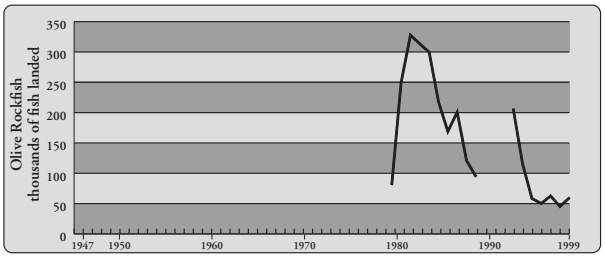

Recreational Catch 1947-1999, Olive Rockfish

Data Source: RecFin data base for all gear types; data not available for 1990-1992

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Quillback Rockfish

History of the Fishery

Quillback rockfish (*Sebastes maliger*) are a minor component of the commercial passenger fishing vessel (CPFV) fishery and in general are only observed from the ports of Monterey northward. Only in the Eureka area does this species rank among the 10 most frequently observed benthic sport fishes caught by CPFV anglers. In the Fort Bragg area, quillback rockfish ranked between 13 and 17 among benthic sport fishes caught by CPFV anglers, and their importance in the fishery diminishes with decreasing latitude. A survey of all recreational sport fishing modes from 1981 to 1986 indicated an average annual harvest of approximately 9,000 fish.

Commercial landings of the "quillback rockfish" market category are significant only from the San Francisco area northward. However, historical landings are difficult to determine because of the low frequency of quillback rockfish and confused identification with other similar species. Statewide landings in this market category in 1999 comprised less than 0.3 percent of all rockfishes. Since 1992, this market category has not been used every year and when used, may have consisted of several different species.

Status of Biological Knowledge

The quillback rockfish was first described by Jordan and Gilbert in 1880. Also referred to as orange-spotted, yellow-back, or stickleback rockfish, it is part of central and northern California's nearshore benthic assemblage.

Quillback rockfish are relatively small, and are of "stout" morphology; a characteristic common among nearshore *Sebastes* found in close association with the bottom. They are usually orange-brown to black in color with a yellow or orange pale area between the eye and pectoral fin. This pale area is also present as a saddle on the first few dorsal spines and as speckling on the mid-dorsal surface. A characteristic that helps distinguish this species from similar species is its long dorsal spines and deeply notched forward dorsal fin membranes. Copper rockfish and other nearshore shallow dwelling rockfish also have deeply notched first dorsals but not so much as quillback.

Quillback rockfish are known from the Gulf of Alaska to Anacapa Passage in southern California, and are considered common between southeast Alaska and northern California. They are found from near the surface to a depth of 900 feet and can be common at depths of several hundred feet.

Like other *Sebastes* of shallow, benthic habit, individual quillback rockfish are not known to range far. Tagging studies in central California and Washington have shown quillback to be residential (no movement) or to show movement of less than six miles. They have also demonstrated homing ability and day-night movement patterns.

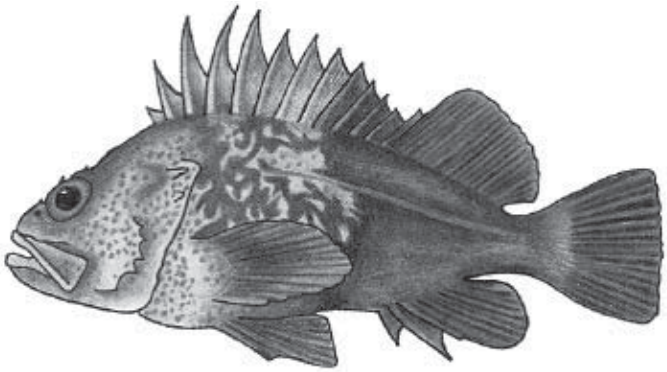
In California, quillback rockfish have been aged to 15 years, but are known to live longer, as they have been aged to 76 years in Canada. Quillback can grow to 24 inches, and growth rates differ along its range. In California, size for a 12-year-old quillback is approximately 7.1 inches. Size at first maturity for males is 8.7 inches (four years), and for females is 10.2 inches (six years). In California, size at 50 percent maturity for males and females was found to be the same as for first maturity.

As with all *Sebastes*, quillback have internal fertilization and produce live young. In California, mating takes place in the late winter and early spring, with birth occurring from April through July. After roughly one to two months in the plankton (0.7 to 2.8 inches), they begin to settle near shore.

As planktonic larvae and after they settle, quillback rockfish feed on other planktonic animals and eggs. As adults they feed on a variety of prey such as crustaceans, especially shrimps; small fish, including rockfishes and flatfishes; clams; marine worms; and fish eggs.

Quillback rockfish larvae are subject to predation by jellyfish and arrow worms. As juveniles, they are preyed upon by fishes, including larger rockfishes, lingcod, cabezon and salmon. Various marine birds and pinnipeds eat juvenile quillback as well. Adults are also subject to predation by larger fishes including some sharks, as well as sea lions, seals, and possibly, river otters.

Juveniles inhabit very nearshore bottom areas and are found over both low and high rocky substrate. They are sometimes found among sponges and algae that provide shelter. Adults are most often found in deeper water and are solitary reef-dwellers living in close association with the bottom. They are often seen perched on rocks or taking shelter in crevices and holes. Adults have also been noted to retreat to eelgrass beds at night. Quillback



Quillback Rockfish, *Sebastes maliger*
Credit: L. Sinclair
Miller and Lea

are also associated with the rock-sand interface, but are rarely seen in the open away from suitable cover.

Status of the Population

While no stock assessment has been done for quillback rockfish in California, length-frequency data exist on their occurrence in the recreational fishery in northern and central California, as well as in the commercial fishery from the same region. Between the late 1980s and mid-1990s, quillback rockfish experienced increased take by the commercial fishery as the market demand for premium, live fish increased, yet no significant trend was noted in the average size of fish. Fishing pressure has relaxed somewhat in recent years because of restrictions placed on the fishery. Concern over sustainability of the commercial and recreational nearshore fishery has made this species of particular interest to managers.

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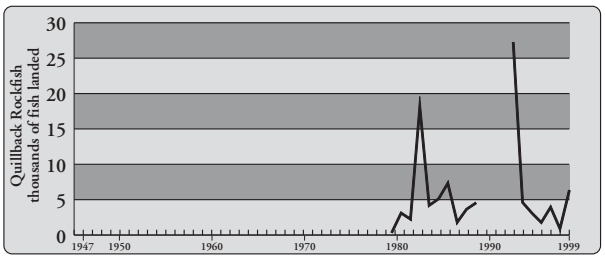
California Department of Fish and Game



Recreational Catch 1947-1999, Quillback Rockfish
Data Source: RecFin data base for all gear types; data not available for 1990-1992

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Vermilion Rockfish

History of the Fishery

Vermilion rockfish (*Sebastes miniatus*), though highly desirable because of their brilliant color and the flaky texture of their flesh when cooked, are only of moderate importance in California's commercial and sport fisheries.

It is difficult to accurately determine what percent of the commercial catch is comprised of vermilion rockfish, because individuals in reported landings are often misidentified or combined with other red and orange-colored rockfishes in the market category of "rockfish, Group Red." From 1991 to 1993, vermilion rockfish landings were less than 2,000 pounds annually, statewide. This may be in part because, prior to 1994, there was no printed market category for vermilion rockfish on landing receipts; thus, they were only designated by species when fishermen added the category. Since 1994, "Rockfish, vermilion" has been a printed market category on landing receipts. From 1994 to 1999, pounds landed for both market categories progressively declined. During this period annual landings quotas became more restrictive. Commercial landing in the San Francisco area in 1994 and 1995 accounted for 59 percent of statewide landings. From 1996 through 1998, this percentage declined to 44, 28, and 17, respectively. From 1996 through 1998, the Eureka area reported the highest landings within the state (54 percent average for the three-year period).

Vermilion rockfish comprised less than two percent of all landed fishes observed on commercial passenger fishing vessels (CPFV) from Fort Bragg to Monterey from 1992 through 1995. During this same period, they constituted between six and eight percent of all landed fishes observed on CPFVs from Port San Luis and Morro Bay and averaged 14 inches in length. Along lightly fished areas of the central coast, fish of comparable size comprised eight percent of the total CPFV catch. Fish taken north of Monterey by CPFV anglers were slightly larger on average. In a survey of southern California CPFVs from 1985 through 1987, vermilion rockfish ranked third in species composition and represented eight percent of the total observed rockfish catch. Between 1983 and 1988, they ranged from two to five percent of the observed commercial catch of rockfish landed south of Point Conception.

The average size of observed vermilion rockfish taken by recreational hook-and-line anglers fishing from Point Piños to Yankee Point in Monterey County, based on creel surveys at the Monterey Harbor, declined from 1981 to 1999. The average size was 18.8 inches in 1981, 16.1 inches in 1983, 15.5 inches in 1985, and 14.3 inches in 1987. In 1999, the average size rose to 15.5 inches.

Vermilion rockfish are marketed primarily in a fresh dressed form. Because the flesh has a short freezer life, it is rarely frozen. These rockfish are best when filleted, skinned, and deep-fried. They are also delicious when baked with vegetables in the oven or microwave. As with most other members of the family, the flesh is white, fine in texture, and mild in flavor.

Status of Biological Knowledge

Vermilion rockfish are found from the San Benito Islands, Baja California, to Prince William Sound, Alaska, and occur over rocky bottoms from the shallow subtidal to 1,400 feet. Large fish are more common at depths greater than 100 feet due to the combined fishing pressure in shallower waters from commercial and recreational fishermen. Vermilion rockfish generally remain on the same reef system on which they settle during their first year. Tagging studies have shown no movement of fish at liberty for one to three years. Vermilion rockfish are extremely long-lived. A 20-inch individual weighing 5.4 pounds was aged, using surface aging, at 25 years. Lengths up to 30 inches have been reported. Vermilion rockfish have lengthy juvenile life stages. Fifty percent of the population is mature at eight years and these fish average 14 inches. The slow growth and long juvenile period make vermilion rockfish very susceptible to overfishing. Once large individuals are removed from a reef system they are replaced only by larval settlement.

Peak spawning months are September in central and northern California and November in southern California. The number of developing eggs increases from 63,000 in a fish 12.5 inches long to about 1.6 million in a 21.5-inch fish. Females are fertilized internally by males. In October of 1997, while conducting population scuba surveys of subtidal fishes in Point Lobos Ecological Reserve, Monterey County, California, several vermilion rockfish courtship displays were observed and videotaped by divers from California Department of Fish and Game. The absence of previously published description of vermilion rockfish mating or courtship may be due to the scarcity of mature individuals in habitat shallow enough to allow routine observations. Newly released larvae are free swimming and lead a pelagic existence for three to four months,

Vermilion Rockfish, *Sebastes miniatus*
Credit: DFG

mers and tend to be very secretive, often taking refuge in dense algae.

The pelagic young of vermilion rockfish feed primarily upon crustaceans, while adults feed on octopus, squid, and small fishes such as anchovies and blue lanternfish. At times, macroplanktonic organisms such as euphausiids, pelagic red crabs, and pyrosomes (pelagic colonial tunicates) are found in their stomachs.

Status of the Population

In 1995, mean total length of observed vermilion rockfish taken during CPFV trips in central and northern California were consistently above the size of sexual maturation. Larger individuals and higher catch per-angler-hour were generally observed when fishing occurred in deep water and greater than 10 nautical miles from ports. Based on adjusted logbook data from San Simeon, Port San Luis, and Morro Bay, an estimated 23,000 vermilion rockfish were landed by CPFV anglers in 1995. This total is 2.7-fold higher than the combined estimate (8,530) from the remaining central and northern California ports.

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Yellowtail Rockfish

History of the Fishery

Yellowtail rockfish (*Sebastes flavidus*), frequently called "greenies" by commercial fishermen, are a major component of the groundfish fishery. Over the period from 1983 to 1998, yellowtail rockfish accounted for 13 percent of all rockfish landed on the U.S. West Coast and six percent of all groundfish, exclusive of Pacific whiting. Among the rockfish/rockcod, only widow rockfish have supported a greater West Coast harvest. The center of yellowtail rockfish population abundance is off the states of Oregon and Washington, with lower abundance off California. Even so, from 1980 to 1998, the total combined landings among all yellowtail rockfish fisheries in the state have ranged from 370 to 2,460 tons per year, with an average catch over that period of 1,080 tons per year. Catches exceeded 2,200 tons per year during 1982 and 1983, declined to 550 tons per year through 1988, rose to levels above 1,100 tons per year from 1989 through 1992, and then declined to about 550 tons per year thereafter. After bocaccio and blue rockfish, yellowtail rockfish was the third most abundant rockfish taken in the California recreational fishery for several years.

Over the last two decades, the recreational fishery has been responsible for a substantial portion of the yellowtail rockfish catch in California, accounting for over one-third of all landings. Among the commercial fisheries, trawl fishing has produced the greatest catch (28 percent of total landings), but hook-and-line and setnet fisheries have also been important, accounting for 24 percent and 13 percent, respectively. Thus, yellowtail rockfish have been harvested in significant quantities by all groundfish fisheries in the state, perhaps more so than any other species, with the exception of bocaccio.

The northern distribution of the yellowtail rockfish stock is distinctly evident in the commercial landings statistics compiled from each port of landing within the state. Of the combined "greenie" catch, 94 percent has been taken from Monterey north. Similarly, in the recreational fishery 86 percent of the catch has come from northern California waters. There are, however, differences in the types of commercial fishing conducted at each port. For example, from Fort Bragg north, trawling has been the primary method of harvesting yellowtail. In contrast, commercial fisheries in San Francisco, Bodega Bay, and Monterey have relied more heavily on hook-and-line and setnet fixed gear to capture this species. In recent years, the setnet fishery has declined to negligible quantities, but from 1983 to1986 large quantities of yellowtail rockfish were taken in the gill net fishery that operated between Monterey and San Francisco.

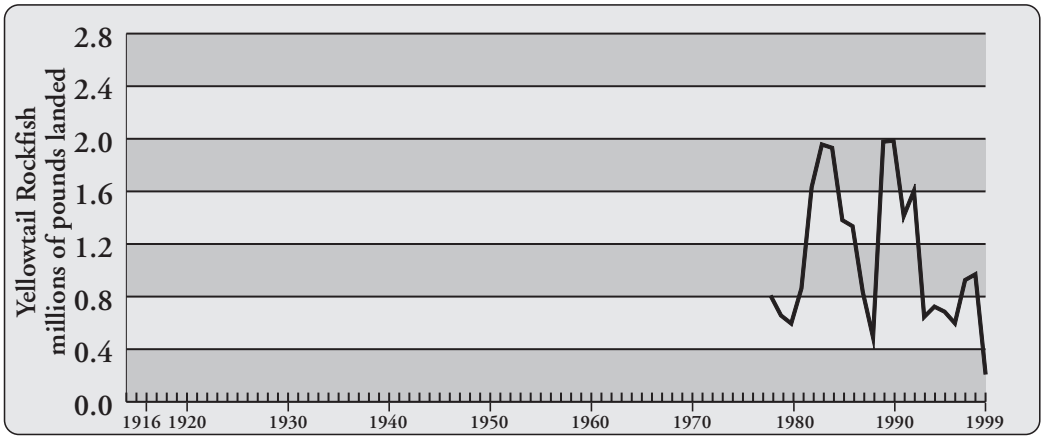
Yellowtail Rockfish, *Sebastes flavidus*
Credit: J. Mello DFG

Status of Biological Knowledge

Yellowtail rockfish are found from Kodiak Island, Alaska to San Diego, although they are rare south of Point Conception. They are wide-ranging and are reported to occur from the surface to 1,800 feet and are known to form large schools, either alone or in association with other rockfish, including widow rockfish, canary rockfish, redstripe rockfish, and silvergray rockfish. They are primarily distributed over deep reefs on the continental shelf, especially near the shelf break, where they feed on krill and other micronekton.

There is some controversy about the existence of distinct stocks of this species. Some allozyme and parasitological evidence supports the view that multiple stocks exist, whereas other genetic data indicate one single coastal stock. Within U.S. waters, the species is currently managed as two stocks, with a separation at Cape Mendocino, although that boundary is purely based on human considerations, including differences in fishing patterns and data availability.

Like many other species of rockfish, yellowtail are long-lived. The age distribution of fish sampled in commercial fisheries off Oregon and Washington can span six decades, with the oldest known specimen a 64-year-old male. They typically reach their maximum size at about 15 years of age and the largest recorded specimen was a 28-inch female. Females begin to mature at 10 to 15 inches, with half reaching maturity by a size of 15 to 18 inches; males do not grow quite as large as females.



Commercial Landings 1916-1999, Yellowtail Rockfish
Data Source: CalCom, a cooperative survey with input from Pacific Fisheries Information Network (PacFin), National Marine Fishery Service (NMFS), and California Department of Fish and Game (DFG). Data are derived from DFG commercial landing receipts with expansions based on port samples collected by PacFin samplers. Expansion data not available for years prior to 1978.

Status of the Population

A recent assessment of the northern portion of the population indicates that unlike many of our rockfish stocks, the resource is very healthy. Based on a wide variety of information collected over the last 30 years or more, population abundance is currently believed to be about 77,000 tons, down to 60 percent of the virgin population size, but still well above the target population size, which is 40 percent of the unexploited level.

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National Marine Fisheries Service

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California Scorpionfish

History of the Fishery

The California scorpionfish (*Scorpaena guttata*) is a valuable commercial fish in southern California. For many years, the fishery experienced a long decline, with peak catches of 223,000 pounds in 1925 and fluctuating catches thereafter. However, the rise of the live fish fishery in the 1990s led to the fishery's resurgence, as this species' bright red color and hardiness after capture has made it a favorite target. Today, about 85 percent of the commercial California scorpionfish catch goes to the live fish fishery. Catches in 1998 totaled about 75,000 pounds valued at $175,000. Most fish are taken in traps or by hook-and-line.

California scorpionfish are a moderately important part of the sport fishery in southern California. They are taken primarily from party boats and private vessels, and occasionally from piers and jetties, mostly from Point Mugu southward.

Status of Biological Knowledge

California scorpionfish are easily distinguished from most other California fishes. They are a relatively heavy-bodied species, with strong head and fin spines, ranging in color from red to brown, often with purple blotches and always covered with dark spots. They reach a length of 17 inches.

California scorpionfish live from tide-pool depths to about 600 feet (usually in about 20-450 feet) from Santa Cruz to southern Baja California, and in the northern part of the Gulf of California. Preferring warmer water, the species is common as far north as Santa Barbara. While they are most abundant on hard bottom (such as rocky reefs, sewer pipes and wrecks), they are also found on sand.

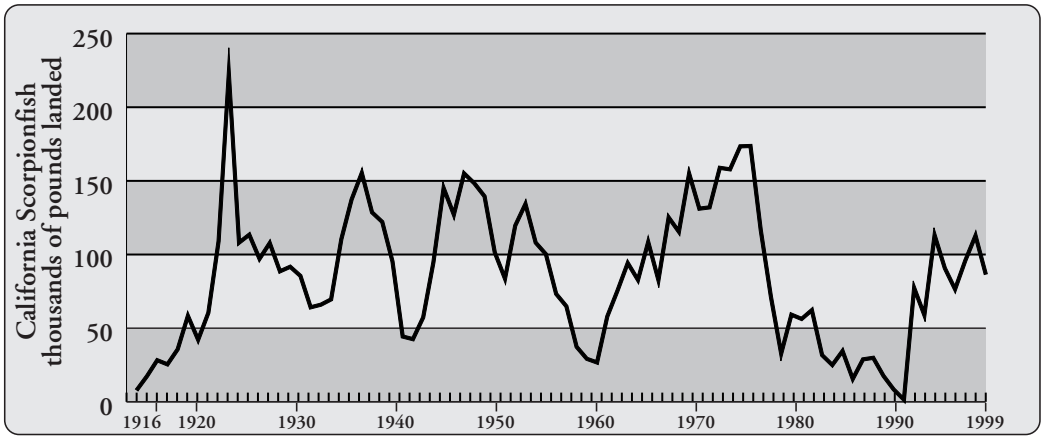
California scorpionfish grow to 17 inches and some live at least 21 years. After four years of age, females grow faster than males and reach a larger size. Although a few fish mature at six inches (one year), over 50 percent are mature by seven inches (two years) and all reproduce by nine inches (four years). Spawning occurs from April to August, peaking in June and July. Scorpionfish are oviparous, have external fertilization, and females produce eggs imbedded in the gelatinous walls of hollow, pear-shaped "egg-balloons." These paired structures, each five to 10 inches long, are joined at their small ends. The walls of these "balloons" are about 0.1 inch thick, transparent or greenish in color, and contain a single layer of eggs. Each egg is about .05 inch in diameter. The egg masses float near the surface and the eggs hatch within five days. Very young fish live in shallow water, hidden away in habitats with dense algae and bottom-encrusting organisms. Small crabs are probably the most important food of California scorpionfish, although other items, such as small fishes, octopuses, shrimps and even pebbles are sometimes eaten. These animals are primarily nocturnal and feed at night. Octopuses prey on small individuals. California scorpionfish make extensive spawning migrations in late spring and early summer, when most adults move to 12 to 360 foot depths, forming large spawning aggregations on or near the bottom. During spawning, these aggregations rise up off the bottom, sometimes approaching the surface. Spawning occurs in the same areas year after year, and it is likely that the same fish return repeatedly to the same spawning ground. When spawning ends, the aggregations disperse and many (though not all) of the fish move into shallower waters.

The sharp spines on the dorsal, anal and pelvic fins are poisonous. The toxin is produced in glands that lie at the base of each spine and run up to the tip through a groove. A wound, although painful, is seldom fatal, and bathing the wound in hot water can reduce the pain. The heat alters the toxin's structure making it harmless. One should be careful not to make the water so hot as to damage tissue.

Status of the Population

No population estimates exist for California scorpionfish. However, data from trawl studies conducted by the Los Angeles County Sanitation Districts, Southern California Coastal Water Research Project and the Orange County Sanitation District from 1974-1993 show that there are substantial short-term fluctuations in California scorpionfish abundance within the Southern California Bight.

California Scorpionfish, *Scorpaena guttata*
Credit: DFG



Commercial Landings 1916-1999, California Scorpionfish
Data Source: DFG Catch Bulletins and commercial landing receipts.

Management Considerations

See the Management Considerations Appendix A for further information.

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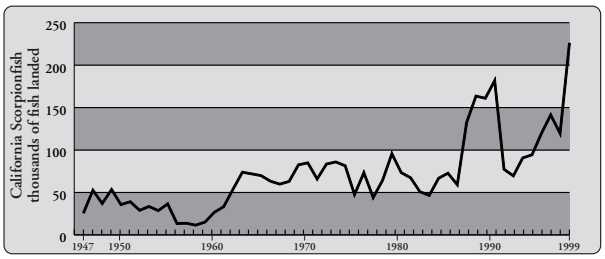

Recreational Catch 1947-1999, California Scorpionfish
CPFV = commercial passenger fishing vessel (Party Boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

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Albacore

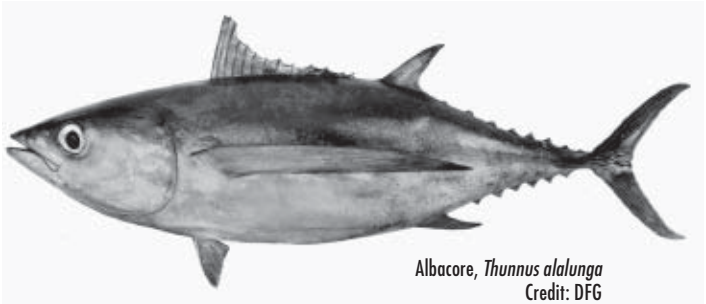
History of the Fishery

Albacore (*Thunnus alalunga*) is a highly migratory species that has been targeted by California's recreational anglers and commercial fishermen for more than 100 years. Currently, it ranks among the state's most important marine fish resources, in terms of both economic value and sport-related benefits. Commercial landings of albacore at California ports have increased from $4 million to $10 million (ex-vessel dollars) on an annual basis since 1996. In recent times, the recreational fishery for albacore has contributed at least $25 million per year to California's economy through angling-related expenditures.

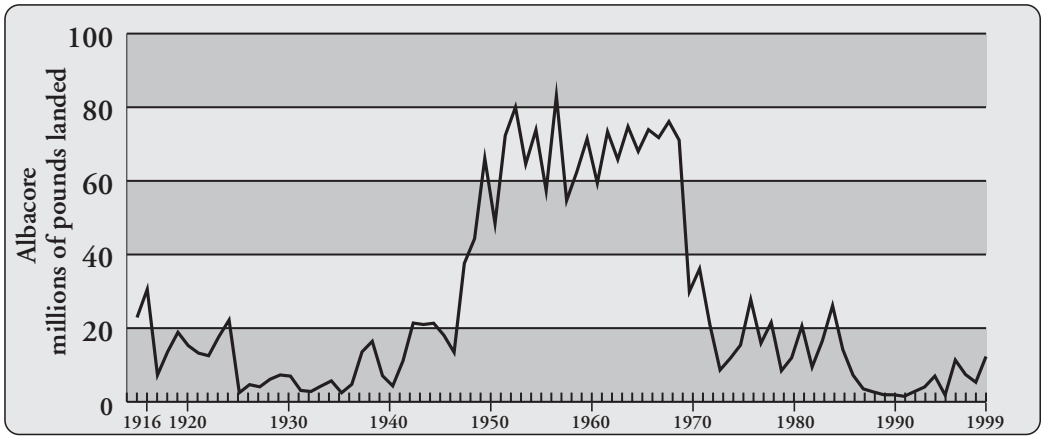
The commercial fisheries for albacore developed rapidly following the first canning operations of this species in 1903 in San Pedro Bay, California. The vast majority of albacore commercially harvested by California fishermen is processed as canned "white meat" tuna that generally commands premium prices in the marketplace. Through the first quarter of the 20th century, the tuna-canning industry and its related fisheries endeavored to meet increasing demands for seafood, particularly packed products that had a long shelf life. The commercial fisheries for albacore continued to expand through the mid-1940s, extending northward to coastal waters off northern California, Oregon, and Washington, and westward to the central Pacific Ocean, several hundred miles off the California coast. The geographic expansion of the fisheries slowed during the 1950s through the mid-1960s, but the flourishing market continued, with record landings during this period that averaged roughly 30 million pounds annually. During the mid-1970s, the commercial fishing fleet extended farther into the central Pacific Ocean, with some vessels fishing north and west of the Hawaiian Islands, as far as the International Date Line. Since the 1980s, the albacore fisheries of California have typically operated within roughly 900 miles of the U.S. Pacific coast; the distance largely dependent on the stock's migratory route in any given year. California's commercial fishery for albacore has generally concentrated on the North Pacific albacore stock during the summer and fall seasons as the fish move through waters of the northeastern Pacific Ocean during their annual migration. However, in recent years during the winter months, some vessels have also targeted the South Pacific albacore stock that inhabits waters off New Zealand's east coast between the International Date Line and 110˚W longitude. Commercial landings of albacore in California have varied over the last decade, ranging from a high of 12.3 million pounds in 1999 to a low of 1.8 million pounds in 1995.

During the early years of California's commercial fisheries for albacore, pole-and-line (live bait fishing) and troll (artificial-jig fishing) gears were used extensively. Other gears, such as longlines, purse seines, and drift gillnets have also been used by California fishermen, but trolling operations have dominated since the early 1980s and now contribute over 90 percent of the annual catch of albacore. Generally speaking, troll, pole-and-line, purse seines, and drift gillnet vessels operate in surface fisheries that target two to five-year-old fish (juvenile albacore) in the upper portions of the water column, and longline vessels operate in subsurface fisheries that harvest five to ten year-old fish (adult albacore) from deeper waters. California-based troll vessels, or jig boats, can be broadly classified into two groups – relatively small boats (30-50 feet in length) that typically carry a crew of two or three fishermen, spend one to three weeks at sea, and target albacore in inshore waters; and larger boats (50-90 feet in length) that commonly operate with three to five fishermen, spend one to two months at sea, and fish both inshore and offshore waters. Historically, commercial fishing effort for albacore has fluctuated over the past 100 years, based primarily on market and oceanic conditions. For example, from 1916 to 1925, about 300 vessels equipped for one-day trips participated in the fishery, operating exclusively in coastal waters. The commercial fleet that fished the central Pacific Ocean, as well as inshore waters, grew steadily over the next 25 years, reaching 3,000 boats in 1950. The number of vessels declined during the 1950s, and by 1960, 1,000 boats were involved in the fishery. During the 1970s, the commercial fleet began to increase once again to over 2,000 vessels, but by the late 1980s and through the 1990s, fewer than 500 boats typically landed their commercial catches at California ports.

Albacore are harvested commercially by countries other than the United States, including Japan, Taiwan and South and North Korea in the western Pacific Ocean, and Canada and Mexico in the eastern Pacific Ocean. Currently, the California troll fishery accounts for roughly 10 percent of the total commercial landings of North Pacific albacore, with Japan (75 percent) contributing the largest amount, followed by Oregon/Washington, Taiwan, and Canada (about five percent each). In a typical year, during the late spring and summer, the Japanese pole-and-line fleet will target the juvenile albacore as they



Albacore, *Thunnus alalunga*
Credit: DFG



Commercial Landings 1916-1999, Albacore
Data Source: DFG Catch Bulletins and commercial landing receipts. Data includes shipments and landings from areas north and south of the state between 1916 and 1969.

form identifiable schools and begin their annual migration in waters off the east coast of Japan to the central Pacific Ocean (Emperor Seamount). In the summer and into the fall, the U.S. and Canada troll fleets will follow the albacore as they continue their migration to the eastern Pacific Ocean and coastal waters off the U.S. Pacific Coast.

Recreational fishing for albacore developed during the early 1900s, when vessel owners in southern California first realized that the angling community was very willing to charter their boats for fishing. As the popularity of albacore increased, as a food and sport fish, so did the partyboat (commercial passenger-carrying fishing vessels or CPFV) industry. In the very early years of the sport fishery, only a few CPFV trips were made, concentrating in waters around the Channel Islands; however, by the mid 1950s, more than 100 CPFVs carried anglers to other inshore waters in pursuit of the stock as it conducted its annual migration. The CPFV industry continued to grow during the 1960s, with increases in fishing capacity and range, which allowed boats to carry more anglers and venture further from port in years when the albacore remained farther offshore. Over the last 10 years, from 40 to 60 large CPFVs, that typically accommodate from 15 to 60 anglers for one-to three-day trips, have fished for albacore in California waters, mostly based in southern California, with several operations further north in Morro Bay and San Francisco. Additionally, from 60 to 90 smaller CPFVs have routinely operated in California since the early 1990s, with these vessels usually carrying six to 10 anglers on one-day fishing excursions. Catches of albacore on CPFV trips have been highly variable over the years, based largely on the migratory behavior of the stock in any given year. For example, in 1994, as the stock approached the coast of North America, the bulk of the population traveled north to waters off Oregon and Washington, resulting in a poor fishing season for recreational anglers in California, where less than 200 albacore were landed on CPFV-related trips. In 1999, the stock took a more southerly route as it neared the U.S. Pacific Coast and spent much of the summer and fall in inshore waters off southern California and northern Mexico, where anglers on CPFVs landed a total of 258,448 fish – the highest total on record. The long tradition of albacore sport fishing in California is not only due to the CPFV industry, but also an increasing number of anglers that fish from privately-owned boats. Both represent an enthusiastic sport fishery that anxiously awaits the arrival of the first pulse of albacore to California's inshore waters each summer. Sport fishing in California typically peaks during the mid-summer months (July and August) as the bulk of the stock travels to inshore waters off the U.S. Pacific Coast. However, arrival and departure times associated with the stock's migration through U.S. owned fishing grounds have varied substantially over the years, with spring arrivals and winter departures frequently observed.

The actual operations of most fisheries, including those associated with albacore, are essentially defined in accordance with the biological characteristics and ecological relations exhibited by the species. This is particularly true for albacore and its related fisheries, given that the migration and distribution patterns of this species are highly influenced by the prevailing oceanographic conditions.

Status of Biological Knowledge

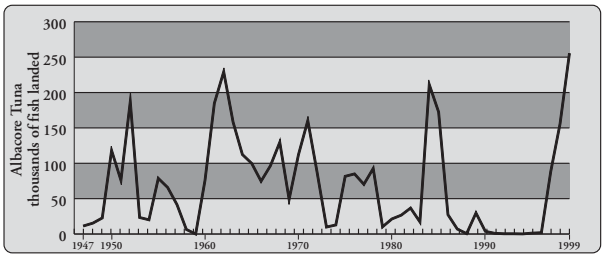
Albacore are members of the Scombridae family, which includes 40 to 50 species of tuna and mackerel, 23 of which are found, for at least a part of their life, in North American waters. Albacore, as well as other species of tuna, have unique biological characteristics that enable them to swim continuously at very high speeds and cover vast areas during annual migrations. Albacore are literally

built for speed, with torpedo-shaped (fusiform) bodies, smooth skin, and streamlined fins, and can reach speeds of more than 50 miles per hour for short periods of time. Albacore are metallic dark blue along the back, with dusky to silvery white coloration along the sides and on the belly. The pectoral fins are exceptionally long, extending to nearly half the length of the body, and albacore are commonly referred to as longfin tuna. In addition to these morphological adaptations, albacore possess highly specialized physiological functions that allow for rapid movement and sustained endurance. First and foremost, many tuna, including albacore, have a highly evolved circulatory system that includes countercurrent exchangers that act to reduce the loss of heat generated by increased muscular activity, allowing them to regulate their body temperature and ultimately, increase the efficiency of their muscles. Additionally, albacore have higher blood pressure and volume than most of the other species of fish.

Albacore are widely distributed throughout the world's oceans in tropical, sub-tropical, and temperate zones. The North Pacific albacore stock, the population targeted by both the commercial and recreational fisheries of California, is centered around 35° N latitude in the Pacific Ocean. This stock's distribution extends from the central (west) coast of Mexico to the Gulf of Alaska in the eastern Pacific Ocean, and from the equator to the north (east) coast of Japan in the western Pacific Ocean. The actual boundaries of the stock's range depend largely on the season of the year and oceanic conditions. Currently, fishery researchers are uncertain whether the population of albacore inhabiting the North Pacific Ocean is strictly a single stock or possibly, composed of two (or more) stocks. Results from some tagging experiments indicate that substocks of albacore may exist in the North Pacific Ocean, based on differences in migratory routes, growth and mortality rates, and size distributions of the commercial catches. However, more information concerning albacore biology and genetics is needed before definitive conclusions can be drawn regarding the stock structure of the North Pacific population of albacore.

As stated previously, the North Pacific albacore stock, particularly juveniles, typically complete an expansive annual migration that begins in the spring and early summer off Japan, continues throughout the late summer into inshore waters off the U.S. Pacific Coast, and ends late in the year in the western Pacific Ocean. It is generally believed that oceanic conditions strongly influence both the timing and geographical extent of the albacore's migration in any given year. Migrating albacore concentrate along thermal discontinuities (oceanic fronts) associated with waters of the Transition Zone in the North Pacific Ocean. The vast majority of albacore are caught in waters with sea-surface temperatures (SSTs) that range from 59˚-67˚F. The migrating fish are typically bounded by these thermal gradients as they conduct their round-trip travel across the Pacific Ocean. Although the bulk of the migrating stock is typically observed within this SST range, telemetry studies have shown that this species will spend brief periods of time in much colder water (49˚F). Upwelling, where nutrient-rich waters from the ocean depths rise to the surface, is another important phenomenon associated with oceanic fronts and ultimately, an event that highly influences the distribution of the migrating albacore. It is likely that the albacore are attracted to upwelling fronts, given these areas are very productive and contain much forage for predatory fish such as albacore. Although scientists are quite certain that oceanic fronts define albacore distribution and thus, vulnerability to fisheries, they feel other oceanographic parameters also influence the migratory behavior of the stock, including salinity, ocean color and clarity, and vertical thermal/density structure. In general, catches from the commercial fisheries indicate that albacore are most abundant along the warm side of upwelling fronts in clear blue oceanic waters that are associated with salinity gradients between 33 and 35 parts per thousand and well defined thermoclines. Recent research indicates that the fish adjust their behavior to very different oceanic conditions when passing through at least four distinct physical regimes (geographical strata) of the North Pacific Ocean. Thus, determining what are the most influential environmental parameters depends on where in the ocean and what time of year the assessment is conducted.

Albacore are top carnivores in the ocean ecosystem and opportunistically prey on schooling stocks, such as sardine, anchovy, and squid. Albacore are preyed upon by man, as well as the larger species of billfish, tuna, and sharks. Similar size albacore travel together in school groups that contain small aggregations of fish, which collectively, can be up to 19 miles wide. At the onset of the migration, during the spring and summer months in the western Pacific Ocean, the young albacore form relatively small, loose, and broadly scattered groups. As the seasons progress, the groups become more compact and contain greater numbers of schools. The more sedentary, older albacore typically form more compact schools. Generally



Recreational Catch 1947-1999 , Albacore Tuna

Data Source: DFG, commercial passenger fishing vessel logbooks.

speaking, albacore schools are not as large or as dense as those of some of the larger schooling tunas, such as yellowfin and skipjack. Bluefin, yellowfin, and skipjack tunas are occasionally caught along with albacore by the surface fisheries off the U.S. Pacific Coast. Although albacore spend much of their time in the surface waters of the ocean, they will also explore deeper waters of the thermocline in search of prey.

North Pacific albacore mature at roughly five to six years of age (approximately 33 inches in length). Peak spawning of albacore in the Pacific Ocean is generally believed to occur in subtropical waters centered around 20˚N and 20˚S latitude. It is assumed that the North Pacific albacore stock spawns from March through July on grounds located in the western and central Pacific Ocean. There is some information, albeit limited, that albacore may spawn multiple times in a year. Albacore are believed to be pelagic spawners that broadcast their gametes in open water, often near the surface, with fertilization being external. Estimates of female fecundity (number of eggs) range from 0.8 to 2.6 million eggs per spawning. The early life history of albacore is not clearly understood, but very young albacore (larvae and juveniles in their first year of life) are believed to remain relatively close to the spawning grounds and eventually, congregate in waters south and east of Japan prior to beginning their first migration.

Approximate growth rates for North Pacific albacore are as follows: age-one fish are 14.2 inches and 2.2 pounds; age-two fish are 20.5 inches and 6.5 pounds; age-three fish are 25.6 inches and 12.7 pounds; age-four fish are 30 inches and 20.3 pounds; age-five fish are 33.5 inches and 28.3 pounds, and age 10-12 fish can reach up to 55.0 inches and over 100 pounds. Albacore are believed to reach a maximum age of roughly 11-12 years, although interpretations of age for older fish are typically subject to increased uncertainty and thus, longevity cannot be strictly defined at this time. The sex ratio of juvenile albacore is approximately one to one, but males appear to outnumber females as the fish age, e.g., the sex ratio of the catches from the longline fisheries, which target adult fish, is generally skewed towards higher numbers of males than females.

Status of the Population

Fishery researchers generally agree that the North Pacific albacore population is currently a relatively healthy stock that has responded favorably to rates of exploitation over the last decade or so. Recent assessments of the entire stock indicated that sustainable yields, on a global basis, likely range between 176.4 and 220.5 million pounds, roughly the level of total annual catch observed during the latter part of the 1990s. For example, the combined commercial and recreational landings in 1999 (U.S. and foreign) was approximately 209.5 million pounds. Catches and fishing effort associated with U.S. fisheries for albacore, both commercial and recreational, were considerably higher in the latter part of the 1990s than during the early and mid 1990s, which is baseline information that generally indicates the population has responded relatively well to recent levels of exploitation. Catch-per-unit-effort (CPUE) data from the U.S. troll fishery, a fishing statistic often used as an index of population size, has been relatively constant over the last 10 years (30 to 60 fish per day), with the exception of 1996 and 1998, when fishing success peaked at roughly 100 fish per day. The CPUE statistics from the pole-and-line fishery of Japan, which harvests juvenile albacore similar to the U.S. troll fleet, have been generally consistent since the early 1990s as well, with the trend increasing noticeably during the late 1990s. The CPUE time series associated with the Japan longline fishery, which targets adult albacore and larger juveniles, indicates a productive stock that has been increasing in size since the early 1990s. It is more difficult to assess the status of the overall population using CPUE data from the recreational fisheries, given the influence of oceanic factors on albacore's migratory behavior. It is likely that catch and fishing effort associated with the North Pacific albacore stock will remain at or slightly above current levels into the near future, given favorable oceanographic and market conditions.

Although fishing pressure is likely an important factor that influences albacore abundance in the North Pacific Ocean, it must necessarily be interpreted in the context of the overall condition of the stock's environment. That is, albacore abundance in the North Pacific Ocean has fluctuated considerably over the last several decades, with strong and weak periods occurring intermittently, based largely on the ocean's carrying capacity in any given year.

Management Considerations

See the Management Considerations Appendix A for further information.

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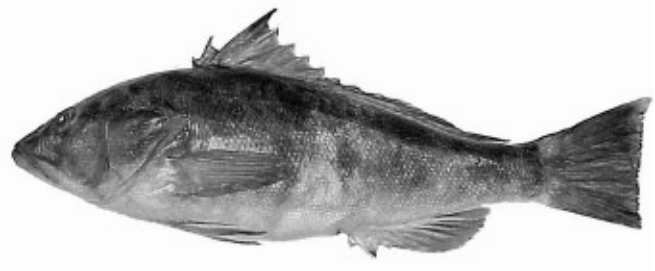
Barred Sand Bass

History of the Fishery

Barred sand bass (*Paralabrax nebulifer*) are commonly caught by anglers in California. Since the late 1970s, this species has consistently ranked among the top 10 species in the southern California marine sport fish catch. The major barred sand bass fishing sites include the Silver Strand, Del Mar, San Onofre, Huntington Flats area off Orange County, the inshore portion of northern Santa Monica Bay off Pacific Palisades and Santa Monica in Los Angeles County, and the Ventura Flats area off northern Ventura County. Barred sand bass are targeted exclusively by sport anglers; the commercial harvest of this species has been illegal since 1953. Throughout the 1930s and early 1940s, sand bass, as well as kelp bass, were not considered to be quality angling fare but gained tremendously in popularity as game fishes by the mid-1950s. At that time, concern about the resource by sport fishermen and fishery managers resulted in the initiation of life history studies and the formulation of conservation measures. By 1959, a 10-fish bag limit and a 12-inch minimum size limit had been imposed on all three kelp and sand bass species, measures designed to counteract the declining numbers, and shrinking size composition of the bass catches. The commercial passenger fishing vessel (CPFV) bass fishery responded positively to this management regime, and landings of kelp and sand bass increased substantially through the 1960s and early 1970s. From 1975 through 1989, the CPFV barred sand bass catch expanded threefold to a peak of 400,000 fish in 1988. Although lacking some of the sporting qualities of kelp bass, barred sand bass are much more susceptible to hook-and-line gear and are somewhat easier to catch. When CPFV skippers target barred sand bass aggregations, they can usually produce substantial catches for their passengers, even for novice anglers possessing minimal fishing skills. In 1985, 1987 and 1988, barred sand bass was the leading bass species in the CPFV catch exceeding kelp bass landings for the first time since 1961 when kelp bass and sand bass landings were first reported separately. Estimates of annual barred sand bass landings from all sport fishing activities (shore, pier, private boat, CPFVs, etc.) ranged as high as 1,940,000 in 1988. The CPFV landings of barred sand bass remained stable at around 600,000 fish from 1993 to 1996, but declined dramatically thereafter. On average, landings of barred sand bass in the 1990s were about 40 percent lower than those in the 1980s.



Barred Sand Bass, *Paralabrax nebulifer*
Credit: DFG

Status of Biological Knowledge

Barred sand bass range from Santa Cruz south to Bahia Magdalena, Baja California, Mexico. They are rare north of Point Conception. Sand bass chiefly inhabit the shallow waters near the southern California mainland, but have been captured at depths as great as 600 feet, but the greatest concentrations are found in depths less than 90 feet. Young sand bass are abundant in very shallow water (five to 30 feet). The name "sand bass" is somewhat unfortunate since they are usually closely associated with sand/rock interfaces of deep reefs and artificial structures and are rarely found out over sandy expanses.

Barred sand bass feed mainly on small fishes (including anchovies, sardines, midshipman), and invertebrates such as crabs, clams, and squid. The largest barred sand bass on record measured 26 inches in length, and the maximum-recorded weight was 11.1 pounds. Like their sympatric congener the kelp bass, barred sand bass are also relatively slow growing. A juvenile barred sand bass is approximately six inches long after one year, and reaches sexual maturity between seven and 10.5 inches in length and about three to five years. The oldest known barred sand bass was found to be 24 years old.

Barred sand bass form large breeding aggregations over sandy bottoms at depths of 60-120 feet in the summer months. Spawning occurs in these aggregations from April through November, usually peaking in July. During spawning, high-contrast, gray and white individuals with large golden-yellow crescents under their eyes are usually males. Sand bass produce a large number of small pelagic eggs that enter the plankton in coastal waters. Young-of-the-year sand bass begin appearing in shallow, nearshore waters in the early fall.

DFG tagging studies have revealed that barred sand bass are capable of movements of from five to 40 miles. In the early 1970s, evidence was presented that tumors, deformities, and other anomalies found in barred sand bass may have been linked to industrial and domestic wastes discharged into the nearshore environment. Reports of such abnormalities have decreased in the past two decades.

Status of the Population

The barred sand bass catch rose steadily in importance from 1975 to late 1989, to the point where sand bass are rivaled only by kelp bass in the nearshore recreational catch off southern California. From 1975 to 1978, barred sand bass ranked in the top ten in CPFV catch. By 1986 to 1989, barred sand bass consistently ranked in the top three species and was the top ranked species in CPFV catch in 1988. CPFVs and private boats take the majority of sand bass while fishing the summer spawning aggregations. Several factors seem to account for the upward trend. Most significantly, CPFVs, which account for the greatest portion of the barred sand bass catch, have begun to target them more frequently, especially during the summer spawning period. The fish are concentrated at that time, usually in well-defined areas along the coast. Also, new barred sand bass spawning sites have been discovered over the last 20 years and are now being exploited by CPFVs and private boats. As fishing effort targeting barred sand bass has increased, there has been concern that the stock may become over-exploited. Although, more information must be collected before the impacts of this intense fishing on barred sand bass populations can be determined, landings have recently begun to decline and there is cause for concern.

Management Considerations

See the Management Considerations Appendix A for further information.

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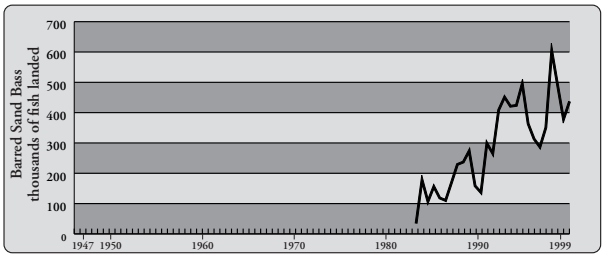

Recreational Catch 1947-1999, Barred Sand Bass
CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks. Prior to 1973, Barred Sand Bass abd Kelp Bass CPFV catch data were aggregated.

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Blue Shark

History of the Fishery

Blue sharks (*Prionace glauca*) are not a major target of California's recreational or commercial fisheries. Urea stored in their blood system quickly turns to ammonia when the shark dies, thus rendering the meat unpalatable. Development of a quality meat product has been the limiting factor in creating commercial interest. Only two serious attempts at developing a quality food product in California have occurred. The first took place in 1979 and 1980 when one vessel fished blue sharks experimentally with longline gear. Product quality was judged to be good enough to establish blue shark as a viable alternate fishery, and 150,000 pounds dressed meat were sold at about $0.25 per pound. Although market interest developed in several western states, a steady demand could not be assured and the fishery was discontinued.

The second attempt at developing a food product began in 1988 with an experimental longline fishery directed at shortfin mako and blue shark. Participants in the fishery were required to develop a market for human consumption with the bycatch of blue sharks, which were not released alive. In 1989 and 1990, a total of 54,000 pounds of blue shark was sold for making jerky and "fish and chips." It was clear from these attempts, however, that a quality food product and related market had not been achieved. Participants in the fishery substantially reduced the incidental mortality of blue sharks by developing a hook removal tool, which allowed up to 88 percent of the blue shark catch to be released alive. As a result, the requirement to develop a wholesale market for blue sharks was dropped in 1991. Between 1991 and 1999, the commercial harvest of blue sharks dropped to 37,500 pounds.

The recreational catch of blue sharks grew tremendously throughout the 1980s. Estimated annual catch increased ten-fold between 1981 and 1988 with over 400,000 angler-trips on private boats, which had "sharks" (including mako sharks) as the primary or secondary target species. Although angler effort for "sharks" remained high throughout the 1990s, blue shark harvest continually declined. This may be due to the fact that most blue sharks are released alive. Shark fishing trips aboard commercial passenger fishing vessels (CPFVs) are offered from most southern California sport fishing landings from two to seven nights per week during the summer.

The greatest source of fishing mortality for southern California blue sharks in the past three decades probably occurred as a result of their incidental capture during the developing years of the drift gillnet fishery for swordfish and thresher sharks. Annual estimated bycatch in the late 1970s and early 1980s was between 15,000 and 20,000 blue sharks. Changes in season length, fleet size, time-area closures and the use of large mesh nets substantially reduced blue shark mortality, although there are no reported estimates of current mortality in this fishery.

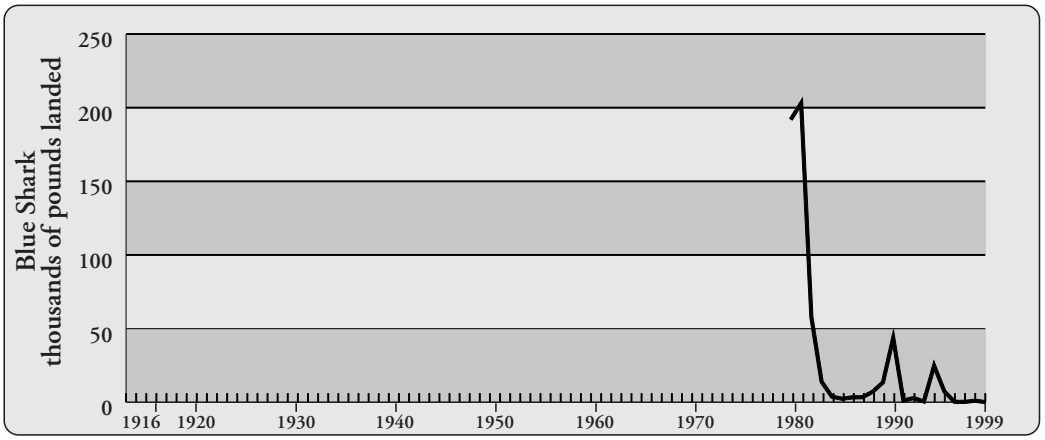
Blue Shark, *Prionace glauca*
Credit: DFG

Status of Biological Knowledge

The blue shark is an oceanic-epipelagic and fringe littoral species with a circumglobal distribution. It is found in all temperate and tropical oceans and is thought to be the most wide-ranging shark species. Although this species can be found in oceanic waters between 43˚F and 82˚F, it is most commonly found in cooler water temperatures between 45 F and 61˚F. In tropical waters, blue sharks show submergence and are typically found at greater depths. In temperate waters, blue sharks are caught within the mixed layer and generally range between the surface and the top of the thermocline, but have been documented as deep as 2,145 feet. In the Pacific, blue sharks are most predominant between 35˚N and 45˚N.

Age and growth studies of blue sharks indicate that they may reach maturity in six to seven years, although there may be regional differences in growth. They are thought to be opportunistic feeders at all life stages and prey primary on small pelagic fishes, crustaceans, and cephalopods. Blue sharks off southern California have also been shown to exhibit seasonal dietary shifts when prey such as squid become abundant during their mass spawning events.

The blue shark is viviparous with a yolk-sac placenta. Litter size is quite variable ranging from four to 135 pups and may be dependent on the size of the female. In the Pacific, it is thought that mating occurs during the summer months in the equatorial region from May through August. Gestation period is thought to range from nine to 12 months and may vary depending on location. Off California, mating occurs in late spring to early winter. The Southern California Bight is a major birthing area and is generally considered a nursery area for immature blue



Commercial Landings 1916-1999, Blue Shark
Data Source: DFG Catch Bulletins and commercial landing receipts. All shark landings were aggregated under the market category "unspecified shark" until 1977.

sharks. Female blue sharks have been shown to exhibit sperm storage, which may also explain variability in gestation period estimates. Late-term pregnant females are found in the northern Pacific in summer months where they give birth to large, well-developed pups averaging 14 inches. This suggests that mature females in the Pacific may only reproduce every other year.

Seasonal migrations are thought to occur in the Atlantic, Pacific, and Indian Ocean populations with seasonal periods of sexual segregation. A shark tagging program recently initiated by the department may further elucidate the migratory movements of blue sharks in the eastern Pacific. However, because no blue shark-tag and recapture programs have been initiated in the central Pacific, the extent of blue shark migration in the central Pacific is still unconfirmed.

Blue sharks appear to aggregate in loose schools and are generally caught more frequently over depths greater than 3,300 feet. They exhibit daily diving behavior similar to that of other pelagic fishes and sharks and appear to show a fair degree of niche overlap with swordfish. Blue sharks are incidentally caught in pelagic longline tuna and swordfish fisheries in the Pacific and can seasonally comprise the largest percentage of the catch in these fisheries. In recent years, there has been an increase in the number of blue sharks taken in the tuna and swordfish longline fishery in Hawaii, where sharks are "finned" at sea, and the fins are then sold to Asian markets. The meat is seldom landed and sold at market due its low commercial value.

Based on spatial and temporal changes in blue shark abundance in the Pacific, it is suspected that the north-south difference in catch rates of blue sharks is mediated by the transition zone. This is the area of water between the cooler Aleutian Current and the warmer water from the North Pacific Current. This transition zone shifts from 31° N and 36° N in the winter to 41° N and 36° N in the fall. Most of the larger catches of blue sharks have been made in or just south of this zone.

Diel movements of blue sharks acoustically tracked off southern California and in the North Atlantic indicate that adult blue sharks increase their activity at night and make shallower dives than during the day. Sharks tracked off southern California ventured inshore at night, presumably to feed on seasonally available spawning squid. The cyclical diving behavior is thought to serve as a hunting, orientation, and/or thermoregulatory function.

Although adult blue sharks are opportunistic feeders and prey mainly on small pelagic fishes, cephalopods, and crustacean, they have also been observed scavenging on marine mammal carcasses at sea. Unfortunately, there are few data on the diet composition of blue sharks in the central Pacific.

Status of the Population

The size of California's blue shark stock is unknown. Local abundance undergoes major seasonal fluctuations with juveniles to three year olds most abundant in the coastal waters from early spring to early winter. Mature adults are uncommon in coastal waters.

Fishery-dependent data needed for determining abundance, mortality, etc. are lacking because blue sharks are usually discarded at sea and the catch often goes undocumented. Local abundance depends on recruitment of juveniles and immigration of individuals from Mexico and offshore into California waters. Although there are no abundance estimates (local or Pacific-wide), some fishermen and field biologists speculate that there are fewer blue sharks than there were 10 to 20 years ago. The combined mortality from recreational anglers, commercial set net and drift net fisheries, Mexican fisheries and foreign high seas fisheries undoubtedly has the potential

to impact the population and the local blue shark stock to an unknown extent. Currently though, all research and statistics indicate that blue shark populations within California waters remain within healthy levels.

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California Barracuda

History of the Fishery

The California barracuda (*Sphyraena argentea*), also known as the Pacific barracuda, has played a significant role in the growth and development of California's commercial and sport fishing industries. Taken primarily off southern California and northern Baja California, Mexico, barracuda figured prominently in the development of the purse seine fishery. Additionally, they have long been a major component of the southern California sport fish catch.

Annual records of commercial barracuda landings date back to 1889, but only nine years of intermittent records exist through 1915, and these are not specific as to catch areas. Commercial landings of barracuda in 1889 were 0.5 million pounds, and by 1915 they were up to 3.6 million pounds. Since 1916, landing records have differentiated barracuda caught in California waters (essentially off southern California) from those caught in waters south of the international border with Mexico (northern Baja California). By 1916, The southern California purse seine fleet consisted of at least seven vessels by 1916. Influenced by the economic impetus of World War I, the commercial barracuda fishery grew concurrently with the rapid development of the purse seine fleet.

Attempts to manage the barracuda fishery began in 1915 with a minimum size limit of 18 inches for hook-and-line caught barracuda. Since then, many commercial and sport regulations on gear, seasons, weight, size, and bag limits have been enacted, modified, or repealed. Today, most commercially caught barracuda are taken by gillnets with 3.5-inch mesh, although some are taken by hook-and-line. The minimum size limit is 28 inches. May and June are usually the peak months of commercial fishing activity for barracuda.

Between 1915 and 1970, commercial landings of barracuda harvested from California's nearshore waters averaged 2.1 million pounds annually, despite a gradual decline in landings since 1925. Landings have remained relatively low since 1970, averaging about 113,500 pounds annually. Prior to 1926, California barracuda harvested south of the international border exceeded those catches made in California. Barracuda harvest from Mexican waters remained an integral part of the California fishery until 1969, averaging over one million pounds annually. But over the past 30 years, landings have been insignificant, averaging only 600 pounds annually. The major cause for the decline was the imposition of increasingly restrictive commercial fishing regulations by Mexico which became increasingly restrictive to California fishermen over the years.

In general, commercial barracuda prices are a function of supply and demand. Historically, the price paid to fishermen has been low. In 1999, commercial fishermen received an average price of $0.70 per pound.

The popularity of California barracuda as a game fish goes back to at least the mid-1920s, as is evident from photographs and newspaper accounts. However, the California Department of Fish and Game (DFG) did not begin collecting records of commercial passenger fishing vessel (CPFV) sport fish landings until 1936. Records from 1936 through 1940 reveal that CPFV barracuda landings (in numbers of fish) exceeded those of other sport fishes, and that they often equaled or exceeded commercial landings (in weight) for barracuda taken in California waters. Annual landings for these five years averaged about 630,000 fish. Records were not kept from 1941 through 1946 due to fishing restraints during World War II. As interest in marine sport fishing grew in the post-World War II era, the sport take of barracuda greatly exceeded that of the commercial fleet in California waters. Between 1946 and 1971, CPFV barracuda landings ranged from 87,600 to 1.2 million fish, for an overall annual average of 447,000 fish. In 1971, the current 28-inch minimum size limit for all sport-caught barracuda became effective, causing an 86 percent decline in CPFV barracuda landings from the previous year. Since 1971, CPFV landings of barracuda have been increasing, ranging between 26,300 and 446,000 fish annually.

The Marine Recreational Fisheries Statistics Survey has shown that, on average, 54 percent of the total barracuda catch is from CPFVs, 45 percent is from private and rental boats, and one percent is from shore. In the late 1980s, a DFG study determined that roughly 60 percent of CPFV-caught barracuda are released (almost all of which are less than 28 inches). The study also indicated Los Angeles County accounted for 58 percent of the CPFV barracuda landings.

Sport anglers, especially aboard CPFVs, usually use live anchovies or sardines to fish for barracuda. Anchovies and sardines are also used to chum and hold barracuda schools close to the boat. Metal or plastic artificial lures in a variety of shapes and colors are also popular. Sport-caught barracuda are taken mainly near the surface. Most fishing activity occurs from May through September, when surface water temperatures range between 62° and 70°F.

California Barracuda, *Sphyraena argentea*
Credit: DFG

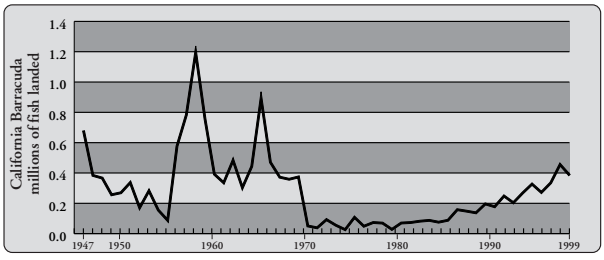
Status of Biological Knowledge

The California barracuda is a nearshore, epipelagic, schooling fish found from Cabo San Lucas, Baja California to Kodiak Island, Alaska. Catch origins indicate the population is centered between San Quentin, Baja California and Point Conception, California. During warm water oceanic events, such as El Niños, a portion of the population may shift northward into central California. Frequently seen at the surface, barracuda have been taken at depths of 120 feet.

Growth in length is most rapid during the first year of life. Barracuda reach a total length of 14 inches at one year. At two years, they have grown to 20 inches and weigh about one pound. However, the maximum growth by weight of nearly one pound per year is achieved by four- and five-year-old fish. The minimum size limit of 28 inches, approximately a three-pound fish, is near the average size for a four-year-old. At this age, females are about 0.75 inches larger than males, and the difference increases to about 2.5 inches in fish over six years old. The oldest fish aged was an 11-year-old measuring 41 inches and weighing about nine pounds. Larger and presumably older fish include the state angling record of 15 pounds 15 ounces and a 17-pound fish caught off Carpenteria in 1958 that measured 46.5 inches.

California barracuda produce pelagic eggs and larvae. Fertilization takes place externally as the sexes simultaneously release their gametes. At two years, almost all males and 75 percent of females are sexually mature. All are mature at three years of age. Full sexual maturity occurs in males at a length of 20 inches and in females at 22 inches. In a single spawning, a two-year-old female may produce 50,000 eggs, increasing to about 400,000 by age six. Individuals may spawn more than once during a spawning season. Off southern California, spawning takes place from April to September, peaking in June.

Feeding habits of California barracuda are not well documented, but some potential prey species can be mentioned. During pelagic schooling movements, barracuda may feed on other open water schooling fishes such as northern anchovy, Pacific sardine, Pacific mackerel, jack mackerel, and Pacific saury. In association with kelp beds or shallow water habitats, they may feed on topsmelt and California grunion. Opportunistic feeding on market squid made vulnerable during their spawning activity is likely.



Recreational Catch 1947-1999, California Barracuda

CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

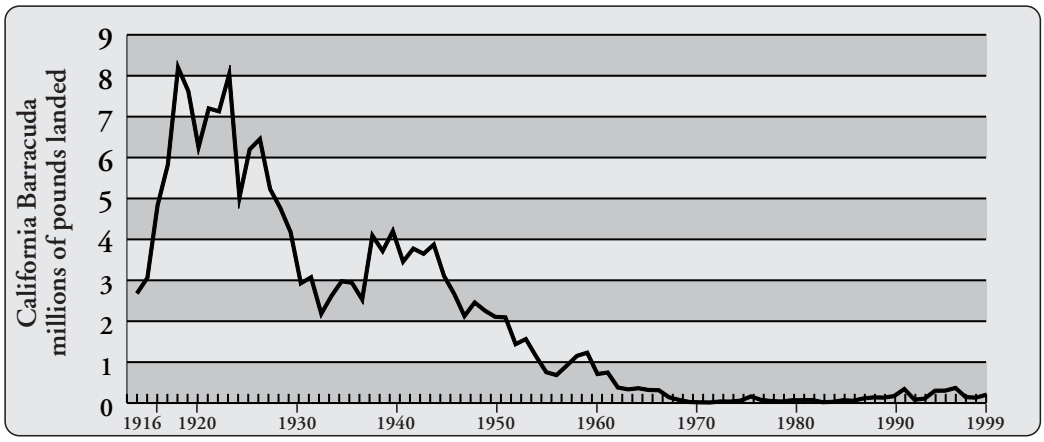
Previous references to the predators that feed on California barracuda have listed sea lions, seals, porpoises, and giant sea bass. Analyses of the gut contents and scat from marine mammals have failed to discover barracuda remains. Observations of California sea lions and harbor seals opportunistically feeding on barracuda injured or entrapped by fishing gear are common, but these animals more typically feed on the same size prey as adult barracuda. Giant sea bass are more likely predators on juveniles and adult barracuda.

California barracuda have an inshore distribution during their early life history. Fish a few inches long are observed in protected bays and marinas. Larger young-of-the-year fish school below the canopy of semi-protected kelp-bed habitats. Older juveniles and adults form large schools that disperse widely in the open-water environment.

Movements of California barracuda have been studied by tagging. Fish tagged during May 1959 at locations off northern Baja California and off southern California were recovered at intermixed locations, indicating a single population. Movements of up to 100 miles north and south occurred during the summer, but a portion of the recoveries were at the release sites. However, a general migration pattern that was distinctly northward during the summer and less distinctly southward during the fall was indicated. Movements are presumably a response to sea temperature, and warm overwintering temperatures off southern California reduce the southward return. High catch success during spring and summer off southern California has been correlated with warm sea temperatures the preceding winter.

Status of the Population

The status of the California barracuda population is unknown, because data concerning catch, fishing effort, and age composition are scarce. Barracuda catches off California are variable for many reasons, one of which is that barracuda are migratory with a preference for warmer waters. During an El Niño event, when warmer than normal water masses move up the coast, barracuda are caught far north of their normal range and in greater than average numbers off southern California, suggesting a higher population level. This was apparent during the 1957-1959 El Niño event, one of the most intense on record. However, during the similarly intense 1982-1983 and 1997-1998 El Niño events, barracuda catches did not



Commercial Landings 1916-1999, California Barracuda
Data Source: DFG Catch Bulletins and commercial landing receipts.

increase appreciably. Assuming fishing effort and the percentage of the population migrating northward were similar, the difference suggests that the barracuda population was depressed during the latter El Niño periods. Since the late 1980s, catches have increased but remain well below those reported prior to 1970. This is due to the fact sport anglers may no longer keep short barracuda as they were allowed to do prior to 1971. Only during one three-year period, 1958 though 1960, has the number of barracuda off southern California been estimated by the DFG. Estimates ranged from 1.6 to 2.9 million fish.

Because of uncontrollable factors such as migration, water temperature, and Mexico's management policies, the DFG's management policies for this species probably have a limited effect on its population level. Nevertheless, the regulations are intended to reduce the likelihood of overfishing this valuable resource.

Management Considerations

See the Management Considerations Appendix A for further information.

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California Corbina

History of the Fishery

The California corbina (*Menticirrhus undulatus*) is a nearshore croaker that is reserved for the recreational fishery. It has been illegal to take corbina with nets since 1909, and illegal to buy or sell them since 1915. This wary species is a challenge to anglers. Sometimes corbina can be seen in small schools, swimming slowly along the bottom seeking food. While feeding in this manner, it seldom takes bait. The corbina is considered one of the most difficult fish to catch in southern California, although on occasion it takes an angler's bait without hesitation. Its temperamental behavior, fine fighting qualities, and tasty flesh make it a popular sport fish.

Corbina can be taken throughout the year, but fishing is best in summer and early fall. Most corbina are caught along sandy surf-swept beaches, but they are also taken from piers and jetties; anglers on private and rental boats, and commercial passenger fishing vessels seldom take them. A 1965-1966 survey estimated that 30,000 corbina were taken by southern California shore anglers along the open coast, making it the third most abundant species accounting for 13 percent of the surf-angler's creel. Anglers use conventional, spinning, and fly-fishing gear. The best baits are soft-shelled sand crabs, mussels, bloodworms, and clams.

The annual number of corbina caught by anglers has been quite variable. Marine Recreational Fishery Statistics Survey annual catch-estimates for 1980 through 1998 ranged between 17,000 and 75,000 fish; the average was 44,600. Annual catch estimates were much lower in the 1990s than during the 1980s; however, catches-per-unit-effort were similar.

Status of Biological Knowledge

The California corbina is a slender croaker with a gray to bluish back and a white flattened belly. It has a short, stiff chin barbel and may have wavy oblique lines on its sides. The corbina ranges from Point Conception, California to the Gulf of California. It is found along sandy beaches and shallow bays to depths of 45 feet, but is most common in about six feet of water. It is usually found in small groups of several individuals, with larger fish being more solitary.

Corbina can grow to 30 inches and weigh 8.5 pounds; a verified specimen measuring 28 inches and weighing seven pounds, four ounces was caught in 1955. Females grow faster than males, especially after two years, and reach a larger size. A three-year-old female is about 15 inches whereas a three-year-old male is about 13 inches. Apparently, corbina residing in bays grow much faster than those on the open coast. A 23-inch female corbina caught on the open coast was eleven years old, whereas similarly sized females from the bay were aged at six years. More than 50 percent of females are mature at 12 inches (two years) and all are mature at 15 inches (three years). Males mature at about 10 inches (two years). The spawning season is from May through September and is heaviest from June through August. Spawning apparently takes place offshore, since running-ripe fish are not often found in the surf zone; eggs are pelagic. Small (1.5 to 3 inches) corbina have been captured inside the surf zone to 30 feet of water.

The corbina feeds predominantly on benthic organisms. Individuals may be seen feeding in the surf, at times in water so shallow their backs are exposed. They scoop up mouthfuls of sand and separate out food by pumping sand through their gill openings. The diet of juveniles consists of clam siphons and small crustaceans. As they grow, they consume larger parts of clams and sand crabs.

Limited tagging studies indicate that the corbina does not move around much; it has no discernible migratory pattern. The greatest distance traveled was 51 miles.

California Corbina, *Menticirrhus undulatus*
Credit: DFG

Status of the Population

Population size, recruitment, and mortality of California corbina are unknown. Beach seine hauls along the open coast from 1994 through 1997 yielded slightly lower but similar numbers of corbina to those obtained during a similar study from 1953 through 1956. In addition, similar angler catch-per-unit efforts during the 1980s and 1990s indicate that the population is sustaining itself under present recreational harvest levels.

Management Considerations

See the Management Considerations Appendix A for further information.

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California Halibut

History of the Fishery

California halibut (*Paralichthys californicus*) is an important flatfish species in both the commercial and recreational fisheries of central and southern California. The highest recorded commercial landing of halibut was 4.7 million pounds in 1919, which was followed by an overall decline to a low of 950,000 pounds in 1932. Since 1932, the average annual catch has been 910,000 pounds, with five notable peaks in landings: 1936 (1.58 million pounds), 1946 (2.46 million pounds), 1964 (1.28 million pounds), 1981 (1.26 million pounds), and 1997 (1.25 million pounds).

The decline in commercial halibut landings after 1919 has been attributed to increased fishing pressure during World War I and to overfishing. Fishing restraints during World War II may have allowed halibut stocks to increase, resulting in peak landings in the late 1940s, followed by low catches in the 1950s. Increased landings in the mid-1960s followed warm water (El Niño) years in the late 1950s. The lowest landings occurred in the early 1970s, with the lowest recorded catch in 1970 of 257,000 pounds. Landings increased during the late 1970s to a peak again in 1981 and 1997. Since 1980, landings of California halibut have remained relatively constant, averaging more than one million pounds annually.

Historically, halibut have been commercially harvested by three principal gears: otter trawl, set gill and trammel net, and hook-and-line. The California halibut trawl fishery evolved late in the 19th century in the San Francisco Bay area. Since then, the boats used to tow this gear across the ocean bottom have gone from sail to steam to gasoline, and finally to diesel powered engines. Today, trawling is permitted in federal waters (three to 200 nautical miles offshore) using trawl nets with a minimum mesh size of 4.5 inches. Trawling is prohibited within state waters, except in the designated "California halibut trawl grounds," which encompass the area between Point Arguello and Point Mugu in waters greater than one nautical mile from shore. Bottom trawls used in this area must have a minimum mesh size of 7.5 inches, and trawling is closed from March 15 to June 15 to protect spawning adults.

A decade after the introduction of the trawl fishery to San Francisco Bay, set gill and trammel nets were fished statewide along the coast. Historically, set nets have been the gear of choice for commercial halibut fishermen because of the restrictions on bottom trawl gear in state waters. In southern California, gill and trammel nets with 8.5-inch mesh and maximum length of 9,000 feet are the principal type of gear used. Today, gill and trammel net fishing is prohibited in Santa Monica Bay, shallow coastal waters north of Point Sal, and is subject to many other area, depth, and seasonal closures throughout the state. A Marine Resources Protection Zone (MRPZ) was established in 1990 extending three miles off the southern California mainland coast from Point Conception to the Mexican border and within one mile or 70 fathoms (whichever is less) around the Channel Islands. Gill and trammel nets have been prohibited in the MRPZ since Jan. 1, 1994.

Historically, commercial catches of halibut by hook-and-line gear have been insignificant when compared to the total pounds landed annually by the trawl and set gillnet fisheries. However, over the last decade, catches of California halibut by hook-and-line have ranged from 11 to 23 percent of the total pounds landed annually. A majority of those landings were made in the San Francisco Bay area by salmon fishermen mooching or trolling slowly over the ocean bottom.

Catches by commercial passenger fishing vessels (CPFV) displayed trends similar to the commercial landings from 1947 through 1974, with two peaks in 1948 (143,000 halibut) and 1964 (141,000 halibut). Following the 1948 peak, annual landings plummeted below 11,000 fish by 1957. The expansion of the CPFV fleet and no size limit restriction for the take of California halibut can be attributed to the 13-fold decrease in landings between 1948 and 1958. While the commercial catch increased in the late 1970s and steadied in the 1980s, the recreational catch remained low and variable with an average annual catch of 8,600 fish from 1971 to 1989. By 1995, CPFV landings surged to a 26-year high of 19,600 fish, declining to 14,200 fish in 1999. Since 1994, CPFVs operating in the San Francisco Bay area have landed a majority of the halibut statewide.

To assist with the restoration of the California halibut resource through the protection of sub-adult fish, a regulation was adopted in 1971 that set a minimum size limit of 22 inches for sport-caught California halibut. Commercial landings increased slowly after this legislation, whereas recreational landings remained low and did not recover to former catch levels.

Although California halibut range from the Quillayute River, Washington to Almejas Bay, Baja California, the

California Halibut, *Paralichthys californicus*
Credit: DFG

commercial fishery is concentrated from Bodega Bay in the north to San Diego in southern California, and across the international border with Mexico. The contribution to California landings of halibut captured in Mexican waters has varied but has generally been insignificant since 1966. Historically, the fishery was centered off southern California and Baja California, but over the past twenty years, the greatest landings have oscillated between ports in southern and central California. A majority of the halibut landings made in central California occurred in the San Francisco Bay area. A limited amount of fishing occurs around the Channel Islands of southern California, with a catch of substantially larger halibut (average length = 27 inches) than those caught in the nearshore mainland fishery (average length = 24 inches).

Commercial fishing laws prohibit the sale of California halibut less than 22 inches in total length, unless the weight is at least four pounds whole, 3.5 pounds dressed with the head on, or 3 pounds dressed with the head off. Four halibut less than the legal minimum size may be retained for personal use.

Recreational regulations also require a minimum size limit of 22 inches, in addition to a daily bag limit of five California halibut when fishing south of Point Sur, Monterey County, and only three halibut per day when fishing north of Point Sur. Halibut can be taken in recreational fisheries using hook-and-line, spear, or hand.

Status of Biological Knowledge

Adult California halibut inhabit soft bottom habitats in coastal waters generally less than 300 feet deep, with greatest abundance at depths of less than 100 feet. Adults spawn throughout the year with peak spawning in winter and spring. Pelagic eggs and larvae occur over the shelf, with greatest densities in water less than 250 feet deep and within four miles of shore. Halibut larvae appear to move inshore as they approach metamorphosis. Early larval stages (about 0.1 to 0.3 inches) occur in midwater more than one mile offshore, whereas transforming larvae occur within 0.6 mile of shore and occupy the neuston (surface zone) at night and the bottom during the day. California halibut have a relatively short pelagic larval stage (less than 30 days), transforming and settling to the bottom at a small size (0.35 to 0.5 inches). Newly settled and larger juvenile halibut are frequently taken in unvegetated shallow-water embayments and infrequently on the open coast, suggesting that embayments are the important nursery habitats. However, settlement either in bays or along the open coast varies yearly and may reflect variability in nearshore currents that influence the onshore transport of larvae. The advantages of bays as nursery areas are probably a decrease in the risk of mortality of newly-settled juveniles and an increase in the growth rate of larger juveniles that feed upon the abundant small fishes in the bays. Juveniles emigrate from the bays to the coast at about one year of age and 6.9 to 8.7 inches in length.

Tagging studies have indicated that California halibut do not tend to move extensively. Most sublegal halibut tagged and released from CPFVs in southern California were recovered within five miles from their tag sites; only 12 percent were found 10 miles or more from where they were tagged. Larger halibut appear to travel the greatest distances. One large tagged halibut (33 inches) was recovered 64 miles away 39 days after release.

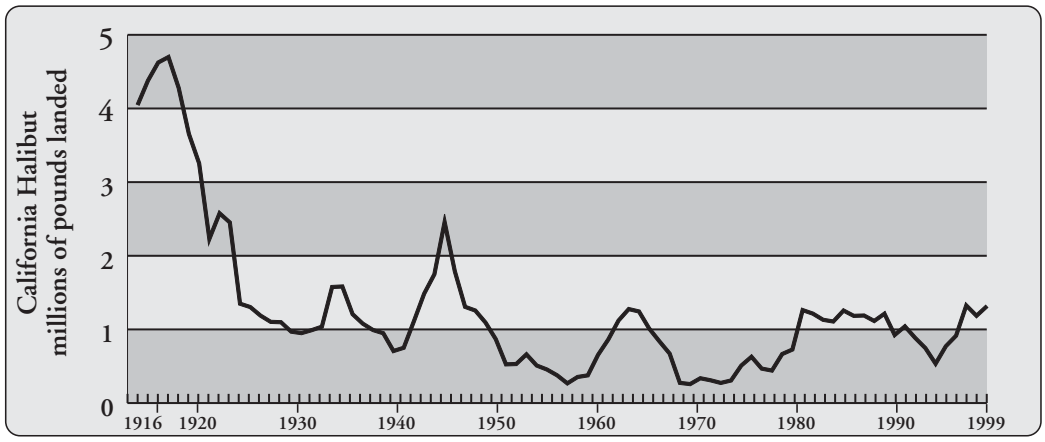
California halibut may live to 30 years and reach 60 inches in length. The maximum-recorded weight is 72 pounds. Male halibut mature at one to three years and eight to twelve inches, whereas females mature at four to five years and 15 to 17 inches. Female halibut attain larger sizes at age than males and represent a greater fraction of the commercial landings (60 to 80 percent). Female halibut reach legal size (22 inches) at five to six years of age, about a year before males.

California halibut are ambushing predators. Adults prey primarily upon Pacific sardine, northern anchovies, squid, and other nektonic nearshore fish species. Small juvenile halibut in bays primarily eat crustaceans, including copepods and amphipods, until they reach about 2.5 inches. They are then large enough to eat gobies that are found commonly in bays but not on the open coast. Juvenile halibut become increasingly piscivorous with size. On the coast, adult halibut feed primarily on Pacific sardine, anchovies, and white croaker.

Status of the Population

Abundance of larval California halibut in plankton surveys is correlated with commercial landings of halibut, suggesting that this species has a cycle of abundance approximately 20 years in length. However, the size of the halibut population may be limited by the amount of available nursery habitat, as juvenile halibut appear to be dependent on shallow water embayments as nursery areas. The overall decline in California halibut landings corresponds to a decline in shallow water habitats in southern California associated with dredging and filling of bays and wetlands.

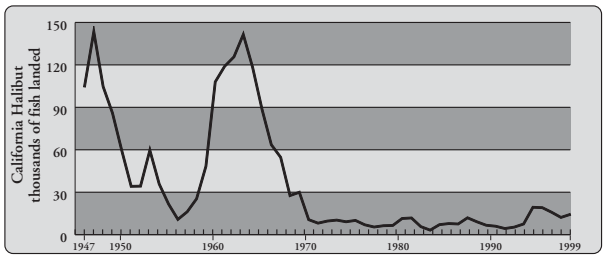
Recreational and commercial fishermen are in conflict over the California halibut resource in southern California. A differential minimum size limit of 22 inches for the recreational fishery and 26 inches for the commercial fishery was investigated as a possible management tool. This strategy would allow recreational anglers to harvest



Commercial Landings 1916-1999, California Halibut
Data Source: DFG Catch Bulletins and commercial landing receipts.

halibut between 22 and 26 inches in length before fish had grown large enough to recruit to the commercial fishery. Yield-per-recruit (Y/R) analysis indicated that: 1) differential size limits would provide an increased Y/R for the recreational fishery, whereas the commercial fishery would experience a loss; 2) overall fishing effort was about twice the optimum level; and 3) Y/R would probably increase with diminished fishing effort.

The total California biomass of the halibut resource obtained from virtual population analysis (VPA) estimates



Recreational Catch 1947-1999, California Halibut
CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

in the late 1980s was 5.7 to 13.2 million pounds, with annual recruitment of fish at age one estimated to be between 0.45 and 1.0 million fish. The number of juvenile halibut emigrating from southern California bays to the open coast (age one) estimated from beam trawl surveys ranged between 250,000 and 400,000 in the late 1980s.

In the early 1990s, a swept-area trawl survey was conducted to better understand California halibut population dynamics. This fishery-independent survey produced a biomass and population estimate for halibut in southern and central California. The survey results indicated a halibut biomass of 6.9 million pounds for southern California and 2.3 million pounds for central California, while the population estimate was 3.9 million halibut for southern California, and 700,000 halibut for central California.

Management Considerations

See the Management Considerations Appendix A for further information.

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California Sheephead

History of the Fishery

Although the commercial catch of California sheephead (*Semicossyphus pulcher*) dates back to the late 1800s, a renewed interest in this fishery has developed only recently. Today, it is exploited by sport divers, anglers, and especially by a growing live fish commercial industry.

In the late 1800s, Chinese fishermen took large quantities of sheephead for drying and salting. Since that time, except for brief periods, sheephead was not a targeted species until the 1980s. In the recently developed live fish fishery, the fish are trapped and taken live to supply Asian seafood restaurants. Because small fish, usually females, are easier to keep alive in small aquaria, prereproductive individuals have often been taken. A recent minimal size limit of 12 inches should reduce this possibility.

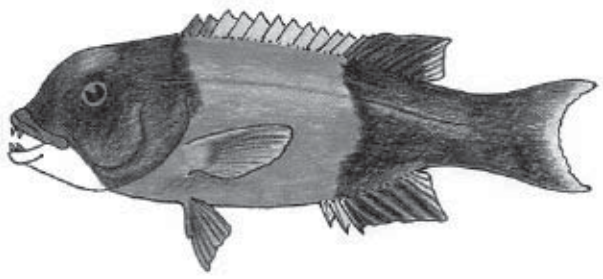
The largest commercial catches of California sheephead were from 1927 to 1931, peaking in 1928 at more than 370,000 pounds. During and shortly after World War II (1943-1947), the sheephead catch increased from 50,000 to 267,00 pounds, probably because of easy availability close to port. Since the 1940s and until the late 1980s, the average annual landing has been about 10,000 pounds and the price of this catch was under $0.10 per pound. During the 1980s, the price and catch increased slightly until the live fish market began in the late 1980s. The price of live fish has reached as high as $9 per pound. Between 1989 and 1990, the catch quadrupled and reached a peak in 1997 of 366,000 pounds and a market value of $840,176. During 1994 to 1999, the live catch varied between 87.8 percent and 73.7 percent of the total sheephead landings. The catch has decreased from 1997 to 1999, but the market value has remained high.

The estimated recreational catch of sheephead between 1983 and 1986 averaged 312,400 pounds with a maximum estimate of 448,800 pounds for 1986. Commercial passenger fishing vessel data from 1947 to 1998 indicate an average take of 28,030 fish per year with a maximum in 1983 of about 69,000 fish. Using an average weight of two pounds per fish (a low estimate) the sport catch, except in the cited maximal periods, often exceeds the commercial catch. During the 1930s, sheephead were considered "junk fish" by most recreational anglers and were not kept because of their soft flesh. However, the large size, fine flavor, and use as a lobster substitute in salads and other recipes has more recently made them a preferred and even targeted species by anglers and divers.

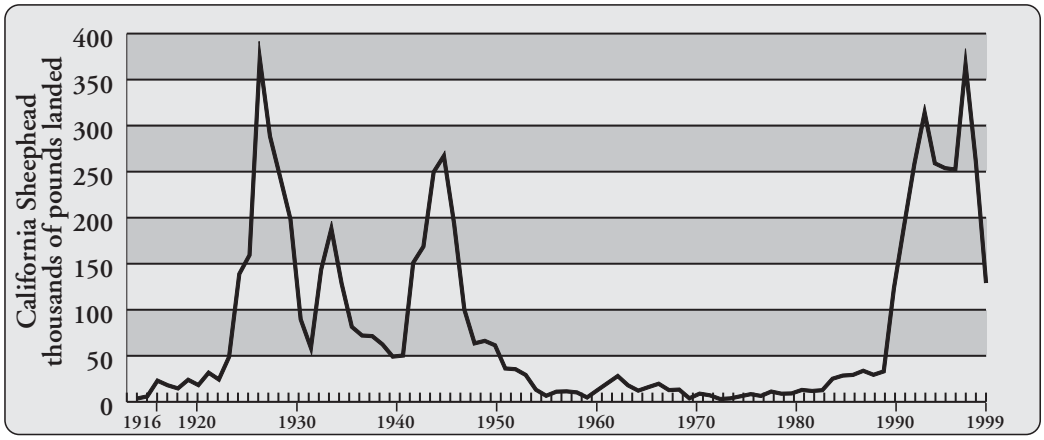
Status of Biological Knowledge

The California sheephead and two other common Southern California species, the rock wrasse and the senorita are members of the mostly tropical, worldwide wrasse family Labridae. All have protruding canine-like jaw teeth and large cycloid scales. The sheephead is easily distinguished from the others by its color pattern, greater body depth, and large size. Males have a black head and tail separated by a reddish middle section. The chin is white in both sexes but females are uniformly pinkish. Young-of-the-year are bright reddish orange with a lateral longitudinal white stripe and large black spots at the rear of the dorsal fin and upper caudal. Although the sheephead ranges from Monterey Bay, California to the Gulf of California, it is not common north of Point Conception. It is a protogynous hermaphrodite, beginning life as a female with older, larger females developing into secondary males. Female sexual maturity may occur in three to six years and fishes may remain female for up to fifteen years. Timing of the transformation to males involves population sex ratio as well as size of available males and sometimes does not occur at all.

Males have been aged at around 50 years, and can achieve a length of three feet and a weight exceeding 36 pounds. As growth rates are higher and mortality lower at the northern end of the range, the sexual transformation occurs later there and the males are larger. Batch spawning occurs between July and September, and estimates of yolky oocytes present in the ovary vary from 36,000 to 296,000 for fish from eight to 15 inches. Larval drift ranges from 34 to 78 days with two settlement patterns. Most larvae settle at about 37 days, but some slow their growth at this time and may continue as pelagic larvae for another month. Settlement size remains between 0.5 and 0.6 inches. The sheephead has a broad diet with crabs, barnacles, mollusks, urchins, polychaetes and even bryozoa occasionally dominant. There appears to be no evidence of its preference for abalone and lobster as cited in earlier literature. Because of its large size of adult males, there are few known predators. The sheephead is a rocky reef, kelp bed species found to depths of 280 feet. Adults are usually solitary, but sometimes are seen in large schools, perhaps associated with spawning aggregations.



California Sheephead (male), *Semicossyphus pulcher*
L.Sinclair
Miller & Lea

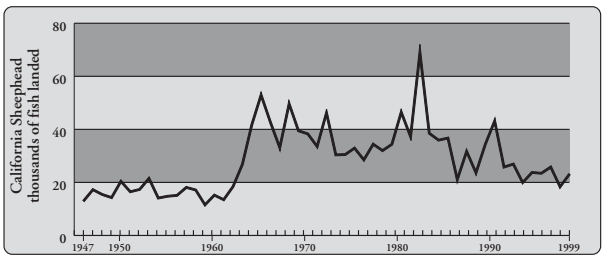


Commercial Landings 1916-1999, California Sheephead
Data Source: DFG Catch Bulletins and commercial landing receipts.

They are considered resident species and no systematic movements have been described.

Status of the Population

There has been no ongoing analysis of the status of the California sheephead. Long-term studies at two localities in southern California, Palos Verdes Point and the King Harbor breakwater, have shown that the species was not abundant in the cool period of the early 1970s. The population increased at both sites with the onset of the little El Niño of 1977-1978. At King Harbor, the population peaked in 1978, decreased through the end of the great El Niño of 1982-1983, and remained low until the early 1990s when it again reached a large size (1994 and 1998). With the exception of 1982-1983 El Niño, the population seems to increase during El Niño conditions and this is reflected in increased recruitment. At Palos Verdes, the population peaked in 1981, then declined until 1983, but has remained relatively stable since. At maximum, the density of sheephead at the Palos Verdes kelp bed was three times that of the King Harbor breakwater. There is no evidence from these very limited data that the population is threatened by existing fishery practices. The projected decrease in landings during 1999 may reflect the imposition of a minimum size limit.



Recreational Catch 1947-1999, California Sheephead
CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

Management Considerations

See the Management Considerations Appendix A for further information.

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California Spiny Lobster

History of the Fishery

Since the late 1800s, there has been a commercial fishery for California spiny lobster (*Panulirus interruptus*) in southern California. Commercial fishermen use box-like traps constructed of heavy wire mesh to capture spiny lobsters. Traps of other materials, such as plastic, are allowed, but wire traps remain the most popular. About 100 to 300 traps per fisherman is common, but some fish as many as 500 at the peak of the season. The traps are baited with whole or cut fish and weighted with bricks, cement, or steel. They are fished on the bottom, and each trap is marked with a buoy bearing the fisherman's license number followed by the letter P. High-speed boats in the 20 to 40-foot size range are popular in this fishery, but everything from 15-foot skiffs to 50-foot fishing boats are used. Most trap boats are equipped with a davit and hydraulics to assist in pulling the traps.

Commercial lobster fishing occurs in shallow, rocky areas from Point Conception to the Mexican border and off the islands and banks (such as Cortes and Tanner banks) of southern California. Some marine life refuges and reserves are closed to the take of lobster, as are areas in Santa Monica and Newport Bays and at Santa Catalina Island. Sophisticated electronic equipment enables trappers to find suitable lobster habitat and relocate their traps there. Traps are fished along depth contours in waters less than 100 feet, or clustered around rocky outcrops on the bottom. At the beginning of the season the traps are usually very close to shore. By the end of the season they are in 100 to 300 feet of water.

Seasonal landings in the 200,000 to 400,000 pound range rose following World War II and peaked in the 1949-1950 season, with a record 1.05 million pounds landed. A general decline followed for the next 25 years, reaching a low of 152,000 pounds in the 1974-1975 season. Landings started back up the next season, but remained between 400,000 and 500,000 pounds for nine consecutive seasons from 1979-1980 to 1987-1988. The next nine years the landings ranged from 600,000 to 800,000 pounds with a peak of 950,000 in the 1997-1998 season. Landings dropped back down after that. The peaks and valleys that have characterized this fishery are not unexpected in a fishery that is strongly influenced by the weather, El Niño and La Niña events, and the export market.

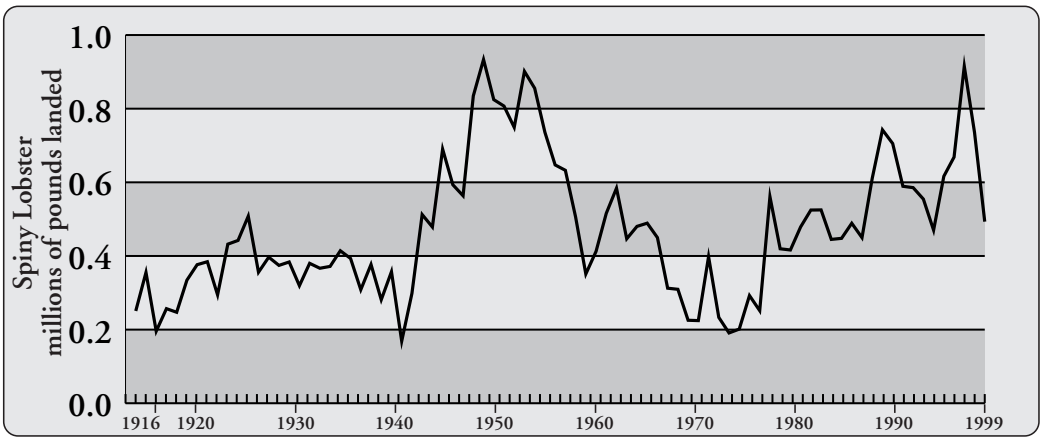
California Spiny Lobster, *Panulirus interruptus*
Credit: DFG

About 90 percent of the legal lobsters taken in the commercial fishery weigh between 1.25 and 2.0 pounds, which produces the size of tail desired for the restaurant trade. Most of the harvest in recent years has been exported to Asian countries and France. However, depressed economies overseas have resulted in an effort to re-establish domestic markets. The price paid to the fisherman is in the range of $6.75 to $8 a pound. The largest portion of the commercial and sport harvest is always taken during the first month of the season, October, which also is the highest month of trapping effort. The effort and catch drop off sharply in January through the middle of March (the season's end). San Diego County, being the most central to the spiny lobster's range, usually produces the highest landings, followed by Los Angeles/Orange, and Santa Barbara/Ventura counties.

Commercial and recreational lobster fishermen are restricted to a minimum size limit of 3 1/4 inches carapace length (CL). Historically, the season for both has run from early October to mid-March. Since 1992, the sport season has opened the weekend before the first Wednesday in October, the official commercial season opener. Commercial fish traps, including lobster traps, must have a destruct-device of a type approved by the Department of Fish and Game. This is to ensure that lost or abandoned traps do not continue to capture marine life indefinitely. Since the 1976-1977 season, it has been required that lobster traps be fitted with rectangular escape ports (2 3/8 by 11 1/2 inches) to minimize the retention of undersized lobsters. This requirement has been credited with reversing the long downward trend in landings previous to that.

A formal commercial restricted access program was initiated in April of 1997. All lobster fishermen are required to have an operator permit ($285). Deckhands that assist them must have a lobster crewmember permit ($125).

Recreational harvesters need a valid sport fishing license with an ocean enhancement stamp, and may use hoop nets or bare (gloved) hands when skin or scuba diving for lobster. No appliance, such as a fish spear or a short hooked pole, may be used to snag the animals from deep crevices or caves. The daily bag limit for sport fishing is seven lobsters, reduced from 10 in 1971.



Commercial Landings 1916-1999, Spiny Lobster
Data Source: DFG Catch Bulletins and commercial landing receipts.

Status of Biological Knowledge

The California spiny lobster ranges from Monterey Bay, California to Manzanillo, Mexico. There is also a small, isolated population of this species at the northwestern end of the Gulf of California. The majority of the population is found between Point Conception, California and Magdalena Bay, Baja California. Adult lobsters usually inhabit rocky areas from the intertidal zone to depths of 240 feet or more.

Spiny lobsters mate from November through May. The male attaches a putty-like packet of sperm, called a spermatophore, to the underside of the female's carapace. When the female releases her eggs, she uses the small claws at the end of her last (fifth) pair of walking legs to open the spermatophore and fertilize the eggs with the sperm inside the packet. Fertilized eggs are attached to the underside of the female's tail primarily in May and June. "Berried" females are generally in water less than 30 feet deep and carry their eggs for about 10 weeks. The larger the size of the female, the more eggs she produces. Females sampled at San Clemente Island carried between 120,000 (2.6 inches CL) and 680,000 (3.6 inches CL) eggs.

Spiny lobster eggs hatch into tiny, transparent larvae known as phyllosomas that go through 12 molts. They have flattened bodies and spider like legs, and drift with the prevailing currents feeding on other planktonic animals. They may drift offshore out to 350 miles, and may be found from the surface to a depth of over 400 feet. After five to nine months, the phyllosoma transforms into the puerulus or juvenile stage. The puerulus is still transparent, but now looks like a miniature adult with extremely long antennae. The puerulus actively swims inshore where it settles to the bottom in shallow water and starts to grow if the habitat is suitable.

The spiny lobster's outer shell serves as its skeleton, and is referred to as an exoskeleton. To grow, a lobster must shed its exoskeleton. This process of molting is preceded by the formation of a new, soft shell under the old one. An uptake of water expands the new shell before it hardens. Lobsters are vulnerable to predation and physical damage right after they molt, until their new shell hardens.

Molt rates for the California spiny lobster are assumed to be similar to those of the Japanese spiny lobster. A 0.24-inch CL specimen goes through 20 molts to reach 1.18 inches CL at the end of its first year. Four molts during the second year will result in a carapace length of two inches, and there are three molts in the third year. It takes a lobster from seven to 11 years to reach a legal size of 3.25 inches CL. Spiny lobsters molt annually, following the reproductive period, once they reach 2.5 inches CL. Growth rates, or the period between molts, are highly variable. They have been correlated with food availability, size, and sex. The larger an animal, the slower it grows. Injuries or disease will often result in a slowing or complete cessation of growth until the injury has been repaired.

Juvenile lobsters usually spend their first two years in nearshore surf grass beds. Sub-adults have also been found in shallow rocky crevices and mussel beds. Adult lobsters are found in rocky habitat, although they also will search sandy areas for food. During the day, spiny lobsters usually reside in a crevice or hole, dubbed a den. More than one lobster is usually found in a den. At night, the animals leave their dens to search for a wide range of food. Adult lobsters are omnivorous and sometimes carnivorous. They consume algae and a wide variety of marine invertebrates such as snails, mussels, sea urchins, and clams as well as fish, and injured or newly molted lobsters. Lobsters are eaten by sheephead, cabezon, kelp bass, octopuses, California moray eels, horn sharks, leopard sharks, rockfishes and giant sea bass.

A large portion of the spiny lobster population makes an annual offshore-onshore migration that is stimulated by changes in water temperature. During winter months,

male and female lobsters are found offshore at depths of 50 feet and deeper, although individuals of both sexes have also been found in shallow water in winter. In late March, April, and May, lobsters move into warmer onshore waters less than 30 feet. The higher temperatures on shore shorten the development time for lobster eggs. Nearshore waters also have a more plentiful supply of food. In late October and November, the onshore waters cool, and most lobsters move offshore. Winter storms that cause increased wave action in shallow water encourage this movement. Lobsters generally move after dark and in small groups across the sand.

California spiny lobsters of both sexes reach maturity at five or six years and 2.5 inches CL. After maturity, male lobsters grow faster, live longer, and reach larger sizes than the females. Males can live up to 30 years, and females at least 20 years. There are records of male California spiny lobster weighing over 26 pounds and attaining lengths up to three feet. Today, lobsters over five pounds are considered trophy-size. Trophy-size animals are usually taken by recreational divers.

Status of the Population

Population size is unknown for the California spiny lobster. Commercial landings have fluctuated through the years and are influenced by some factors that are independent of the health of the population.

The closed season protects egg-carrying and molting female lobsters. The size limit ensures that there will be several year classes of broodstock, even if all legal-size lobsters are caught each season. The escape port has been effective in reducing the capture and handling of juvenile lobster. An illegal market has always existed for "shorts" (undersized lobsters). Public education and adequate warden enforcement are key elements in reducing this problem.

The Department of Fish and Game has had a commercial logbook system in place since 1973. Catch effort, the numbers of legal and short lobsters taken, number of traps fished, and depths where the traps are fished are required information on the logs. The presence of shorts is generally a good indicator of a healthy fishery.

Management Considerations

See the Management Considerations Appendix A for further information.

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Cabezon

History of the Fishery

Evidence exists for subsistence use of cabezon (*Scorpaenichthys marmoratus*) by prehistoric native Americans along the central California coast. Cabezon represented five percent of the fish remains taken from exposed rocky coastal archaeological sites.

As game fish, cabezon are prized by sport divers for edibility, size, and ease of capture. The recreational take aboard commercial passenger fishing vessels (CPFVs) does not comprise a large proportion of the catch, but those that are taken are usually of a good size, averaging around 3.5 pounds. In central California, cabezon generally account for less than one percent of observed annual CPFV catches. Recreational landings data are available from 1980 to 1999 for CPFV and private boat anglers as well as shore and pier anglers from the National Marine Fisheries Service Recreational Fisheries Information Network (RecFIN). RecFIN data from 1982 to 1999, for all four modes of recreational fishing showed a 40 percent decline in average annual landings between the 1982 through 1989 and 1993 through 1999 periods, from 122 to 74 tons. Data from RecFIN also suggest that cabezon are more common in catches north of Point Conception and more frequently caught by anglers fishing on private boats and from shore than on CPFVs.

Cabezon were taken incidentally in commercial catches by boats fishing for rockfish using hook-and-line or gillnets until 1992. From 1916 to 1992, commercial landings only exceeded 30,000 pounds in 1951 and again from 1979 to 1982, when reported landings reached 62,614 pounds. Development of the live/premium fishery in the late 1980s resulted in increasing commercial catches of many species occupying the nearshore environment in and around kelp beds. The commercial catch of cabezon started increasing in 1992 with the expansion of marketing live fish to markets and restaurants in California's Asian communities. Most of the initial increase in landings was from the Morro Bay area, but by 1995, landings in most central and northern California ports had increased dramatically. Sampled catches from the Morro Bay area from 1995 to 1998 suggested a large proportion of landings were immature fish.

Commercial landings continued to increase through 1998 with over 373,000 pounds reported, then declined slightly in 1999 but remained over 300,000 pounds. Live fish are taken primarily by trap and hook-and-line gear. About 90 percent of the catch is landed live. Markets demanded top quality live fish, and fishermen received premium prices for their catches evidenced by the increase in average price per pound from $0.85 in 1990 to $3.30 in 1998. The estimated value of reported landings in 1998 was $1,231,700.

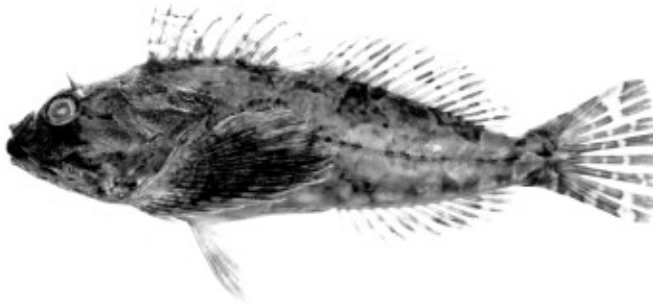
Concerns over the increased harvesting of nearshore species and potential impacts on fished populations led to passage of legislation known as the Marine Life Management Act of 1998 (MLMA) which was enacted in January of 1999. Within the MLMA, minimum commercial size limits were implemented for several nearshore species including a 14-inch size limit for cabezon. Implementation of the size limit may have been responsible for the decline in landings between 1998 and 1999.

Status of Biological Knowledge

The cabezon is the largest member of the cottid family. In Spanish, *cabezon* means bigheaded or stubborn and, proportionally, the massive head is definitely the largest feature of this fish. The specific name *marmoratus* refers to the marbled or mottled appearance of the body, which can be reddish, greenish, or bronze. Generally the belly is a pale turquoise or white, and there are no scales on the body.

Populations range along the eastern Pacific coast from Point Abreojos, Baja California to Sitka, Alaska. They are found on hard bottoms in shallow water from intertidal pools to depths of 250 feet. Fish frequent subtidal habitats in or around rocky reef areas and in kelp beds.

Cabezon may reach an age in excess of 20 years. The largest recorded size is 39 inches in length and over 25 pounds. Limited information available on age at sexual maturity in published literature suggests that in central California males begin to mature in their third year and all are mature by their fourth year. Average size of males in their fourth year is 17 inches. Some females begin to mature in their fourth year between 16 and 20 inches in length, and all females are sexually mature by the sixth year when they are 19 to 23 inches in length. These data collected from 1950-1951 suggest a size of female 50 percent maturity greater than 16 inches. Unpublished DFG data collected in the Morro Bay area from 1996 to 1999 indicates that half of females are mature at 14 inches.



Cabezon, *Scorpaenichthys marmoratus*
Credit: DFG

In California, spawning commences in late October, peaks in January and continues until March, whereas in Washington, the spawning season begins in November and extends to September with a peak in March and April. There is some evidence that females may spawn more than once in a season. Females spawn their eggs on subtidal, algae-free rocky surfaces, which can be horizontal or vertical in orientation. Up to 152,000 eggs can be expected from a large female (30 inches, 23 pounds). Masses of the pale green or reddish eggs are up to 18 inches in diameter and up to two to four inches thick. As the eggs develop they change to an olive green color.

There have been several reports on the toxicity of cabezon roe. In the 1950s, the well-known ichthyologist Carl Hubbs published a personal account of eating cabezon roe. As part of an ongoing search for another caviar, Hubbs and his wife consumed the roe and flesh of a cabezon for dinner. Four hours later they "... awoke in misery ... and were violently ill throughout the rest of the night." Laboratory evidence indicates that the roe is lethal to mice, rats, and guinea pigs. Anecdotal information on egg masses exposed at low tide suggests they are not preyed upon by natural predators such as raccoons, mink, or birds. Observations of captive cabezon have documented a female eating her own eggs with no resulting ill effects.

Males fertilize the eggs after spawning by the female, and the male guards the nest. Apparently the same nest sites are used from year to year. Fish are very protective of the nests for the two to three weeks it takes the eggs to develop and hatch.

Pelagic juveniles are silvery when small, spending their first three to four months in the open ocean feeding on tiny crustaceans and other zooplankton. At a size of about 1.5 inches, juveniles leave the open water and assume a demersal existence. They appear in kelp canopies, tide pools, and other shallow rocky habitats such as breakwaters from April to June in California.

Cabezon can be aptly described as "lie-in-wait" predators. Their mottled coloration lets them blend in with the surroundings, as they lie motionless to wait for their next meal. With large, robust pectoral fins set low on the body and a powerful tail, they quickly lunge after unwary prey, engulfing it in their large mouth.

Their diet consists mainly of crustaceans, although large and small cabezon have different diets. Adult fish eat crabs, small lobsters, mollusks (abalone, squid, octopus), small fish (including rockfishes), and fish eggs. Small juveniles depend mainly on amphipods, shrimp, crabs, and other small crustaceans.

Juveniles are eaten by rockfishes and larger cabezon, as well as by lingcod and other sculpins. Large cabezon may be preyed upon by harbor seals or sea lions.

Cabezon normally occur nearshore, except as larvae. Usually solitary, juveniles and adults are common on rocky bottom areas with dense algal growth. They are often in the vicinity of kelp beds, jetties, isolated rocky reefs or pinnacles, and in shallow tide pools.

Most of their time is spent lying in holes, on reefs, in pools, or on kelp blades beneath the canopy. As fish get older and larger they tend to migrate to deeper water. In shallower water, they migrate in and out with the tide to feed. Their habit of lying motionless makes them an easy target for sport divers.

Status of the Population

Limited information is available on population biology or changes in biomass over time. Recent increases in commercial fishing pressure on cabezon have intensified efforts to learn more about their life history characteristics, population biology, and to assess stock size. Recreational landings have declined concurrent with the increase in commercial fishing efforts and reported commercial landings. As fishing effort increases, it is likely that populations living in heavily utilized areas will decline further.

Management Considerations

See the Management Considerations Appendix A for further information.

Deborah Wilson-Vandenberg and **Robert Hardy**
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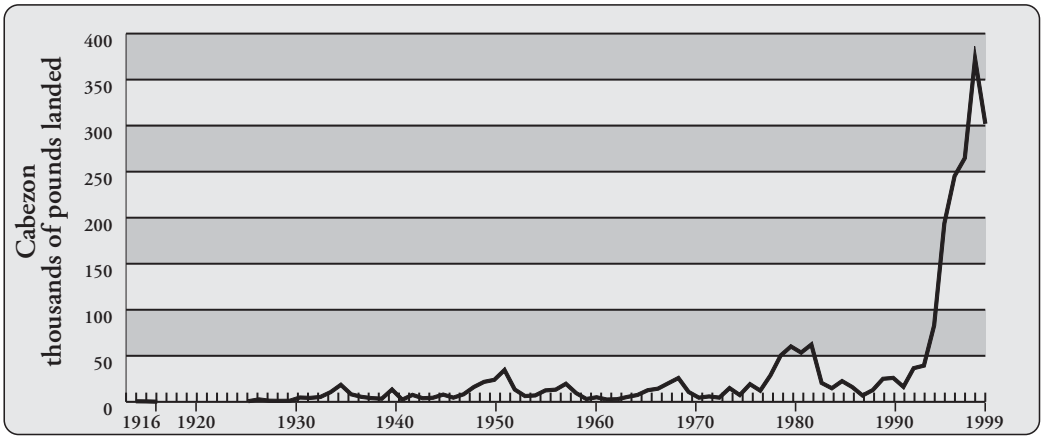
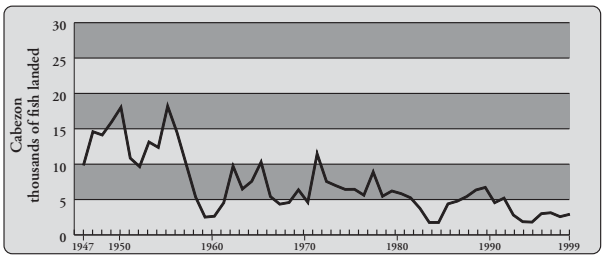


Commercial Landings 1916-1999, Cabezon
Data Source: DFG Catch Bulletins and commercial landing receipts.



Recreational Catch 1947-1999, Cabezon
CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

Giant Sea Bass

History of the Fishery

Because giant sea bass (*Stereolepis gigas*) grow slowly and mature at a relatively old age, they are susceptible to overfishing. As a consequence, they have suffered a serious decline in numbers. Commercial landings from U.S. waters peaked in 1932 near 200,000 pounds before declining. Mexican waters were more productive (peaking at over 800,000 pounds in 1932) and did not permanently sink below 200,000 pounds until 1964. A few hook-and-line fishermen targeted giant sea bass, but they were also caught incidentally by gillnets set for halibut and white seabass.

Recreational landings, reported in numbers of fish rather than pounds, show a similar trend of peaking and permanently declining. The peak in California landings occurred in 1963 while Mexican landings peaked in 1973. That these recreational fisheries peaked after the commercial fishery is due to the later development of the recreational fishery rather than a reflection of the giant sea bass population. A few boats developed a special recreational fishery targeting spawning aggregations during the summer months. Trips made in July to certain reefs between Point Abreojos and Magdalena Bay, Baja California, consistently produced 70 to 100 giant sea bass. One trip produced 255 in three days. Once these aggregations were exploited the fishery disappeared with the fish.

In 1981, a law was passed that prohibited the take of giant sea bass for any purpose, with the exception that commercial fishermen could retain and sell two fish per trip if caught incidentally in a gillnet or trammel net. This law also limited the amount of giant sea bass that could be taken in Mexican waters and landed in California. A vessel could land up to 1,000 pounds of Mexican giant sea bass per trip but could not land more than 3,000 pounds in a calendar year. The law was amended in 1988, reducing the incidental take to one fish in California waters. Although this law may have prevented commercial fishermen from selling giant sea bass in California, it did not prohibit fishing over habitats occupied by this species and probably did little to reduce the incidental mortality of giant sea bass, as giant sea bass that were entangled in the nets were discarded at sea. The 1981 rule changes were more effective in protecting giant sea bass in Mexico, since large landings had been historically made by hook-and-line fishermen targeting grouper, cabrilla, and giant sea bass off the Pacific coast of Baja California. The banning of inshore gillnets displaced the California fishery from the majority of areas inhabited by giant sea bass; it is reasonable to assume that this closure significantly reduced the incidental mortality of giant sea bass in California.

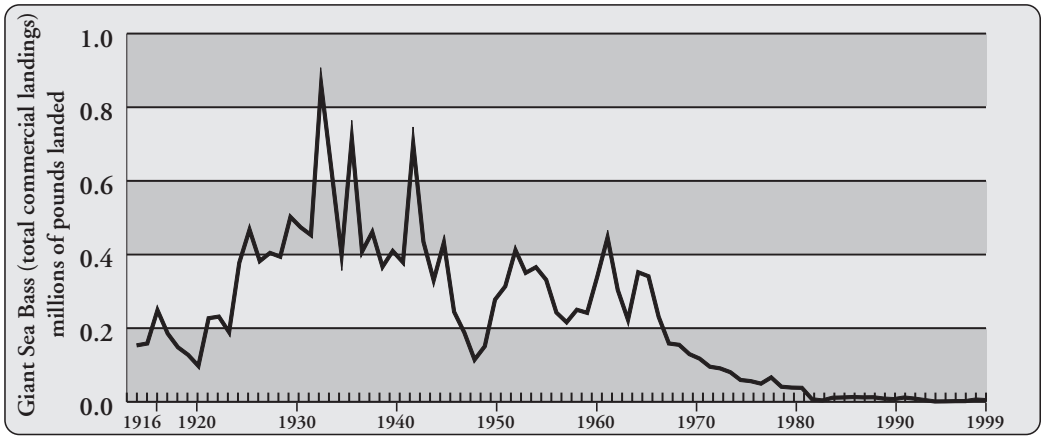
Status of Biological Knowledge

Although this species is most frequently referred to as black seabass in California, the American Fisheries Society has designated the common name as giant sea bass. Black seabass is an unrelated Atlantic coast species. Giant sea bass were originally assigned to the grouper family, Serranidae, but later placed in a new family, Percichthyidae. Although family placement has still not been resolved, similarities between larvae of wreckfishes and giant sea bass seem to support placement in the family Polyprionidae.

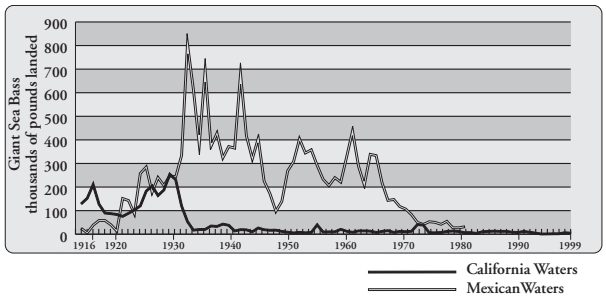
Small juveniles are bright orange with large black spots. As they grow they lose the orange coloration and take on a bronzy purple color. The spots slowly fade as the fish gets larger and darker, with large adults appearing solid black to gray with a white underside. Giant sea bass are capable of rapid and dramatic color changes. Large fish retain the ability to display large black spots, can take on a bicolor appearance (light below, dark above), white mottling, jet-black or light gray. As implied by the name, the most dramatic feature of giant sea bass is their large size. The International Game Fish Association world record for this species is 563.5 pounds, caught at Anacapa Island in 1968. Giant sea bass reach lengths in excess of seven feet, and are nearly as big around as they are long.

Despite the conspicuous size and protected status of giant sea bass, there are no published scientific studies to provide details of the biology and habits of this creature. In the eastern Pacific, giant sea bass range from Humboldt Bay to the tip of Baja California, and occur in the northern half of the Gulf of California. Some authors have stated that this species is also found along the coast of northern Japan and the Sea of Japan, but this may be a case of mistaken identity. Within California it is rarely found north of Point Conception. Adult giant sea bass seem to prefer the edges of nearshore rocky reefs. These reefs are relatively shallow (35 to 130 feet) and often support thriving kelp beds. Although the kelp may disappear due to a strong El Niño or overgrazing by sea urchins, giant sea bass remain at the reef. At certain times of the year,

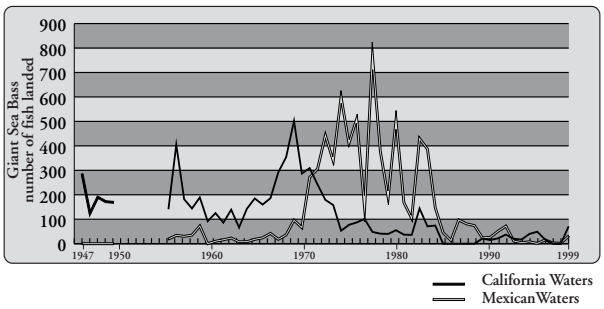
Giant Sea Bass, *Stereolepis gigas*
Credit: DFG



Commercial Landings 1916-1999, Giant Sea Bass
Data reflects catch from both California and Mexican waters landed in California. Data source: DFG Catch Bulletins and commercial landing receipts.



Commercial Landings by Location 1916-1999, Giant Sea Bass
Landings separated by location of catch. All landings were recorded at California ports. Data Source: DFG Catch Bulletins and commercial landing receipts.



Recreational Catch 1947-1999, Giant Seabass
Data derived from commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1936; no data available for 1941-1946; data separated by location of catch. Catch Data was not available for 1999.

adults can be found well away from the reef foraging for squid over a sandy bottom.

The orange juvenile phase has been reported among drifting kelp scattered over the bottom in 20 to 35 feet of water, over the soft muddy bottom outside of the Long Beach breakwater, and over flat sandy bottom in Santa Monica Bay. Larger juveniles up to 31 pounds have been found over flat sandy bottom and are sometimes caught over deep ridges (230-265 feet) off the coast of Del Mar by anglers targeting rockfish.

Given their depressed population and protected status, it is unlikely an aging study of giant sea bass will be completed in the near future. Although aging data are sparse, it is safe to say these fish grow slowly and live a long time. Estimated growth-rates are six years to reach 30 pounds, 10 years to reach 100 pounds, and 15 years to reach 150 pounds.

Spawning has never been observed in nature, but gonad examinations suggest that it occurs between July and September. Male fish have been observed to be mature at 40 pounds, and females at 50 to 60 pounds. Anecdotal information suggests that giant sea bass aggregate at specific locations and times to spawn. Because of the large size of this species, females are capable of producing enormous numbers of eggs. The ovaries of a 320-pound specimen contained an estimated 60 million eggs. Fertile, hydrated giant sea bass eggs are relatively large for a marine species, measuring about 0.06 inch in diameter. The eggs float to the surface and hatch in about 24 to 36 hours. The larvae drift and feed in the plankton for about a month before settling to the bottom and beginning their lives as juveniles. Giant sea bass have spawned in captivity several times, most recently at the Long Beach Aquarium of the Pacific where a single pair spawned in two successive years, nearly weekly beginning in June and ending in August or September.

Examinations of fish caught in Mexico indicate that the principal prey items are sting rays, skates, lobster, crabs, various flatfish, small sharks, mantis shrimp and an occasional kelpbass or barred sandbass. Earlier analyses found blacksmith, ocean whitefish, red crab, sargo, sheephead, octopus and squid. Giant sea bass are not built for speed, and the majority of their prey consists of organisms that

live on the bottom. The vacuum produced when the huge mouth is rapidly opened draws such organisms into their mouth. Giant sea bass themselves are eaten by a variety of fishes and marine mammals when they are small. In addition to humans, large sharks prey on adults.

Except for the short period of time they spend as planktonic larvae, giant sea bass live in close association with the bottom. This way of life may become a problem for this species. The sediments along the coast of southern California carry high loads of toxins. In fact, an area off the Palos Verdes peninsula is thought to contain higher levels of DDE (a breakdown product of DDT) than anywhere else in the world's oceans. PCB is another pollutant that is prevalent along the coast of southern California. Many forms of invertebrates live in these sediments, ingesting the pollutants along with the organic material they feed on to survive. These organisms occupy very low trophic levels, and the toxins are passed up the food chain in increasing concentrations. Long-lived, top level predators accumulate the highest levels of toxins. Giant sea bass caught in southern California have been found to have high body burdens of DDE and PCB. Fish collected 200 miles south of the Mexican border were found to be free of toxins. Thus, California populations of giant sea bass may suffer from more than just overfishing. These two toxins have been found to affect reproduction in other species of fish, as well as in amphibians, reptiles, and birds.

It is presumed that giant sea bass migrate to specific sites to spawn. This was almost certainly the case prior to the exploitation of the spawning aggregations, but it is not known how far individuals traveled to participate in the aggregation, or whether these migrations take place today. The process of site selection for spawning aggregations is not well understood, but experimental manipulation of small aggregating reef species suggests that once a site is selected young fish learn its location from older fish. In this way, the same traditional spawning aggregation sites are used by subsequent generations of fish. Once the learning cycle has been broken it is not known how a new (or the same) spawning aggregation may form. The population may have to reach a particular density before the process of forming annual spawning aggregations becomes a possibility. Giant sea bass have been found in groups year round at a few locations in southern California. Although anglers that come across these areas and hook several giant sea bass in one day may be led to believe that this species is thriving, giant sea bass remain absent from the vast majority of our coast. It is likely that the fish are gregarious, and after heavy exploitation, the population has collapsed to a very few focal points where they can be found in healthy numbers.

Status of the Population

The California population of giant sea bass is well below historical highs. Anecdotal information suggests that numbers may be beginning to rebound under current measures. No hard data exist that provide actual or relative numbers of giant sea bass.

Management Considerations

See the Management Considerations Appendix A for further information.

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Grunion

History of the Fishery

The commercial use of grunion (*Leuresthes tenuis*) is very limited, this species forming a minor portion of the commercial "smelt" catch. Grunion are taken incidentally in bait nets and other round haul nets, and limited quantities are used as live bait. In recent years, no commercial landings have been reported. However, since grunion usually are taken with other small fish and are not separated out, catch records would not show any landings.

The grunion's principal value is as the object of a unique recreational fishery. These fish are famous for their spawning habits, which are so remarkable as to arouse an "I don't believe it" response from a person hearing about them for the first time. They are the only species of fish in California to actually leave the water to spawn in wet sand on beaches. They are subjects of widespread popular interest, bringing thousands of people to beaches during night high tides in spring and summer months to catch the fish or just to observe them. Grunion hunting has become one of the famous sports of southern California. As the fish leave the water to deposit their eggs, they may be picked up while they are briefly stranded. Racing for fish spotted far down the beach and clutching for the small bits of slippery, wriggling energy provide an exhilarating time for young and old alike. The attraction provided by grunion can only be realized when one sees the numbers of people lining the more popular beaches in the Los Angeles area on the night of a predicted run. Often there seem to be more people than fish, but at other times, everyone catches fish.

In the 1920s, the recreational fishery was showing definite signs of depletion, and a regulation was passed in 1927 establishing a closed season of three months, April through June. The fishery improved, and in 1947, the closure was shortened to April through May. Grunion may be taken by sport fishermen using their hands only. No appliances of any kind may be used to catch grunion, and no holes may be dug in the beach to entrap them. Anglers sixteen years of age and older must posses a valid sport fishing license. Grunion may be taken June 1 through March 31. There is no bag limit for grunion.

Grunion, *Leuresthes tenuis*
Credit: Mike Brock

Status of Biological Knowledge

The grunion is now classified in the family of New World silversides, Atherinopsidae, along with the jacksmelt and topsmelt in California. They are small, slender fish with bluish green backs, silvery sides and bellies. Silversides differ from true smelts, family Osmeridae, in that they lack the trout-like adipose fin. They normally occur from Point Conception, California, to Point Abreojos, Baja California. They are rarely found from San Francisco on the north to San Juanico Bay, Baja California, on the south. They inhabit the nearshore waters from the surf to a depth of 60 feet. A description of their essential habitat would be the surf zone off sandy beaches. Marking experiments indicate that they are nonmigratory.

Young grunion grow very rapidly and are about five inches long by the time they are one year old and ready to spawn. Grunion adults normally range in size from five to six inches with a maximum size recorded at 7.5 inches. Average body lengths for males and females respectively are 4.5 and 5.0 inches at the end of one year, 5.5 and 5.8 inches at the end of two years, and 5.9 to 6.3 inches at the end of three years. The normal life span is two or three years, but individuals four years old have been found. The growth rate slows after the first spawning and stops completely during the spawning season. Consequently, adult fish grow only during the fall and winter. This growth rate variation causes annuli to form on the scales, which have been used for aging purposes.

Grunion spawn at night on the beach, from two to six nights after the full and new moon, beginning a little after high tide and continuing for several hours. As a wave breaks on the beach, the grunion swim as far up the slope as possible. The female arches her body, keeping her head up, and excavates the semi-fluid sand with her tail. As her tail sinks, the female twists her body and digs tail first until she is buried up to her pectoral fins. After the female is in the nest, up to eight males attempt to mate with her by curving around the female and releasing their milt as she deposits her eggs about four inches below the surface. After spawning, the males immediately retreat toward the ocean. The milt flows down the female's body until it reaches the eggs and fertilizes them. The female twists free and returns to the sea with the next wave. The whole event can happen in 30 seconds, but some fish remain on the beach for several minutes.

Spawning may continue from March through August, with possibly an occasional extension into February and September. However, peak spawning is from late March through early June. Once mature, an individual may spawn during successive spawning periods at about 15-day intervals. Most females spawn about six times during the season. Counts of maturing ova to be laid at one spawning ranged from about 1,600 to about 3,600, with the larger females producing more eggs.

The eggs incubate a few inches deep in the sand above the level of subsequent waves. They are not immersed in seawater, but are kept moist by the residual water in the sand. While incubating, they are subject to predation by shore birds and sand-dwelling invertebrates. Under normal conditions, they do not have an opportunity to hatch until the next tide series high enough to reach them, in 10 or more days. Grunion eggs can extend incubation and delay hatching if tides do not reach them, for an additional four weeks after this initial hatching time. Most of the eggs will hatch in 10 days if provided with the seawater and agitation of the rising surf. The mechanical action of the waves is the environmental trigger for hatching, and the rapidity of hatch, in less than one minute, indicates that it is probably not an enzymatic function of softening the chorion, as in some other fishes. One can witness the spectacle of grunion eggs hatching. If you gather a cluster of eggs after a grunion run, keep them in a loosely covered container of damp sand in a cool spot. After 10 to 15 days, place some in a jar of seawater shaken briefly, and they will hatch before your eyes in a few minutes.

Grunion food habits are not known. They have no teeth, and feed on very small organisms, such as plankton. In a laboratory setting, grunion eat live brine shrimp. Humans, larger fish, and other animals prey upon grunion. An isopod, two species of flies, sandworms, and a beetle have been found preying on the eggs. Some shorebirds such as egrets and herons prey on grunion when the fish are on shore during spawning. The reduction of spawning habitat, due to beach erosion, harbor construction, and pollution is probably the most critical problem facing the grunion resource.

Status of the Population

Despite local concentrations, the grunion is not an abundant species. While the population size is not known, all research points to a rather restricted resource that is adequately maintained at current harvest rates under existing regulations.

Management Considerations

See the Management Considerations Appendix A for further information.

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Jack Mackerel

History of the Fishery

The jack mackerel (*Trachurus symmetricus*), originally known as horse mackerel, was reported in the commercial catch as early as 1888, and was a minor component of the coastal pelagic species (CPS) fishery until 1947. The CPS fishery uses encircling nets (purse and drum seine, and lampara nets) to target market squid, Pacific sardine, Pacific mackerel, northern anchovy, and jack mackerel in the waters off California. Much of the catch between 1926 and 1946 was taken incidentally with sardine and Pacific mackerel and was sold at fresh fish markets where it did not spoil as quickly as Pacific mackerel. Landings were low, varying between 200 and 15,000 tons annually and comprising less than three percent of the CPS landings each year.

In 1947, jack mackerel landings increased almost tenfold to 65,000 tons as the canning industry turned to jack mackerel in the face of the collapsing sardine fishery. The U.S. Food and Drug Administration authorized changing the common name from horse mackerel to jack mackerel in 1947 to increase consumer appeal. Between 1947 and 1979, jack mackerel landings ranged from 800 to 73,000 tons, comprising six percent to 65 percent of the annual CPS landings.

The recovery of the Pacific mackerel population in the late 1970s shifted effort away from jack mackerel. The CPS fleet prefers Pacific mackerel, because jack mackerel occur farther from port and tend to aggregate over rocky bottom where there is increased chance of damage to the encircling nets. The recovery of the Pacific sardine and increased demand for squid worldwide have also contributed to the decline in jack mackerel landings in California.

Since 1991, jack mackerel has been caught primarily from December through April, with landings low during the remainder of the year. Landings have averaged less than 2,000 tons each year, comprising only two percent of the CPS landings. Most of the catch occurs in southern California.

The CPS fleet catches jack mackerel only when the young fish, less than six-years-old form schools near the surface. As jack mackerel grow older, their behavior changes, and they inhabit deeper waters farther offshore. The unpredictable availability of jack mackerel also plays a part in the erratic catches, since there are times when the fleet cannot find jack mackerel schools for several months.

Large, adult jack mackerel were taken incidentally in the Pacific whiting (hake) trawl fishery off California in the 1970s and 1980s. Because of this, jack mackerel was included in the Pacific Fisheries Management Council's (PFMC) Pacific Coast Groundfish Fishery Management Plan (FMP). The allowable biological catch (ABC) and equivalent quota for jack mackerel was set at 13,230 tons from 1983 to 1990 for the fishery which occurs north of 39° latitude (Point Arena). The fishery south of 39° is not regulated. In 1991, the ABC was raised to 57,990 tons and the quota to 51,530 tons where it remained throughout the 1990s.

Since much of the trawl-caught jack mackerel is discarded at sea, total catch is not available. Estimates of jack mackerel caught by Pacific whiting trawlers has ranged from less than 500 tons to over 2,000 tons in the 1970s and 1980s. After a US-USSR survey of jack mackerel conducted in 1991, an experimental fishery was attempted off California. Large factory trawlers from Alaska came south searching for jack mackerel, but found few fish and the fishery never developed.

In the early 1990s, southern California fishermen and processors became concerned over the possible expansion of the jack mackerel fishery and lobbied heavily for Federal management of the CPS fishery. In 1999, the Coastal Pelagic Species Fishery Management Plan (CPS FMP) was adopted by the PFMC and jack mackerel was included in the plan as a monitored species and dropped from the Pacific Coast Groundfish FMP. The CPS FMP sets the ABC at 52,910 tons with a quota of 34,170 tons based on the portion (65 percent) of the population in US waters. Should the jack mackerel catch exceed the quota for two consecutive years, the PFMC would have to decide whether to change the fishery to active status, resulting in a need for an annual biomass estimate and subsequent harvest guideline.

In addition to the whiting trawl fishery, a few adult jack mackerel are also taken in the northern California salmon troll fishery. Landings from the salmon fishery are a small portion (less than one percent) of the total jack mackerel landings.

Large jack mackerel have occasionally contributed to the commercial passenger fishing vessel (CPFV or partyboat) sport fishery. In 1953, a run of large fish was encountered in southern California, which contributed 13 percent of the CPFV catch in southern California and 8.6 percent

Jack Mackerel, *Trachurus symmetricus*
Credit: DFG

statewide. That was an exceptional year and, since then, jack mackerel have been of minor importance in the CPFV catch. Smaller jack mackerel are caught at times from fishing piers in southern and central California. Since 1980, recreational landings have been highly variable, ranging from an estimated 5,000 fish to over 350,000, based on data collected by Pacific States Marine Fisheries Commission samplers. These data are expanded from direct observations and information collected from anglers. For minor recreational species, such as jack mackerel, these expansions may greatly over-estimate the catch. Live bait landings of jack mackerel in the 1990s have been negligible due to a preference for Pacific sardine and northern anchovy as bait by sport anglers.

Status of Biological Knowledge

Jack mackerel are actually members of the jack family, Carangidae, and are not true mackerel. They are widely distributed throughout the northeastern Pacific Ocean, where young fish (up to six years and 12 inches fork length) are found schooling over shallow rocky reefs, generally less than 200 feet deep, and along rocky shorelines of the coast and islands off southern California and Baja California. Large fish (16 years and older and 20 inches fork length) are found offshore and farther north, east of a line that goes from Cabo San Lucas to the eastern Aleutian Islands, and includes the Gulf of Alaska. The offshore segment of the population does not form the dense, shallow-water schools observed in young fish. The distribution of jack mackerel between six and 15 years is not well known. The movement of the larger fish into the Gulf of Alaska appears to be related to summer warming of the surface waters. Not all of the large fish migrate north, since some large jack mackerel are caught off southern California and Baja California waters throughout the year.

Jack mackerel spawn in the offshore waters (60 - 300 miles) between Punta Eugenia and Point Conception from March through July. The center of offshore spawning activity moves north as the season progresses. There is little production in the inshore waters (up to 80 miles) of the Southern California Bight until July, presumably when the young fish begin to spawn. Little is known about the seasonal and geographic limits of the offshore and northern spawning areas. A 1955 survey found jack mackerel eggs and larvae offshore (100 - 1,000 miles) off Oregon and Washington in August. A second survey in October 1972 found an area of spawning jack mackerel 200 to 600 miles off Washington.

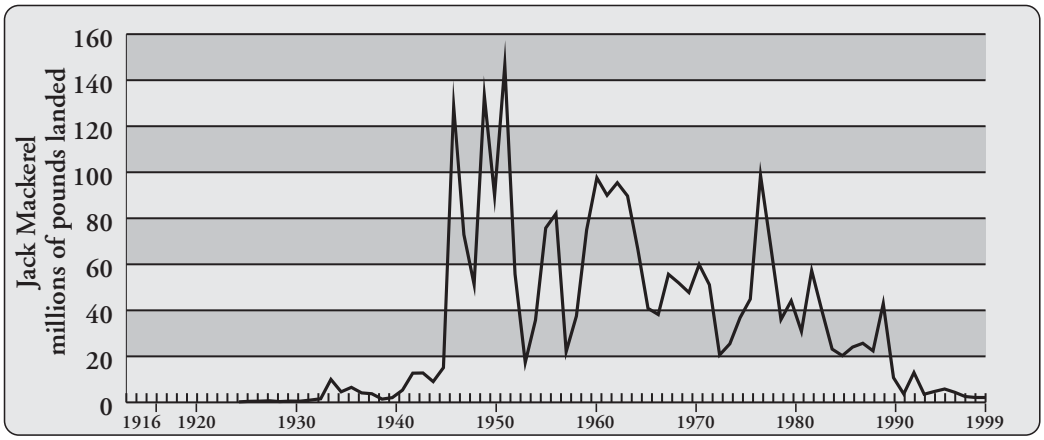
Like anchovy and Pacific mackerel, jack mackerel appear to be multiple spawners, with females spawning on average every five days and 25 times per year. Batch fecundity (number of eggs per spawning event) changes over time with females producing almost 104,000 eggs during the first spawning event and 73,000 during subsequent events. Most (70 percent) female jack mackerel from the southern California fishery become mature around their first birthday. By their second birthday, 90 percent of the females are spawning. Most of the eggs are spawned in 57° to 61° F water. Eggs are about 0.04 inches in diameter and float free in the ocean for three to five days before hatching, depending on the water temperature.

Larval jack mackerel feed primarily on copepods. Juvenile jack mackerel seem to prefer copepods, pteropods, and euphausiids, although at times they feed almost exclusively on juvenile squid and anchovies. Food habits of the older, offshore fish are unknown. Jack mackerel are preyed upon by large fish like tuna and billfish. Smaller fish and marine birds are unlikely to feed on jack mackerel, except young-of-the-year and yearlings, because they are too large to be eaten. A study of the diet of the California sea lion in the northern Channel Islands from 1981 to 1995 found that jack mackerel ranked as the fourth most frequently occurring species. The importance of jack mackerel in the diet of other marine mammals is not well known.

Status of the Population

The most recent estimate of total biomass was made more than 17 years ago, in 1983. Total biomass was estimated at 1.63 to 1.99 million tons with spawning biomass accounting for 1.50 million tons. These estimates must be viewed as tentative approximations of the population because of two factors. First, at the time, the spawning frequency of jack mackerel was not known, and estimates were based on the spawning frequencies of northern anchovy (15 percent of females spawn each day during the peak spawning months) which has similar gonad morphology and a protracted spawning season like jack mackerel. Second, estimates were derived from plankton surveys for eggs and larvae in the Southern California Bight, which did not cover the entire range of the spawning population, and assumptions were made for the contribution of older jack mackerel outside the survey area. A recent study estimated the spawning frequency for jack mackerel at 20 percent of the spawning population. Using a spawning frequency of 20 percent would have yielded a lower biomass estimate in 1983. Although we now have an estimate of spawning frequency, no other biomass estimates have been produced since 1983.

There has been a decrease in the percentage of older fish (three to six years) in the catch since the 1960s, which has caused some concern. It is unclear whether this change



Commercial Landings 1916-1999, Jack Mackerel
Data Source: DFG Catch Bulletins and commercial landing receipts. Jack mackerel were aggregated as unclassified mackerel prior to 1926.

is due to a decrease in the number of older fish or to a change in the distribution of these fish.

Management Considerations

See the Management Considerations Appendix A for further information.

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Revised by:
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Kelp Bass

History of the Fishery

Kelp bass (*Paralabrax clathratus*) are popularly referred to as calico bass and represent one of the most important nearshore, recreational species in the waters off of southern California. This important species has been the target of southern California anglers and commercial fishermen since the early 1900s. In the early years of the fishery, catch statistics grouped kelp bass and the two other *Paralabrax* species, barred sand bass and spotted sand bass, into a single "rock bass" category. Based on recent information, it is very likely that kelp bass comprised most of this catch category early on. The largest commercial landings of rock bass occurred during the 1920s and 1930s; annual landings averaged 500,000 pounds. A sharp decline in fishing activity occurred during and after World War II and landings never exceeded 150,000 pounds from 1941 through 1953. The general decline of the rock bass resource prompted conservation measures, which in 1953 made commercial fishing for rock bass illegal in California waters. Legally sold fish imported from Mexico dwindled to insignificant levels since the late 1950s. Sport anglers using light hook-and-line tackle catch kelp bass while fishing from piers, beaches, private boats, and commercial passenger fishing vessels (CPFVs). Sport catch records for rock bass taken by CPFVs have been available since 1935, but only CPFV records since 1975 reliably differentiated kelp bass catches from the other rock bass. Early sport anglers considered the kelp bass a nuisance when attempting to catch more desirable gamefish. Only the largest "bull bass" were sought. In 1939, a limit on sport fish catches in California, 15 total fish in an aggregate of several species, was the first management attempt to prevent depletion of popular sport fish populations.

Intense fishing immediately after World War II may have caused a progressive decrease in the size of landed bass, and the popular kelp bass fishery was deteriorating. The California Department of Fish and Game (DFG) instituted comprehensive studies in 1950 that resulted in size and bag limits for sport caught kelp and sand bass combined. The new size limit began at 10.5 inches and was increased several times until the 12-inch limit was reached in 1959.

Kelp Bass, *Paralabrax clathratus*
Credit: DFG

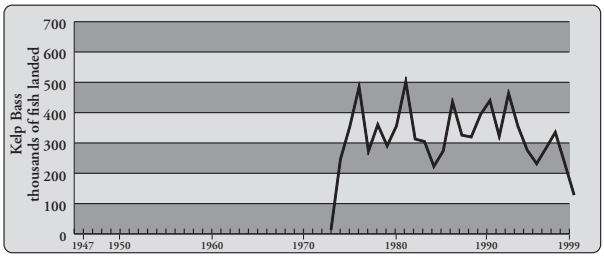
The kelp bass catch has fluctuated greatly since the 1960s. The largest CPFV catches occurred during the mid-1980s, estimated at over 1,000,000 fish annually. Since 1980, the CPFV kelp bass catch has ranged from 273,000 to 2,795,000 fish in 1988 and 1986, respectively, and averaged about 1,000,000 kelp bass per year. CPFV landings of kelp bass typically peak in the late spring and early fall. The recent Federal Marine Recreational Fishery Statistics Survey estimated that since 1990 the catch from shore, pier, and private boat anglers averages about 900,000 kelp bass per year which exceeds that of CPFV fishermen (about 800,000 fish per year). The CPFV landings of kelp bass steadily declined each year from 1993 to 1999.

The most productive fishing areas for kelp bass in recent years have been off the Coronado Islands, Baja California, Mexico; Point Loma and La Jolla in San Diego County; Dana Point and Huntington Beach in Orange County; Santa Catalina Island and Horseshoe Kelp in Los Angeles County; and around the Channel Islands in Santa Barbara and Ventura Counties.

Status of Biological Knowledge

Kelp bass have ranged historically as far north as the mouth of the Columbia River and south to Bahia Magdalena, Baja California, Mexico. However, they are rare north of Point Conception. They are abundant in southern California waters including the shores of all the Channel Islands. They are typically found in shallow water (surface to 150 feet) being closely associated with high relief structure, including kelp. Kelp bass range throughout the water column, but seem to concentrate between eight and 70 feet. In general, they live solitary lives but form assemblies to spawn and to feed on small schooling fish. Early tag and release studies showed little movement for the majority of kelp bass and concluded that if they move at all, it is to nearby rocky reefs or short distances to gather into breeding assemblages. More recently, tagging studies in the northern portion of the Southern California Bight from Point Conception south the northern Channel Islands indicated the kelp bass were quite mobile with some fish traveling as far as 50 miles.

Kelp bass have the broad diet of a generalized carnivore consisting of small fishes (including anchovies, sardines, surfperch, queenfish), squids, octopuses, crabs, shrimps, and amphipods. They forage primarily in the midwater, but occasionally feed on the bottom. Young kelp bass feed on small crabs, copepods, and plankton. They feed lightly in the winter and most heavily during May through September.



Recreational Catch 1947-1999, Kelp Bass
CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks. Prior to 1973, Kelp Bass and Barred Sand Bass CPFV catch data were aggregated.

Kelp bass mature between seven and 10.5 inches in length and about three to five years and form breeding aggregations in deeper water off of kelp heads and rocky headlands, generally, in depths down to 150 feet. Several hundred ripe adults may aggregate in a small area during spawning. During spawning, high-contrast, black and white individuals with yellow-orange snouts are usually males, and fish with golden hues and yellow chins and jaws are usually females. Spawning occurs primarily around the full moon from April through November peaking in the summer months. Kelp bass produce pelagic eggs (0.04 inches in diameter) which enter the plankton in coastal waters. Larvae remain in the plankton for 28 to 30 days at which time they settle out in shallow water in attached, as well as drift algae including kelps. Young-of-year kelp bass grow to a length of about two inches in the first 90 days of life.

Kelp bass are known to grow to 28.5 inches and 14.5 pounds. The oldest known kelp bass was 34 years old and 25 inches long. Juvenile kelp bass can be five to six inches after one year and are about 12 inches (legal size) at five years. The average 10 year-old kelp bass is about 18 inches in total length. As with most fishes, growth is highly variable with the largest fish not necessarily being the oldest. The world record kelp bass (14.5 pounds) caught off Newport Beach in 1995 was 27 years old while a 9.5 pound fish caught at San Clemente Island in 1993 was 34 years old.

Status of the Population

In the 1970s and 1980s, the kelp bass was among the top three species taken by the average angler per hour of fishing (along with barred sand bass and Pacific mackerel). In 1986 and 1989, kelp bass were the most commonly taken species in the CPFV fleet. Throughout the 1980s, kelp bass have consistently ranked among the top five fishes caught by CPFV anglers. DFG surveys indicate the estimated total catches of kelp bass have increased since the mid-1970s. Low periods of kelp bass landings in the mid-1970s and early-1980s may be attributed to El Niño events that provide anglers with alternative species to catch. Peak landings have followed each El Niño event. DFG surveys of the CPFV industry in the 1970s and 1980s indicated a stable spawning population is being maintained because of the large number of age classes that are caught and kept by anglers. Approximately 85 percent of the kelp bass kept by CPFV anglers measure between 11.4 to 15.9 inches, representing up to seven age classes. However, the alarming decline of recreational catch from all sources that has occurred in the 1990s is a major cause for concern.

Management Considerations

See the Management Considerations Appendix A for further information.

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Kelp Greenling

History of the Fishery

Kelp greenling (*Hexagrammos decagrammus*) are fished primarily for sport. The commercial fishery has historically been based largely on catch incidental to the lingcod or nearshore rockfish fisheries, although their importance in the commercial catch has increased since 1997 with the emergence of a nearshore "live" fish fishery. Because of their abundance in nearshore rocky areas, they are frequently caught by people fishing from shore or small boats and are a common target for spear fishermen underwater. Sport fishing surveys made from 1958 to 1961 showed that kelp greenling were the most frequent catch of shore fishermen north of San Francisco, where in some areas they made up more than 30 percent of the total catch. In California, during those years, an average of 54,000 kelp greenling were caught by hook-and-line fishermen and another 2,000 by spear fishermen. In later surveys conducted from 1980 to 1999, the estimated sport catch averaged 106,650 fish per year, with 103,000 of those taken between Monterey County and the Oregon border. It should be noted that the two sport fishing surveys used different sampling designs, so results may not be comparable. By comparison, the commercial catch reported from 1981 to 1999 averaged about 8,500 fish per year. This average is somewhat exaggerated by exceptionally large numbers of fish landed commercially in recent years by the nearshore live fish fishery mentioned above. From 1981 to 1996 average commercial catch was only around 5,500 fish per year, while from 1997 to 1999 that average increased to 27,400 fish per year. Until recently most of these fish were sold in the fresh-fish market, although now many are sold live to restaurants. Though fillets from kelp greenling are not as large as those from their more popular relative, the lingcod, texture and taste are comparable.

Status of Biological Knowledge

Kelp greenling range from San Diego to the Aleutian Islands, but are common only north of Morro Bay. Here they are one of the most conspicuous fishes in rocky nearshore habitats occurring often in and around kelp beds. The male and female look so different that they were first described as separate species. The body color is variable in both sexes, ranging from light gray to brown. Males, however, have large irregular blue patches anteriorly, while females are uniformly covered with smaller dark spots.

These solitary fish are common at depths between 10 and 60 feet, and range down to 150 feet. Sport catches indicate that larger fish live in deeper water. For example, fish caught at 80 to 100 feet range from 12 to 18 inches long while those caught at 20 to 40 feet tend to be eight to 13 inches long. Kelp greenling grow faster than most nearshore fishes during their first three years. After the third year, growth slows, especially in males (as it does in lingcod), so that by the fifth or sixth year males are smaller than females. The maximum reported age and size is 16 years and 21 inches. At age three, males average 10.6 inches and females 9.1 inches. By age five, the males average 12.6 inches while females are 14.7 inches. Ten-year-olds average 15.5 and 16.4 inches, respectively. These data are from Puget Sound, Washington.

The reproductive behavior of greenling is similar to that of the lingcod. Females are mature by their fourth year and spawn adhesive egg masses on the sea bed and encrusting biota within the territories of courting males. In Puget Sound, females deposit egg masses that range from golf-ball to tennis-ball size, with an average of about 4,000 eggs per cluster. Females are batch spawners, capable of producing multiple clutches of eggs per spawning season. Males fertilize the eggs and guard the nests until larvae about one third of an inch long emerge four to five weeks later. Often, males guard more than one egg mass at a time, each possibly produced by a different female. Studies done in British Columbia and California showed some nests did contain egg masses from multiple females. Hatching occurs from December through February in northern California and gets progressively earlier to the north, November through January in Puget Sound and August through September in Alaska. Larvae and early juveniles feed on small copepods and spend about one year in the pelagic environment before entering the nearshore benthic community.

After they settle in the nearshore environment, kelp greenling have flexible food habits. During most of the year, they consume a variety of prey that are consistently available in the habitat, including crabs, amphipods, polychaetes and ascidians. There are brief periods when organisms such as juvenile fishes or herring spawn become exceptionally abundant, and kelp greenling shift their food habits to take advantage of these opportunities.

Kelp Greenling, *Hexagrammos decagrammus*
Credit: DFG

The primary predators of adult greenling are lingcod and harbor seals. As juveniles they are probably prey to many nearshore predators.

Status of the Population

There are no estimates of abundance for kelp greenling in California. The yearly sport catch remained relatively constant during the first ten years (1980-1989) it was surveyed, but has declined steadily from 1993 to 1999. Since decline in catch is one symptom of overfishing, this may be an indication that current levels of fishing are having adverse effects on the population, although no population data are available at present to confirm this. Spear fishermen could overfish local populations, however, because they can select individual targets, and greenling are particularly vulnerable to spears when guarding their nests. Also, although commercial catch has been traditionally very low compared to recreational catch, the increased fishing pressure in recent years by the nearshore live fish fishery could have a much broader impact on the kelp greenling population in California.

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Revised by:
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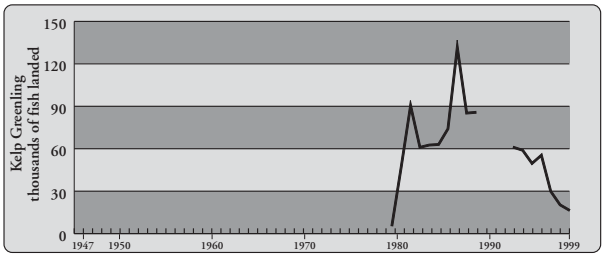

Recreational Catch 1947-1999, Kelp Greenling
Data Source: RecFin data base for all gear types; data not available for 1990-1992

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Leopard Shark

History of the Fishery

The leopard shark (*Triakis semifasciata*) is taken as both a food and game fish in California, and its distinctive markings and hardiness also make it desirable for public aquarium displays. Although some commercial landings may be lumped under a general "shark, unspecified" category, those reported as "leopard shark" have ranged from 9,270 pounds in 1958, to a high of 101,309 pounds in 1983. These landings, while not extensive, increased in the south and decreased in the north during the 1980s. Landings in southern California began increasing in 1981, and in 1985 surpassed landings in northern California for the first time since the collection of statistics began in the 1940s. Since 1991, landings have averaged about 31,000 pounds per year, with about 57 percent of the landings occurring south of Point Piedras Blancas. Legislative curtailment of inshore gillnetting in the San Francisco/Monterey Bay area undoubtedly contributed to much of the decline in northern California landings after 1986.

Judging from estimates made since 1980 by the National Marine Fisheries Service (NMFS) Marine Recreational Fisheries Statistics Survey, the recreational leopard shark catch appears to be greater than the commercial catch, although these estimates are subject to large sampling variability. According to the survey, sport catches in California between 1980 and 1988 averaged over 52,000 fish per year with a low of 33,000 fish taken in 1980 and a high of 59,000 fish taken in 1988. Since 1993, an estimated average of 45,000 leopard sharks have been taken by anglers, with a low of 34,000 taken in 1993 and again in 1994, and a high of 58,000 taken in 1997.

A variety of fishing methods and gear types are used in the fisheries for leopard sharks. Most of the recreational catch is taken angling with baited hooks with some spearfishing by divers. Analysis of tag-recaptures in the central California area in the 1980s suggests that most angler-caught leopard sharks are taken from private boats (55 percent), and from shore (41 percent), with a small percent landed by partyboats (four percent). The commercial catch, largely incidental in recent years, is taken mainly by set net (53 percent), hook-and-line (30 percent), and trawl (13 percent).

Leopard Shark, *Triakis semifasciata*
Credit: CA Sea Grant Extension Program

A 36-inch minimum size and a possession limit of three fish have been in effect for the sport fishery since 1991. This size limit was also extended to the commercial fishery in 1994, both for market and aquarium display. Additionally, the state has general restrictions on usage of certain types of commercial gear in the nearshore zone.

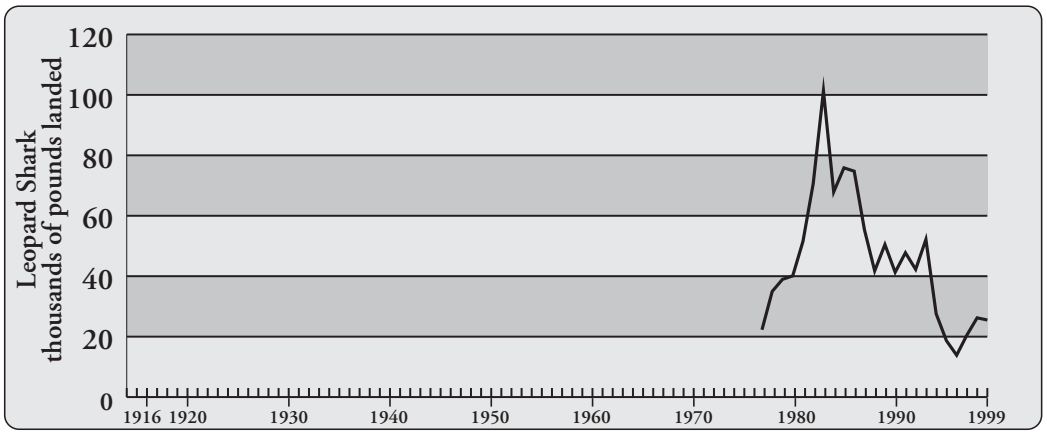
Status of Biological Knowledge

The leopard shark, also known as "tiger shark" and "cat shark," ranges from Mazatlan, Mexico, into the northern Gulf of California, and northward to Oregon. It is most common in shallow water from the intertidal down to 15 feet, less so down to 300 feet or deeper in ocean waters. Favoring muddy bays and sloughs, especially in northern California, it is known to move out and in with the tides to feed over shallow tidal mudflats. It also occurs along the open coast and around offshore islands off southern California, where it frequents kelp beds, sandy bottoms near rocky reefs, and the surf zone along sandy beaches.

The population structure throughout its range is not clearly understood, but is thought to consist of regional stocks among which there is relatively little exchange. Tagging studies in central California have shown there is at least some mixing between stocks in San Francisco Bay and those in central and southern California, but such exchange appears limited. The Gulf of California, Mexico, stock is presumed to be separate from the California stocks.

The maximum recorded and verified total length is about six feet long. The oldest validated age that has been determined by reading tetracycline-labeled rings on the vertebrae, is 26 years for a 49-inch female, an average of 1.8 inches per year. Size at birth is about eight to 10 inches in total length. Longevity is presumed to be around 30 years.

The live-bearing female leopard shark produces from seven to 36 offspring in an annual reproductive cycle. Males mature at seven years, and females at 10 years, when fish reach lengths between 40 and 42 inches total length. The gestation period is estimated at 10 to 12 months. Birth apparently takes place from March through July. The only known eye-witness account of leopard sharks giving birth in the wild is that of a fisherman who observed "pupping" activity at Santa Catalina Island in southern California in the 1940s. Dozens of large females,



Commercial Landings 1916-1999, Leopard Shark
Commercial landings for leopard shark were not reported prior to 1977. Data Source: DFG Catch Bulletins and commercial landing receipts.

with backs and dorsal fins breaking the surface of the water over a shallow mudflat in Catalina Harbor, were observed releasing their pups in the three to four-foot deep water; some of the pups were seen milling around in water only about a foot deep.

This shark is an opportunistic benthic feeder. Invertebrates taken include crabs, ghost shrimp, clam siphons and sometimes whole clam bodies, polychaete worms, fat innkeeper worms, and octopuses. Fishes in the diet include herring, anchovy, topsmelt, croakers, surfperches, gobies, rockfishes, midshipman, flatfishes, and small elasmobranchs such as smoothhounds, guitarfishes, and bat rays. Leopard sharks seasonally consume the eggs of herring, topsmelt, jacksmelt, and midshipman.

The leopard shark is preyed upon by the white shark and sevengill shark, and presumably other large sharks as well, which are known to enter bays. The phenomenon of young sharks being preyed on by larger sharks is not uncommon.

These nomadic sharks often occur in schools, sometimes with smoothhounds, which also belong to the houndshark family. Numbers of animals may suddenly appear in an area, then move on. Although generally timid and wary of divers, there is one record of an attack on a skin diver in 1955 in California.

Movements of this species have been studied in central California. Tagging in San Francisco Bay has revealed that this stock is mostly resident, although at least 10 percent of the population moves out of the bay into the ocean during fall and winter. One female at liberty for 20 years was recaptured in south San Francisco Bay less than five miles from where she was originally tagged. Of the longer distance migrants, one three-foot male tagged in San Francisco Bay was recaptured in Santa Monica Bay a decade later.

Status of the Population

The leopard shark is one of the many species considered, but not now actively regulated, under the Pacific Fishery Management Council's Groundfish Management Plan. Regulatory actions enacted by the State of California have contributed significantly toward protecting this species. Even though the commercial catch may be underestimated because of reporting problems, this species does not appear to be at risk, judging by the combined landings in relation to previously calculated estimates of fishing mortality and exploitation rates and current conservation measures which appear to have reduced these rates. The imposition of a sport and commercial fishing size limit and general curtailment of gillnetting within this species' nearshore range appear to have halted the increase if not reduced total fishing mortality over the past decade. Commercial sport fishing boat catches of leopard shark in California have dropped from an average of 6.8 fish per trip between 1980 and 1991 to an average of 4.0 fish after the size limit was imposed from 1992 to 1995, as more fish were released. Also encouraging is evidence that mortality from hooking injuries is quite low.

The size of the California leopard shark population has not been estimated, and the only information on relative changes in stock abundance is what can be inferred from catch statistics. Because of its rather limited geographical range with little exchange among regional stocks within this range, resident stocks near large population centers may be particularly vulnerable to heavy localized fishing pressure. A recent re-assessment of the leopard shark's intrinsic productivity and vulnerability to harvest revealed it to be even more susceptible to over-exploitation than previously reported. Its annual rate of increase under maximum sustainable yield exploitation has been calculated at only about two to three percent per year. And while the size limit protects juveniles, it does not protect

mature adults in their prime reproductive years in feeding and near shore pupping areas. Nonetheless, it appears that current conservation measures, as long as they are in place, appear to provide adequate protection for the sustainability of the California stock of this species at the present time. Possible future fishing mortality increases within regulatory constraints could be a concern if mature females become an increasingly important component of the catch, or if inshore fisheries develop that are efficient at targeting this species.

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Monkeyface Prickleback

History of the Fishery

The monkeyface prickleback (*Cebidichthys violaceus*) is a nearshore fish that is a minor component of the recreational and commercial catch. It is frequently referred to as monkeyface eel and blenny eel due to its eel-like appearance. However, it is more closely related to bass-like fishes (Perciformes) than to true eels. It is a member of the prickleback family, Stichaeidae, of which 17 species occur in California. Its elongate body shape is an adaptation for living in cracks, crevices, and under boulders, primarily in the intertidal zone. Monkeyface prickleback have been found in coastal Indian middens of California along with cabezon and rockfishes and were undoubtedly exploited as a food resource in historic and prehistoric times.

A specialized recreational fishery by shore anglers fishing in rocky intertidal and shallow subtidal habitat exists for this species. The most common fishing method is "poke poling," which normally consists of fishing with a long bamboo pole, a short piece of wire, and a baited hook. The bait is placed in front of or in holes or crevices in the rock. Skin and scuba divers also spear them.

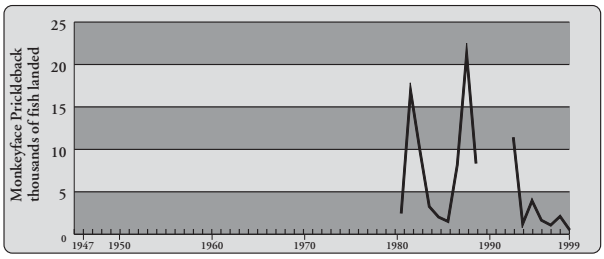
The monkeyface prickleback did not rank among the top fifteen species observed in either beach/bank or jetty/breakwater fishing categories in a 1980 through 1986 Marine Recreational Fisheries Statistics Survey (MRFSS) in California. The most recent (1999) MRFSS total catch estimate for northern California from all recreational fishing categories was 2,000 fish; however, the standard error of the estimate was much higher than the estimate.

Commercial landing records in California date from 1928. Catch since then can best be described as of minor significance. Since 1991, annual landings have ranged from 12 to 935 pounds, primarily from the port areas of San Francisco and Santa Barbara. However, catch statistics may include California moray, rock prickleback, wolf-eel, and other eel-like fishes or true eels.

Status of Biological Knowledge

The monkeyface prickleback ranges along the Pacific coast from San Quentin Bay, Baja California, Mexico to central Oregon. It is most common off central California from San Luis Obispo County to Sonoma County, and is uncommon south of Point Conception. They normally occur in the intertidal zone with a depth range extending from the high intertidal to a reported depth of 80 feet. Typical habitat for monkeyface prickleback includes rocky intertidal areas with ample crevices, boulders, and algal cover, including high and low tide pools, jetties and breakwaters, and shallow subtidal areas, particularly rocky reefs and kelp beds. Juveniles are particularly adapted for living in the high intertidal zone. The species is capable of living out of water under algae for extended periods and has air-breathing capacity. It is considered to be a residential species, moving short distances from crevices or under rocks to foraging sites. It appears to occupy a small home range of several meters and is primarily active during periods of a flooding tide.

The coloration of the species is a uniform light brown to dark green, often with several rust-colored blotches on the sides of the body. Two dark stripes radiate behind the eye. Adults have a lumpy ridge on top of the head. The coloration of both sexes is similar.

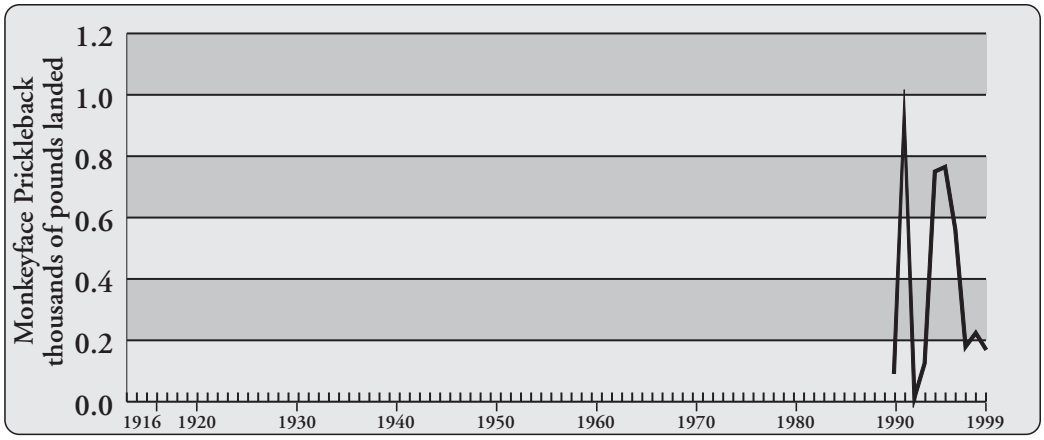


Recreational Catch 1947-1999, Monkeyface Prickleback
Data Source: RecFin data base for all gear types; data not available for 1990-1992

Monkeyface prickleback grow slowly, particularly after the first few years of life. A 12-inch fish is approximately three years old, while a 24-inch fish will be 15 to 17 years old. Monkeyface prickleback have been aged to 18 years using the otolith and opercular bone, but the largest specimens have not been aged. The maximum reported size is 30 inches in total length; 18 to 24 inch individuals are not uncommon.

Information available on age at sexual maturity suggests that both sexes begin to mature in their third or fourth year at a total length range of 11.0 to 14.2 inches, while 50 percent maturity occurs at approximately 15.4 inches at five years of age. Fertilization is internal and spawning activity occurs from January to May, with the peak spawning period from February to April. Females are oviparous, depositing their eggs on subtidal, rocky surfaces. Fecundity is known to range from 17,500 eggs for a 16-inch, seven-year old fish to 46,000 eggs for a 24-inch, 11-year-old fish, with smaller fish producing fewer eggs. Nest guarding behavior has been observed but it is unclear

Monkeyface Prickleback, *Cebidichthys violaceus*
Credit: PSMFC



Commercial Landings 1916-1999, Monkeyface Prickleback
No commercial landing are reported for monkeyface prickback prior to 1990. Data Source: DFG Catch Bulletins and commercial landing receipts.

if the female, male, or both sexes guard the egg mass. Larval length at hatching is unknown; larvae begin to settle out of the plankton at 0.7 to 0.9 inches.

The diet of monkeyface prickleback shifts from carnivorous to herbivorous with an increase in size. As early juveniles, up to 3.1 inches, prey items are predominantly zooplankton and include copepods, amphipods, isopods, mysids, and polychaetes. At approximately three inches, they then become almost exclusively herbivorous. Over sixty species of algae have been recorded as food items. Despite this wide array, they appear to feed selectively on eight to 10 species of red and green algae, mostly in the genera *Ulva, Porphyra, Mazzaella, Microcladia,* and *Mastocarpus.* Adults appear to prefer annual red and green algae to perennial red algae. This preference is determined to some degree by ocean season and availability.

Predators of monkeyface prickleback include piscivorous birds, such as great egrets and red-breasted mergansers, and fishes such as cabezon and grass rockfish. Predation is primarily on the earlier life stages of this species; large juveniles and adult fish most likely evade or outgrow these predators.

Other intertidal boulder and crevice-dwelling eel-like fishes, such as the rock and black pricklebacks and penpoint and rockweed gunnels, are possible competitors with monkeyface prickleback for space and food resources.

Status of the Population

No information is available on the status of stocks of monkeyface prickleback. The primary source of fishing mortality is from recreational poke polers and commercial anglers fishing from shore or the shallow subtidal, with a lesser number taken spearfishing by free and scuba divers. Historically, both recreational and commercial landings are considered to be low.

Management Considerations

See the Management Considerations Appendix A for further information.

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Lingcod

History of the Fishery

The lingcod (*Ophiodon elongatus*) has long been an important source of food for people living along the West Coast of North America, although current catches are low due to overexploitation of the stock. Archaeological studies of native American habitations along the central California coast indicate that between 6200 BC and AD 1830, large inshore species such as rockfishes, lingcod, and kelp greenling comprised more than half of the fishes caught on the open coast. American Indians used spears, nets, weirs, traps, and lures of wood with bone hooks to catch lingcod. Early Caucasian settlers caught lingcod as well. Fishing methods in the 1800s were similar to the hook-and-line techniques currently used to catch lingcod in the small boat jig fishery.

Catches of lingcod have been reported as a separate category since 1916 in California. Commercial landings from 1916 through 1929 ranged from 400,000 pounds to 1.2 million pounds. Landings in the first half of the century reached a peak in 1930 at 1.3 million pounds, and then declined to a low of 314,000 pounds in 1942. The California lingcod fishery grew again from 1943 through 1950, as landings ranged from 719,000 pounds to a high of 2.1 million pounds in 1948, due primarily to strong markets for liver oil and seafood. For the next two decades, landings averaged 1.2 million pounds per year, and then began to increase in the 1970s, due to the burgeoning west coast trawl fishery.

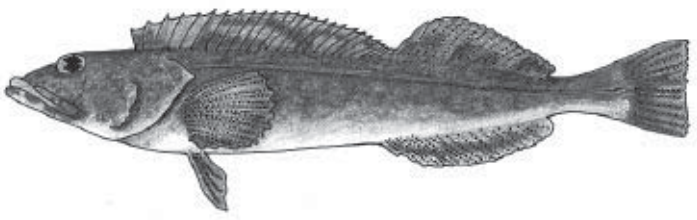
During this period of rapid fishery growth, lingcod landings in California almost tripled. From 1972 through 1982, commercial landings of lingcod averaged almost three million pounds per year. After a decline in the mid-1980s, landings rebounded to a high level again in 1989. Since then, however, commercial catches have rapidly declined, partly due to management restrictions enacted to rebuild depressed stocks. In 1999, commercial landings were only 313,000 pounds, valued at $283,000.

The character of lingcod fisheries has changed greatly in the past 30 years. In the 1970s, about 85 percent of the commercially landed lingcod were caught with trawls; however, hook-and-line gear now account for half of the commercial landings. In addition, the recently developed nearshore fishery that delivers live fish to markets and restaurants landed an average of more than 40,000 pounds per year in the 1990s. There has also been a shift in the lingcod fishery away from commercial and towards recreational catches. Recreational landings as a percentage of total lingcod landings increased from 20 percent in the 1970s to about 50 percent in the late 1990s. This was because recreational fishing effort in California increased by 65 percent between the time periods 1958 through 1961, and 1980 through 1986. Average annual landings in the California recreational fishery almost doubled during that period, from 510,000 pounds per year to 890,000 pounds per year. The increase was due largely to an increase in the private boat fishery. In 1961, 61 percent of the recreational landings came from commercial passenger fishing vessels. Now, 70 percent of the recreational landings come from the private boat fishery. In both the commercial and recreational fisheries, landings occur predominately in central and northern California.

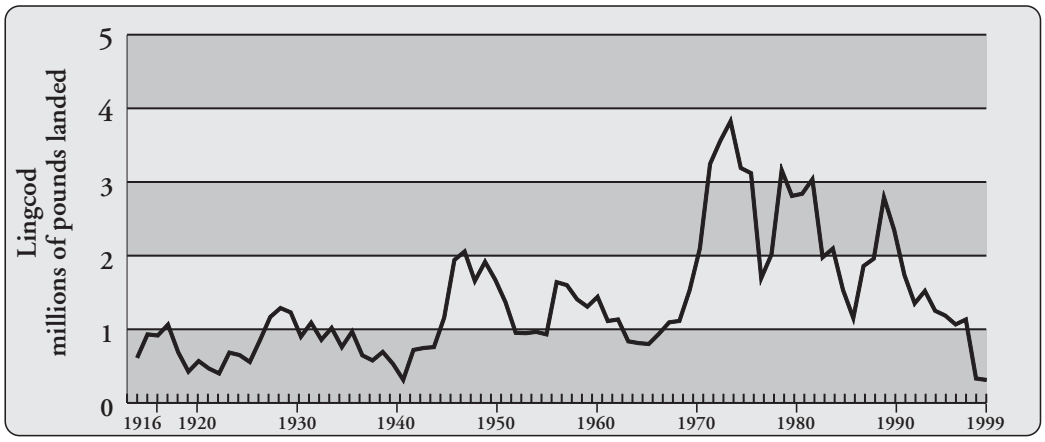
Stock assessments conducted by the Pacific Fishery Management Council (PFMC) have indicated large population declines for lingcod along its entire range. For the management areas that include California and Southern Oregon (the Eureka, Monterey, and Conception management areas), the current estimate of female spawning biomass is 13 percent of the unfished level. Consequently, fishery regulations have become more stringent, as fishery managers try to rebuild the stock.

With the implementation of the PMFC's Groundfish Plan in 1983, the combined Acceptable Biological Catch (ABC) for the Eureka, Monterey, and Conception management areas was 4.8 million pounds, or more than 1.5 million pounds higher than the commercial landings. In 1995, the combined quota for these areas was reduced by about 50 percent, and a 22-inch commercial size-limit was instituted. A monthly commercial boat-limit of 20,000 pounds per month was established along with a trawl trip-limit of 100 pounds under the 22-inch size-limit. By 2000, the combined ABC for the Eureka, Monterey, and Conception International North Pacific Fisheries Commission (INPFC) areas was reduced in half again to less than 1.2 million pounds. The monthly boat limit was reduced to 1,000 pounds and the commercial size-limit was increased to 24 inches.

Prior to 1980, there was a recreational catch limit of 10 lingcod per angler. This bag limit was reduced to five fish in 1980, and a 22-inch size-limit was introduced in 1981. In 1996, the bag-limit was reduced to three fish to conform to Oregon and Washington regulations, and the size-limit



Lingcod, *Ophiodon elongatus*
Credit: L. Sinclair, Miller and Lea



Commercial Landings 1916-1999, Lingcod
Data Source: DFG Catch Bulletins and commercial landing receipts.

was increased to 24 inches. In 1999, the bag-limit was reduced to two fish. In 2000, the size-limit was increased to 26 inches. Also, the lingcod fishery was closed south of Lopez Point, Monterey County during the months of January and February and from Lopez Point north to Cape Mendocino during March and April.

Status of Biological Knowledge

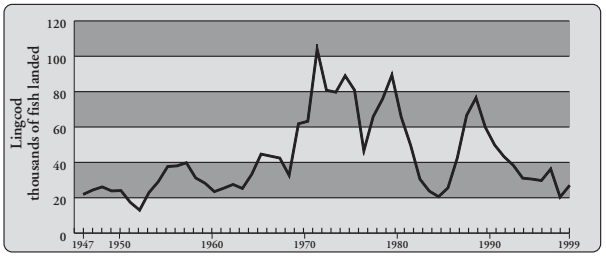
The lingcod is the largest member of the Hexagrammidae family. The scientific name *Ophiodon* is a combination of two Greek words meaning snake and tooth, a reference to the lingcod's large teeth. The name *elongatus* is of Latin origin and refers to the elongated body. Lingcod are found only off the West Coast of North America. They are distributed in nearshore waters from northern Baja California to the Shumagin Islands along the Alaskan Peninsula. Their center of abundance is off British Columbia, and they become less common toward the southern end of their range.

Lingcod lack a swimbladder and thus will rest on the bottom or actively swim in the water column. They are found over a wide range of substrates at depths from 10 to 1,300 feet, but most occur in rocky areas from 30 to 330 feet. Typically, larger lingcod occupy rocky habitats; larger animals are found on deeper banks and reefs, whereas smaller animals live in shallower waters. Adult lingcod are strongly residential, tending to remain near the reefs or rocky areas where they live. Large-scale conventional tagging studies have found that the vast majority of mature lingcod are recaptured within six miles of where they were tagged, however acoustic tagging studies have indicated frequent short-term movements. Juveniles tend to disperse and travel over a wider range than adults.

Individuals grow to a maximum length of 39 inches for males and 59 inches for females. Maximum age is thought to be 25 years. Although there is large variation in length at age, the average one-year-old fish is 13 inches long, and a two-year-old is 17 inches long. After age two, females begin to grow faster than males. The average length of a four-year-old female is 24 inches, of an eight-year-old is 32 inches, and of a 12-year-old is 35 inches. The average length of a four-year-old male is 22 inches, of an eight-year-old is 29 inches, and of a 12-year-old is 32 inches. In California, the oldest lingcod on record is a 19-year-old, 45-inch female, and the longest is a 51-inch female.

Lingcod length and age at sexual maturity vary with latitude; lingcod in the northern part of their range are larger and mature later than fish in the southern part of the distribution. As with most fishes, fecundity increases with size of fish. In the northern end of the lingcod range, females can produce 50,000 eggs at a length of 24 inches, 124,000 eggs at a length of 32 inches, and 170,000 eggs at a length of 36 inches. This level of fecundity is low compared to many other marine species in the eastern Pacific, but high for a species that guards eggs.

Lingcod exhibit an interesting spawning behavior, which includes a spawning migration into nearshore habitats for



Recreational Catch 1947-1999, Lingcod
CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

the deposition of eggs in gelatinous masses, termed nests, on rocky substrates. Males establish territory as early as a month before females lay eggs, and remain on guard at the nest until eggs are hatched. Preferred nest sites are rocky areas in shallow water where there are strong currents. Males move on to spawning grounds first, followed by large females, who spawn earlier than smaller females. After a female chooses a male and a spawning site, she swims over the site and deposits a layer of several eggs. The male then swims over the site and fertilizes the eggs. This process is repeated until spawning is completed, after which the female immediately leaves the spawning grounds. The eggs become firmly cemented to each other within the gelatinous mass in 24 to 48 hours. A relatively strong current is necessary to oxygenate the egg mass and prevent death of the embryos.

After spawning, males guard the nests from predation until the eggs hatch. On occasion, males have been found guarding two nests if they were close together, and sometimes if the male is removed, a new male will assume the guardian role. The nest guarding behavior of lingcod make them susceptible to targeted fishing during the spawning period. Males guarding nests are territorial and will aggressively strike at bait or lures that come close to the nest. Targeted fishing during the spawning season can thus directly increase lingcod mortality by increasing catch rates. It can also indirectly increase mortality by dislodging animals from the nest, resulting in increased egg mortality. Fish predators such as kelp greenling, striped seaperch, and small sculpins will eat lingcod eggs if a guardian male is removed from the nest. Invertebrates such as sea urchin, sunflower star, and snails also feed on lingcod eggs, but are not chased away by males guarding the nest. The eggs generally hatch about seven weeks after they are laid, but incubation can last from five to 11 weeks. Hatching may continue for 24 to 48 hours, after which the guardian male leaves.

Egg hatching is generally synchronous, with most eggs hatching within two to seven days of each other. Newly hatched larvae are 0.25-0.4 inches in length, and grow about 0.06 inches per day. The larvae are pelagic for about three months from early March to early June and settle to the bottom when they are about three inches long. Newly settled juveniles reside in shallow bays and on nearshore sand and mud bottoms from the beach to 333 feet in depth. Juveniles occur over a wide range of habitats including mud, sand, gravel, and eelgrass, but by age two occupy similar habitats as adults.

During the pelagic juvenile stage there is a gradual transition from a diet of small copepods to one of larger copepods, crab larvae, amphipods, euphausiids, and herring larvae. As small benthic juveniles, lingcod feed on herring, flatfishes, shiner perch, and other fishes. Even young lingcod have a very large mouth for their body size, allowing them to feed on prey much larger than other fish of their age and size. For large juvenile and adult lingcod, fish is the dominant prey, accounting for about 80 percent (by volume) of the stomach contents. In California waters, juvenile rockfishes are the most important prey.

Most predation on lingcod occurs during the egg stage, and predation becomes less common with age. On rare occasions, pelagic juvenile lingcod (1.5 to 2.6 inches) are found in the stomachs of chinook salmon. Other predators of juvenile fish, such as seabirds and marine mammals also prey on juvenile lingcod. Small benthic lingcod are probably eaten by adult lingcod and marine mammals, but have few other predators. Because of their large size, large juvenile and adult lingcod escape all but the occasional predator.

Status of the Population

Lingcod harvest has been higher than generally accepted population replacement rates for the last twenty years. Recent lingcod stock assessments have concluded that the lingcod stock is seriously depleted, and that California populations appear to be less than 25 percent of their pre-1970s level. By federal law, this level of stock depletion requires a management plan that rebuilds lingcod populations. The rebuilding plan is intended to restore the lingcod stock within 10 years. The substantial reduction in ABC after 1997 and resulting reduced fishery harvest was triggered by that rebuilding plan. Low levels of ABC and harvest will continue until lingcod populations show signs of rebounding. California lingcod appear to be highly productive, however, and there is good potential for rapid population increases given appropriate decreases in fishing effort.

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Northern Anchovy

History of the Fishery

Three separate fisheries in both California and Mexico exploit northern anchovy (*Engraulis mordax*). Anchovy landed by the reduction fishery are converted to meal, oil, and soluble protein. These products are sold mainly as protein supplements for poultry food, and also as feed for farmed fish and other animals. Meal obtained from anchovy is about 65 percent protein compared to about 50-55 percent for meal from other fishes.

Anchovy harvested by the live bait fishery are not landed but kept alive for sale to anglers as bait. Transactions between buyers and sellers of live bait take place at sea or at bait wells tied up at docks. Live bait dealers generally supply bait to commercial passenger fishing vessels (CPFVs) on a contract basis and receive a percentage of the fees paid by passengers. Bait is also sold by the "scoop" to anglers in private vessels. Anchovy landed by the non-reduction (other than live bait) fishery are used as dead frozen bait, fresh fish for human consumption, canned fish for human consumption, animal food, and anchovy paste.

Reliable records of California landings of northern anchovy date from 1916. Landings were small until the scarcity of Pacific sardines caused processors to begin canning anchovies in quantity during 1947, when landings increased to 9,464 tons in 1947 from 960 tons in 1946. To limit the quantity of anchovies being reduced to fishmeal, the California Fish and Game Commission required each processor to can a large proportion of the harvest (40-60 percent depending on can size). Anchovy landings declined with the temporary resurgence of sardine landings around 1951. Following the collapse of the sardine fishery in 1952, anchovy landings increased to nearly 43,000 tons in 1953, but subsequently declined due to low consumer demand for canned anchovy and increased sardine landings. Landings remained low through 1964. During the early years (1916 through 1964), anchovy were harvested almost exclusively by California fishermen. Mexico did not begin harvesting anchovy until 1962.

Beginning in 1965, the California Fish and Game Commission managed anchovy on the basis of a reduction quota. This quota had been taken by a fleet of approximately 40 small purse seine vessels operating off southern California known collectively as the "wetfish" fleet, which fishes for other species in addition to anchovy. In 1965, only 171 tons of anchovy were landed for reduction, which increased to an average of over 64,000 tons per year between 1965 and 1982. After 1982, reduction landings decreased dramatically to an average of only 923 tons per year from 1983 to 1991, and fell to zero in 1992 through 1994. During the period 1995 to 1999, only four tons were reported as reduction landings. Although Section 147 of Title 14, California Code of Regulations, currently provides a process for the California Department of Fish and Game (DFG) to issue permits for reduction fishing, decreased prices of fishmeal and the low prices offered to fishermen have deterred any significant reduction fishing in recent years.

The non-reduction live-bait fleet in recent years has consisted of about 18 boats that are distributed mostly along the southern California coast to serve the principal sport fishing markets. Live bait boats fish for a variety of species, but anchovies comprised approximately 85 percent of the catch prior to 1991. Pacific sardines became available to the live bait fishery again in 1992, and the composition of live bait catches shifted from primarily anchovy to primarily sardine. From 1996 through 1999, sardines constituted approximately 72 percent of the live bait catch. Historically, the anchovy live bait catch ranged from 4,000 to 8,000 tons per year and averaged approximately 4,500 tons annually between 1974 and 1991. This average dropped to slightly over 2,500 tons between 1992 and 1994. Current estimates of the live bait catch are available from the DFG Pelagic Fisheries Assessment Unit in La Jolla, California. Non-reduction (other than for live bait) landings averaged slightly over 2,200 tons per year from 1965 to 1994, and increased to an average of about 4,122 tons per year between 1995 and 1999.

Anchovy landed in Mexico, other than a small amount used for bait, have been used primarily for reduction. Mexico's harvesting and processing capacity increased significantly in the late 1970s when several large seiners were added to the fishing fleet and a large reduction plant was constructed in Ensenada. Mexican anchovy landings averaged approximately 85,500 tons from 1962 to 1989, with a high of over 285,000 tons in 1981. Northern anchovy catch decreased sharply in 1990, and despite landing 19,600 tons in 1995, average annual Mexican landings from 1990 to 1999 were only 3.600 tons.

The U.S. northern anchovy central subpopulation fisheries have been managed by the Pacific Fishery Management Council since 1978, and the central and northern subpopulations since 1998. The fishery management plan has been

Northern Anchovy, *Engraulis mordax*
Credit: DFG

amended to include all four species of finfish collectively known as coastal pelagic species (CPS); Pacific sardine, Pacific mackerel, jack mackerel, in addition to northern anchovy, and has been renamed as the Coastal Pelagic Species Fishery Management Plan. Regulations described in the fishery management plan designate the northern anchovy fishery as not actively managed due to low fishery demand and high stock size. If conditions change, and active management is required, then provisions in the fishery management plan require calculation of an Allowable Biological Catch (ABC) for northern anchovy fisheries in U.S. waters. As of May 31, 2000, there were 63 vessels licensed to fish CPS finfish under the NMFS limited entry program, which is in effect south of 39° N. latitude (Pt. Arena, California). North of this area, there is open access to the fishery.

Maximum Sustainable Yield (MSY) for northern anchovy in the central subpopulation is estimated to be 135,600 tons per year at a total biomass level of about 808,000 tons. At present, northern anchovy are not actively managed, but a recommended default MSY control rule gives an ABC for the entire stock equal to 25 percent of the MSY catch, or just over 34,000 tons. An estimated 82 percent of the stock is resident in U.S. waters. ABC in U.S. waters is, therefor, 82 percent of 34,000 tons or 27,600 tons. Under federal management, there is no longer a separate quota for reduction landings of anchovy. Although fisheries in Mexican as well as U.S. waters harvest the northern anchovy, there is no bilateral management agreement with Mexico. The Mexican fishery is managed independently and is not restricted by a quota.

Economics explain a great deal about the current dynamics of anchovy fisheries in California, because the fisheries are more limited by prices and markets than by biological constraints. The price paid to fisherman for anchovy landed as live bait in southern California was about $440 per ton in 1999, slightly less than the $480 per ton paid for sardines as live bait. Although prices and revenues for live bait tend to be surprisingly high, annual catches have been modest due to market limitations.

During 1981 to 1999, the price paid for anchovy landed for non-reduction purposes other than live bait averaged about $330 per ton. As with live bait, market limitations have resulted in modest annual catches despite relatively high prices paid to fishermen.

The average price for anchovy landed by the U.S. reduction fishery during 1981 to 1999 was about $80 per ton, but the price paid during 1997 was only $40 per ton. Low prices, as well as market problems have prevented a significant U.S. reduction fishery in recent years.

Status of Biological Knowledge

Northern anchovy are distributed from the Queen Charlotte Islands, British Columbia to Magdalena Bay, Baja California. The population is divided into northern, central, and southern subpopulations or stocks. The central subpopulation ranges from approximately San Francisco, California to Punta Baja, Baja California, with the bulk being located in the Southern California Bight.

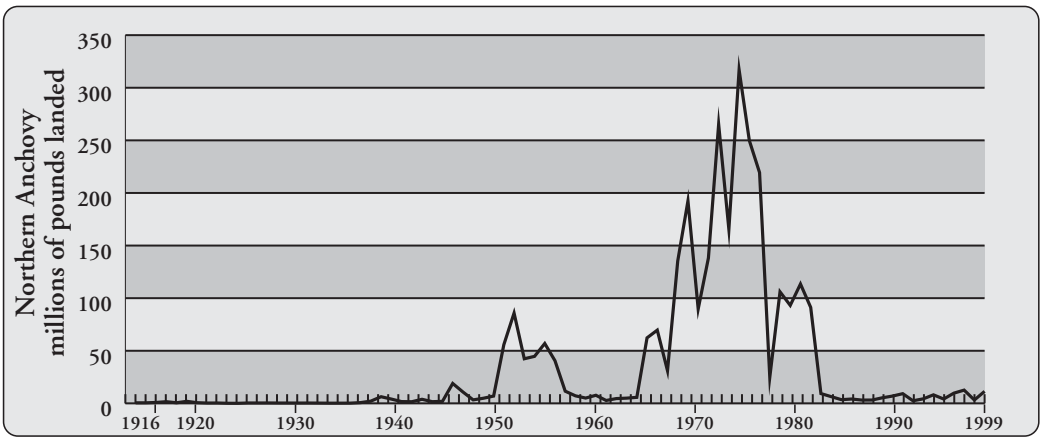
Northern anchovies are small, short-lived fish typically found in schools near the surface. They rarely exceed four years of age and seven inches total length, although individuals as old as seven years and nine inches have been recorded. There is a great deal of regional variation in age composition (number of fish in each age group) and size at age with older fish and larger fish found at relatively offshore and northerly locations. In warm years, relatively old and large fish are found farther north than during cool years. These patterns are probably due to northern and offshore migration of large fish, regional differences in growth rate, and water temperatures. Northern anchovies in the central subpopulation are typically found in waters that range from 54° to 71° F.

Information about changes in anchovy abundance during 1780 to 1970 is available from scales counted in sediment cores from the Santa Barbara basin. These data indicate significant anchovy populations existed throughout the time period and that biomass levels during the late 1960s were modest relative to those during most of the 19th and early 20th centuries.

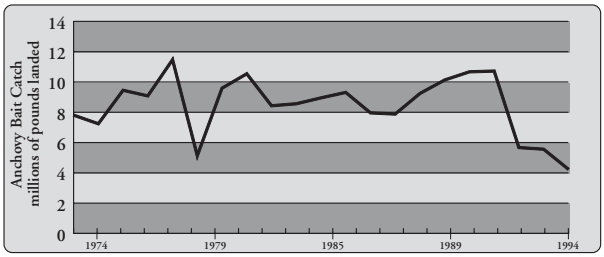
The age at which northern anchovy become vulnerable to California fisheries depends on the location of the fishery and type of fishery. Fish become vulnerable to the inshore live bait fishery at an earlier age than they become vulnerable to the reduction fishery. However, substantial numbers of zero and one-year-old fish are taken by both fisheries in most years.

Anchovy are all sexually mature at age two. The fraction of one-year-olds that is sexually mature in a given year depends on water temperature and has been observed to range from 47 to 100 percent. They spawn during every month of the year, but spawning increases during late winter and early spring and peaks during February to April. Spawning has been observed over a temperature range of 54° to 71° F. Individual females spawn batches of eggs throughout the spawning season at intervals as short as seven to 10 days. The eggs are found near the surface, and require two to four days to hatch, depending on water temperatures. Eggs and larvae are both found near the surface.

Northern anchovy are subject to intense predation throughout all life stages. Anchovy eggs and larvae fall prey to an assortment of invertebrate and vertebrate



Commercial Landings 1916-1999, Northern Anchovy
Data Source: DFG Catch Bulletins and commercial landing receipts.



Live Bait landings of anchovy in CA, 1974-1994
Data source: DFG Database

planktivores. As juveniles in nearshore areas, anchovies are vulnerable to a variety of predators, including birds and some recreationally and commercially important species of fish. As adults offshore, anchovies are fed upon by numerous marine fishes (some of which have recreational and commercial value), mammals, and birds, including the state and federally listed California brown pelican. A link between brown pelican breeding success and anchovy abundance has been documented.

Northern anchovy eat plankton either by filter feeding or biting, depending on size of the food. Adult anchovy are known to filter anchovy eggs and it is possible that this type of cannibalism is an important factor in regulating population size.

Status of the Population

Estimates of the biomass of northern anchovy in the central subpopulation averaged 359,000 tons from 1963 through 1972, increased rapidly to over 1.7 million tons in 1974 and then declined to 359,000 tons in 1978. Since 1978, biomass levels have tended to decline slowly, falling to an average of 289,000 tons from 1986 through 1994. Anchovy biomass during 1994 was estimated to be 432,000 tons.

Total anchovy harvests and exploitation rates since 1983 have been below the theoretical levels for maximum sustained yield, and stock biomass estimates are unavailable for recent years but, based on abundance index data, the stock is thought to be stable at a modest biomass level. The size of the anchovy resource is now being determined mostly by natural influences, such as ocean temperature.

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Opaleye and Halfmoon

History of the Fishery

The commercial catch of opaleye (*Girella nigricans*) and halfmoon (*Medialuna californiensis*) has been small. Neither of these species is part of a designated fishery but both appear regularly as incidental catch in commercial and recreational fisheries.

During the 40 years prior to 1990, the average catch of halfmoon has been 16,714 pounds, with a high of 50,007 in 1956. Recently, catches have been well below this mean, with a peak in 1989 of 5,204 pounds. The mean catch of opaleye in the 43 recorded years prior to 1990 was 4,748 pounds with a high of 23,688 pounds in 1973. The mean catch for the last 10 years is 2,709, with very small catches recorded since 1995. Interestingly, a small number of halfmoon and opaleye are entering the live fish market. The 1999 landings of opaleye were largely live fish (616 pounds) and the price for the catch is now up to $1.37 per pound. Neither species was recorded in large numbers in the California Department of Fish and Game's gill and trammel net study, although the opaleye was at one time a bycatch of nearshore purse seiners.

CPFV landings of opaleye are low, averaging 679 fish per year since 1990. By contrast, CPFV catches of halfmoon have averaged over 50,000 fish per year. 1998 was an extremely poor year for catches of these species, yielding only eight percent and 16 percent of the average catch of opaleye and halfmoon respectively. In the last reported survey of pier and jetty fishing (1965-1966), both species were abundant and it is likely they remain an important part of that fishery today.

Status of Biological Knowledge

As herbivores, the members of the sea chub family, Kyphosidae, play an important role in kelp forest communities. They regulate kelp growth, and on occasion may overgraze, causing damage to newly transplanted or isolated kelp plants or small kelp beds. The opaleye reaches a length of 26 inches and a weight of 16 pounds, while the halfmoon reaches 19 inches and 5 pounds. Kyphosids have small mouths with a single prominent row of blade-like, incisor teeth that are used for cutting vegetation. The opaleye is olive green with two light spots under the mid-dorsal. The halfmoon is blue to blue-gray, sometimes with a lateral white stripe, and the spinous dorsal fin is much lower than the soft dorsal. Both species range from central California to Baja California. While the opaleye is more common north of Point Conception, the halfmoon extends its range to the south into the Gulf of California. Both reach a depth of a little over 100 feet.

Larvae of both species are pelagic and are followed by a pelagic juvenile schooling stage, which appears in the nearshore environment. Larval distributions mirror the adults latitudinally, with the larval stages distributed primarily in the neuston. CalCOFI data indicate that halfmoon larvae are occasionally taken well off shore, while most opaleye larvae are taken within 70 miles of the coast. Young opaleye leave the pelagic environment and enter the intertidal when they are about an inch long. They are found in relatively high tide pools preferring warm water (>75° F), and feed largely on small invertebrates. As they grow to a size of three to six inches, the young leave the pools and form small schools in the shallow subtidal, eventually changing their diet to include primarily algae. Adults browse in the kelp bed on kelp and other algae, often moving in medium sized schools. Young halfmoon stay in the shallow subtidal and kelp bed habitat occupying the same position as the adults. Juvenile opaleye have been reported to clean parasites from other fish on occasion.

Status of the Population

The abundance of opaleye and halfmoon, and their status as incidental catch rather than as targeted species, makes it unlikely that either the sport or commercial fisheries will have an effect on the populations. Data gathered in southern California since 1974 at Palos Verdes and King Harbor show no population trends and suggest both species are stable with regular recruitment.

John Stephens
Occidental College (retired)

Opaleye, *Girella nigricans*
Credit: DFG

Other Flatfishes

History of The Fishery

Several flatfish species are taken incidentally in commercial groundfish fisheries. These include the rock sole (*Pleuronectes bilineatus*), butter sole (*Pleuronectes isolepis*), fantail sole (*Xystreurys liolepis*), sand sole (*Psettichthys melanostictus*), slender sole (*Eopsetta exilis*), bigmouth sole (*Hippoglossina stomata*), California tonguefish (*Symphurus atricauda*), curlfin turbot (*Pleuronichthys decurrens*), hornyhead turbot (*Pleuronichthys verticalis*), spotted turbot (*Pleuronichthys ritteri*), C-O turbot (*Pleuronichthys coenosus*), diamond turbot *(Hypsopsetta guttulata*), arrowtooth flounder (*Atheresthes stomias*), and Pacific halibut *(Hippoglossus stenolepis*). Some of these, notably the Pacific halibut, diamond turbot, and rock sole, are taken by recreational anglers as well, but most are caught primarily by commercial boats. Arrowtooth flounder and Pacific halibut are considered as minor flatfishes in California flatfish fisheries because they are landed in relatively small quantities. However, both species are major components in the flatfish fisheries in northern waters from Oregon to Alaska.

Landings of most of these flatfishes are difficult to extract from landings data for the early years (beginning in 1916), because many were combined with other categories of flatfish. For example, prior to 1931 turbots were included with soles. Also, some species such as Pacific halibut are included in California landings, even though most were landed elsewhere and shipped to California ports. Starting in the early 1950s, some of these flatfish landings, primarily arrowtooth flounder (1950) and soles (1953), were listed separately in the catch data.

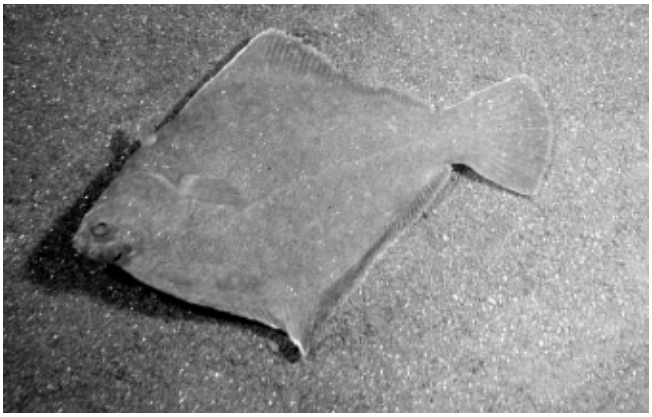
Generally, incidental flatfish catches have contributed only a small amount to the annual statewide commercial landings. From 1953 to 1999, these annual flatfish landings averaged about 0.1 percent of the total statewide landings. During this period, flounders (mostly arrowtooth flounder) comprised 49.2 percent of incidental flatfish landings, soles 41.2 percent, turbots 8.0 percent, and Pacific halibut 1.6 percent. Starting in the 1960s, commercial landings of minor flatfish, as a group, have declined, although not all species showed this trend.

Since 1950, arrowtooth flounder landings averaged 278,300 pounds per year with peak years occurring in 1956 (1,070,700 pounds), 1960 (1,007,700 pounds), and 1961 (1,100,900 pounds). These high landings were due, in part, to the less desirable fishes, such as arrowtooth flounder, finding a market with the animal food industry, primarily as mink food. Arrowtooth flounder no longer is used for mink food, but is processed for human consumption. Incidental sole landings since 1953 averaged about 244,000 pounds per year, with a peak in 1979 when 839,000 pounds were landed. After 1979, there was a general decline in the annual landings of sole. Turbot landings averaged about 47,000 pounds per year from 1953 to 1999, with a peak of 176,000 pounds in 1954, and another good year occurring in 1959 (129,000 pounds). Since 1964 there has been an overall general decline in commercial turbot landings. Landings in 1999 were approximately 8,000 pounds, the lowest since 1953. Pacific halibut contributed heavily to the minor flatfish fishery prior to the mid-1950s. The last good year for Pacific halibut landings was 1952, when 242,600 pounds were landed. Landings then began a rapid downward trend. From 1969 to 1988, no landings were recorded, except for three years: 1971, 1972, and 1986 (25, 235, and 34,500 pounds, respectively). From 1989 to 1999, landings did increase somewhat, averaging approximately 4,600 pounds per year.

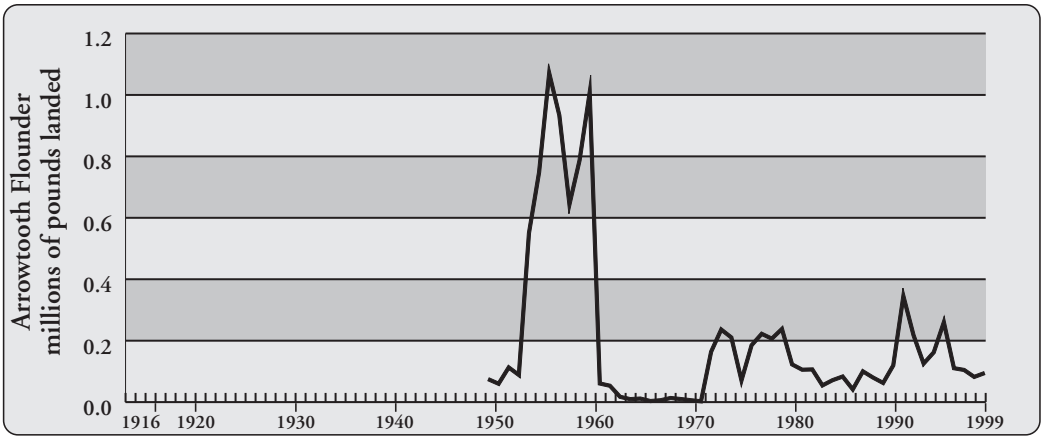
Most of the incidental flatfish are taken by otter trawls. The exception is Pacific halibut, where set longline is the dominant gear used. Trammel nets are used to catch some flatfish in central and southern California waters, and many small-boat commercial fishermen use hook-and-line. Recreational anglers occasionally catch soles or turbots while fishing for sanddabs, starry flounder, or California halibut. Diamond turbots are sought by recreational anglers in quiet coastal waters, bays, and sloughs.

Status of Biological Knowledge

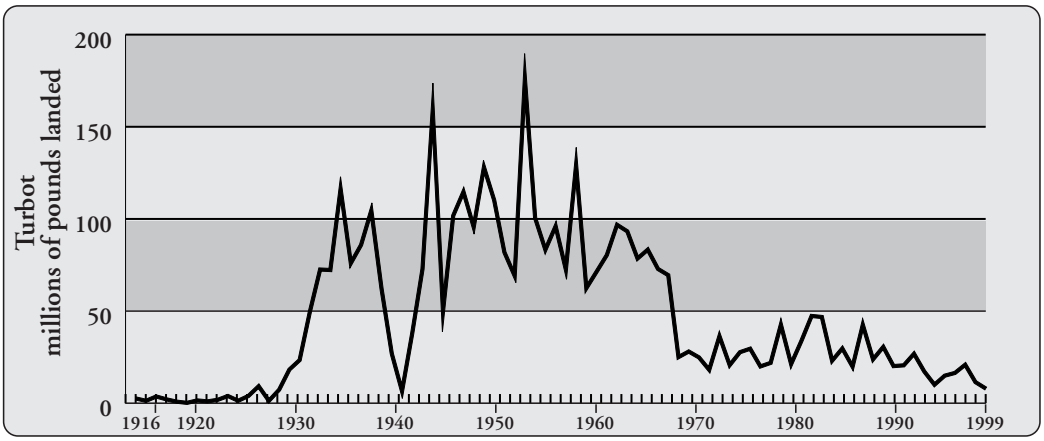
In general, flatfish spawn during late winter and early spring. Arrowtooth flounder, however, spawn as late as August in the southeast Bering Sea and Gulf of Alaska, where the greatest concentrations of this species are found. The larvae are pelagic and undergo metamorphosis to the adult form. After flatfish settle on the bottom, they eat small crustaceans, polychaetes, and mollusks. As they grow, they eat larger food forms of the same groups. Some, such as sand sole, arrowtooth flounder, and Pacific halibut, include fish in their diet.



Diamond Turbot, *Hypsopsetta guttulata*
Credit: DFG



Commercial Landings 1916-1999, Arrowtooth Flounder
Arrowhead flounder were aggregated under the landing classification "unclassified sole" prior to 1950. Data Source: DFG Catch Bulletins and commercial landing receipts.



Commercial Landings 1916-1999, Turbot
Data Source: DFG Catch Bulletins and commercial landing receipts.

As a group, minor flatfish species range from the Gulf of California/Baja California to the Bering and Chukchi Seas off Alaska. Within this overall range some species are quite restricted while others are found throughout most of this range. They occur from shallow water to depths in excess of 3,000 feet (Pacific halibut).

Status of the Populations

Major fluctuations of commercial landings of flounder, soles, and turbot have occurred since 1950. Despite these fluctuations and declining commercial landings that started in the 1960s, market sampling and commercial landing records indicate that these populations remain in good condition and currently are not being over-harvested. Arrowtooth flounder stock assessment work conducted in 1993 by the Washington Department of Fisheries indicated that the status of the population, at that time, was in good condition because there was no decline in fishery catch-per-unit-effort (CPUE) between 1987 and 1992 and no trend in triennial bottom trawl survey CPUE from 1977 to 1992. Current catch levels remain well below the level of acceptable biological catch (ABC) established by the Pacific Fishery Management Council (PFMC). The densities of arrowtooth flounder are low south of Cape Blanco, Oregon. Pacific halibut landings in California have declined since the peak years during the 1930s; however, the species is considered uncommon in California waters. Pacific halibut are monitored extensively by the International Pacific Halibut Commission (IPHC) and recent stock assessment analysis indicates that while abundance in numbers is still quite high relative to the levels of 1975 or 1980, the prospect for a decline in the biomass in waters north of California is a possibility.

Management Considerations

See the Management Considerations Appendix A for further information.

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California Department of Fish and Game

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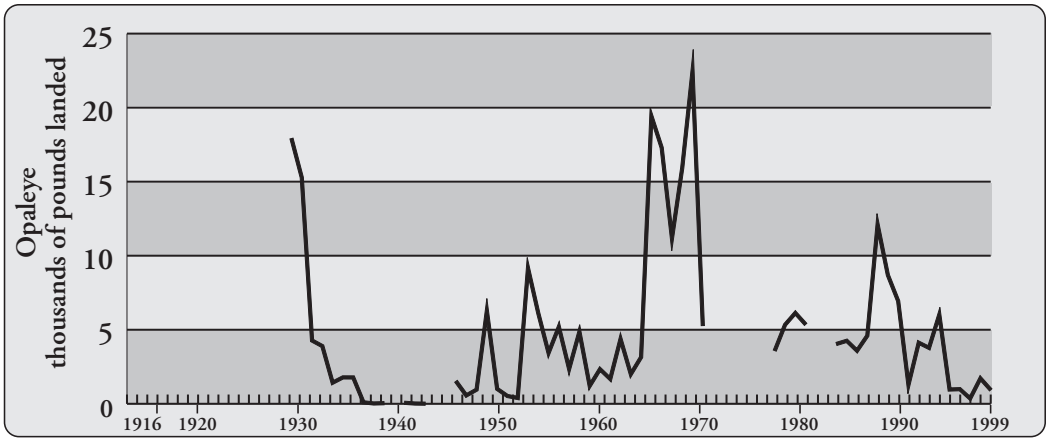

Commercial Landings 1916-1999, Opaleye
Landings data unavailable prior to 1930 and for 1941, 1945-1946, 1972, 176-1977, and 1982-1983. Data Source: DFG Catch Bulletins and commercial landing receipts.

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Pacific Bonito

History of the Fishery

The Pacific bonito (*Sarda chiliensis*) is an economically important commercial species from Magdalena Bay in southern Baja California, Mexico to Point Conception, California, and in most years is ranked as one of the top 15 species sought by recreational fishermen in southern California.

As a result of the expansion of the commercial passenger fishing vessel (CPFV) industry after World War II, Pacific bonito catches by CPFVs increased from 36,500 in 1947 to over one million fish in 1960. Most of these fish were caught between Malibu Beach and the Coronado Islands. CPFV logbook landings of bonito remained high during the 1960s, with more than one million fish taken in 1964, 1968, and 1969. However, in the 1970s and 1980s, CPFV landings dropped and then stabilized with decadal averages for the 1970s and 1980s at 313,200 and 372,700 fish, respectively. In the 1990s, the number of fish taken by CPFVs dropped again. Logbook landings ranged between 2,880 and 263,000 fish with a decadal average of 101,700. The 1999 landings were the lowest annual catch on record and the decadal average the lowest since the 1940s.

During the 1980s, more then one-half of the bonito catch was made from private boats as this method of angling became increasingly popular. A similar trend was observed in the 1990s with private boats landing between 33 percent and 57 percent of the recreational catch. Private boat landings in the 1990s ranged between 1,200 and 128,400 fish with a decadal average of 49,600. This was significantly lower than the 1980s decadal average of 560,000 fish.

Recreational catches can be impacted by the availability of other desirable species. In the 1980s and 1990s, highly desirable species such as yellowfin tuna, bluefin tuna, and albacore occasionally were available in large numbers. The reductions in recreational landings of bonito can be attributed in part to a shift in targeted effort from bonito to these more desirable species.

Changes in regulations can also impact recreational catches. In 1982, a 24-inch size limit was imposed on bonito. Part of the reduction in sport landings after 1982 was probably due to this size restriction, but the impact of this regulation was probably limited because of a five fish tolerance for undersized bonito that was included with the size restriction.

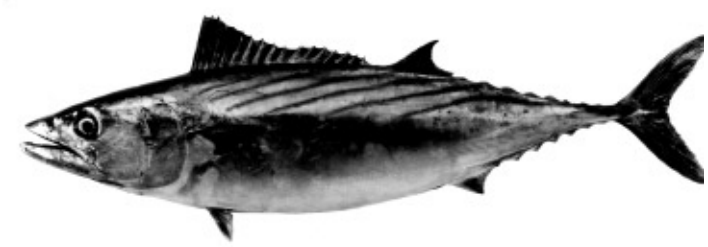
The bulk of the recreational catch consists of one-year bonito approximately 18 inches long. During fall and spring migrations, larger two-year fish become available to anglers. About five to 10 percent of the landings consist of fish larger then 24 inches.

Pacific bonito is well known for its fighting ability and quality as a food fish. Bonito can be caught recreationally with live anchovies and sardines or by casting or trolling with metal lures and feather jigs. Off California, recreational anglers typically catch bonito year round south of Point Conception with the highest catches in summer. North of Point Conception, recreational anglers usually take bonito during the fall months.

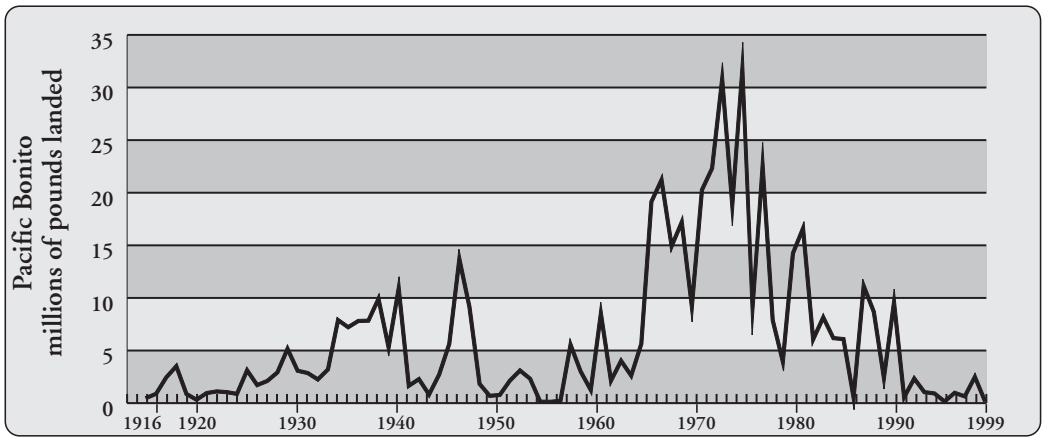
Bonito are taken commercially by troll gear, gillnets, and pole and line gear, but the landings of fish caught by these methods usually average less then two percent of the total catch. The primary commercial fishing gear for bonito is the purse seine. The purse seine fleet consists of two general groups: the local "wetfish" vessels with fish load capacities of 30 to 100 tons, and the larger tuna seiners capable of carrying 150 to 500 tons. Wetfish boats harvest mackerel and sardines, but seasonally target bonito, squid, and bluefin tuna. Nearly all of these wetfish seiners are based in San Pedro and fish in the Santa Barbara and San Pedro Channels. The large tuna seiners, now all but absent from California, operate primarily in the tropical waters off Mexico and Central and South America. Although the primary target for these seiners is yellowfin tuna, these vessels take bonito during their return trips to the United States to help compensate for small tuna catches.

Off California, commercial fishing for bonito occurs year round south of Point Conception with the largest catches in late summer and early fall. North of Point Conception, commercial fishing for bonito occurs primarily in the summer and fall.

Over the last 80 years, commercial landings of bonito have ranged between 127,600 pounds (1956) and 31.9 million pounds (1975). During the first half of the twentieth century, landings of bonito gradually increased from about 500,000 pounds in 1916 to around 10.9 million pounds in 1941. Landings briefly peaked again after World War II, but dropped during the 1950s and early 1960s. Landings then showed a major upward trend from the mid-1960s through the mid-1970s, increasing more than four-fold between 1965 and 1975. Starting in the late 1970s, this trend reversed with landings dropping in the 1980s to a decadal



Pacific Bonito, *Sarda chiliensis*
Credit: DFG



Commercial Landings 1916-1999, Pacific Bonito
Data Source: DFG Catch Bulletins and commercial landing receipts.

average of eight million pounds (compared to 9.7 million pounds for the 1960s and 17.7 million pounds for the 1970s). In the 1990s, landings for this fish ranged between 157,000 and 9.58 million pounds with a decadal average of 1.9 million pounds. This average was higher than that observed in the 1950s (1.8 million pounds) but lower than those from the previous three decades.

In the 1990s, bonito's ranking among the other commercial species also dropped. By total weight, bonito ranked among the top 20 species landed by California fisheries for most of the 1980s. In contrast, during the 1990s, this fish ranked among the top 20 species only in 1990 and 1998.

The amount of bonito landed is impacted by its availability, the availability of other desirable species, market demand, and price. Off of California, the availability of bonito can vary considerably between seasons and years. Some of this variation can be attributed to the migratory movements of these fish and some to oceanic changes. For instance, during El Niño events, more of the stock may move northward, becoming more available to California fisheries, while during La Niña events, fewer fish may move into California waters.

The availability of bonito also can be impacted by fishing restrictions. During the years from 1943 to 1958 and 1975 to 1978, at least 50 percent, and often more than 90 percent, of the landed bonito were taken off Baja California, Mexico. During the last two decades, Mexico has restricted access to foreign vessels fishing in its nearshore waters and California landings originating from Mexico have declined to less than 10 percent of the total landings.

In addition, the availability of bonito in California waters can be impacted by the amount of fish taken by the commercial fishery in Mexican waters. Mexican commercial landings of bonito over the last several decades show sharp periodic increases in the take of this fish. This pattern suggests that the Mexican commercial fishery for bonito is a pulse fishery. When bonito become more abundant, either from a gradual increase in the population or from the recruitment of a strong year class, then some of the commercial fishing effort in Mexican waters shifts to this species. The resource is harvested until the fish are no longer abundant. Effort then is redirected to other species until such time as the bonito resource becomes abundant again.

The availability of other desirable species can have a profound impact on the landings of bonito. Lower availability of other more desirable species due to environmental changes or management changes can increase the amount of bonito landed. For instance, bonito were targeted during seasonal yellowfin tuna closures in the 1970s because an incidental take of the more valuable yellowfin tuna was allowed while fishing for bonito. On the other hand, high availability of more desirable species can reduce the amount of bonito landed. This was likely the case in the 1980s and 1990s when a number of more desirable species including yellowfin tuna, skipjack tuna, albacore tuna, and bluefin tuna were at times quite abundant. In 1986, for example, high availability of bluefin tuna with a value of $1,550 per ton resulted in the wetfish seiners shifting their effort toward that species; as a result, bonito landings in 1986 dropped to a low of 533,000 pounds.

Market demand for bonito has been low over the last two decades. Commercial bonito landings are primarily purchased by canneries that process bonito for human consumption with the offal utilized for pet food or for reduction to fishmeal. Cannery orders for this fish in recent years have been limited. Higher demand exists for yellowfin tuna, skipjack tuna, albacore, and bluefin tuna for human consumption; for Pacific mackerel and jack mackerel as pet food; and for northern anchovy as fishmeal. Bonito also are sold fresh or frozen or are processed by curing or smoking. The market for this product

is currently small, but is growing due to the changes in California's demographics.

Prices for bonito have generally showed an upward trend over time. Between the 1960s and early 1980s, the price of bonito increased from $50 to $90 per ton to $550 per ton. The price then declined to $200 to $300 per ton in the mid-1980s but increased again in the 1990s to an average of $990 per ton. While the 1990s average price is the highest reported for bonito, it is still lower than that paid for desirable fish such as bluefin tuna which usually sells for four to five times the price of bonito.

Status of Biological Knowledge

Pacific bonito is a rapidly growing piscivorous fish. In one year this fish can reach roughly 20 inches in fork length, and weigh about four pounds. At two years of age, bonito average roughly 25 inches in fork length and weigh about eight pounds. Their growth slows in the latter half of life with the fish reaching 32 to 35 inches and 17 to 22 pounds at six years. The California angling record is a 22-pound fish caught off Malibu Beach in 1978, but larger fish are occasionally reported.

Swimming is continuous to maintain orientation and respiration, and is powered by richly oxygenated red muscle tissues near the tail. As the fish grow, the proportion of red muscle tissue increases; hence, larger fish become relatively more powerful swimmers. At a continuous-maintenance swimming speed, aquarium-held fish averaging 22 inches in length swim as much as 43 miles daily.

Bonito is a temperate epipelagic schooling fish with a discontinuous distribution in the eastern Pacific Ocean. It ranges from Chile to the Gulf of Alaska, but is absent from the central coast of Mexico south to Panama. The northern population typically is centered between southern California and central Baja California, but this distribution can shift northward during warm-water years. This species migrates approximately 600 miles along the United States - Mexico coastline, moving southward from southern California in the winter and northward from Baja California in the summer. This migration probably is a response to changing sea temperatures since these fish appear to be impacted by local variations in sea temperature. Individuals tagged and released within warm-water discharges from electrical generating stations have been recaptured near their release site up to three years later. These tagging studies suggest that some bonito do not move southward in the winter and instead overwinter in the Southern California Bight.

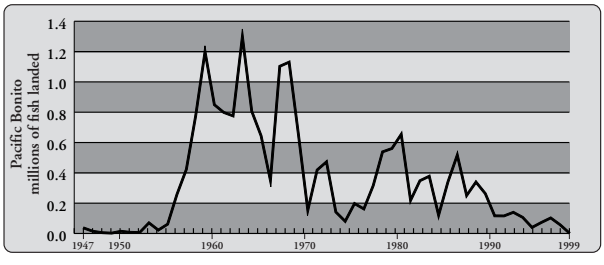
There is no external anatomical differences between the sexes. However, behavioral and visual cues can be used to distinguish males from females. During courtship of bonito observed in an aquarium, females swim with a wobble while males use color barring on their bodies to show their interest and aggressive nature. This aggressive vertical barring coloration in males has also been observed in aquarium-held bonito at feeding time. During courtship, males will follow directly behind the displaying female, jockeying for position. The successful male and female then pair and synchronize the release of gametes at the onset of a tight circle swim. Gametes are broadcast into the seawater where fertilization takes place.

Sexual maturity differs between males and females. Pacific bonito females begin to mature at two years of age and are fully mature at 24 inches. Males are more precocious. About 44 percent of the one-year males spawn, and all are mature at two years of age or 20 inches in length. Spawning begins in January and continues for a five-month period. Peak spawning occurs off central Baja California, but may take place in southern California late in the season or during El Niño episodes. Some localized spawning may also take place near warm-water discharges from electrical generating stations. Individuals may spawn more than once during a season. A 6.6-pound female releases an estimated 0.5 million eggs in one season.

Bonito consume prey equaling about six percent of their body weight per day. Northern anchovies are common prey, but market squid, highly vulnerable to predation while spawning, sometimes become a major part of the diet. Pacific sardines may also be a significant food source.

Status of the Population

Warm water conditions in the 1980s and 1990s may have provided good conditions for bonito survival, but large catches have been sporadic and the trends in both commercial and recreational landings continue downwards. This downward trend may be due in part to a shift in targeted effort from bonito to other more desirable species and to low market demand. It also may be due to changes in the distribution and migration of this northern population in response to oceanographic changes that have taken place over the last two decades. However,



Recreational Catch 1947-1999, Pacific Bonito

CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

this downward trend may well be due to a decline in stock abundance. If this is the case, then current fishing practices may make it difficult for this stock to rebuild.

Management Considerations

See the Management Considerations Appendix A for further information.

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California Department of Fish and Game

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Pacific Mackerel

History of the Fishery

Pacific mackerel (*Scomber japonicus)*, also called chub mackerel or blue mackerel, are harvested by three separate fisheries – the California commercial fishery, a sport fishery based primarily in southern California, and the Mexican commercial fishery. In the commercial fisheries, Pacific mackerel are landed by the same boats that catch jack mackerel, Pacific sardine, and market squid.

Pacific mackerel supported one of California's major fisheries during the 1930s and 1940s and again in the 1980s. The canning of Pacific mackerel began in the late 1920s and increased as greater processing capacities and more marketable packs were developed. Landings decreased in the early 1930s, due to the economic depression and a decline in demand, and then rose to a peak of 73,214 tons in 1935. During this period, Pacific mackerel was second only to Pacific sardine in annual landings. The mackerel fishery then experienced a long, fluctuating decline. A moratorium was placed on the fishery in 1970 after the stock had collapsed.

In 1972, legislation was enacted which imposed a landing quota based on the age one-plus biomass. A series of successful year classes in the late 1970s initiated a recovery, and the fishery was reopened under a quota system in 1977. During the recovery period from 1977 to 1985, various adjustments were made to quotas for directed take of Pacific mackerel and to incidental catch limits. These measures were intended to lessen the impact of the recovering population on the jack mackerel fishery, and to accommodate the development of the Pacific mackerel fishery as the population increased. From 1990 through 1999, Pacific mackerel accounted for 87 percent of total mackerel landings in California. Pacific mackerel ranked third in volume of California finfish landings throughout the 1990s.

Before 1928, when canning began, Pacific mackerel were landed incidentally in the sardine fishery and used primarily as fresh fish. For many years, demand for canned mackerel was steady and exceeded supply. Following the recovery, the market for canned mackerel has fluctuated due to availability and economic conditions. At present, most Pacific mackerel is used for human consumption, canned, or used for pet food, with a small but increasing amount sold as fresh fish. Minor amounts of Pacific mackerel are used by anglers for live and dead bait. Mackerel prices increased from $45 per ton in 1956 to $315 in 1981, but have declined to $120 per ton in 1999. Domestic demand for canned Pacific mackerel appears to have decreased in recent years. During the early fishery, Pacific mackerel were taken by lampara boats, which were replaced in the 1930s by the same purse seine fleet that fished for sardines. The purse seiners fished for Pacific mackerel until the moratorium in 1970, and were able to fish for jack mackerel, northern anchovy, and other species until the fishery reopened in 1977. Fishing originally occurred near port, but by the late 1930s it extended along the entire coast from San Diego to Santa Barbara, and included the Channel Islands. Beginning in the 1952-1953 season, fishing extended to Tanner and Cortez Banks.

Until the mid-1950s, there was a seasonal pattern to the fishery. Pacific mackerel were mostly unavailable from January through May, then increased in availability until late fall. Most of the catch was taken by purse seiners until September, when the sardine fishery began. During the declining years of the fishery, catches became more sporadic, with no apparent seasonal patterns.

At present the purse seine fleet fishes the Southern California Bight, including the Channel Islands and offshore banks. A small portion of the catch (approximately 10 percent in recent years) is taken in the Monterey Bay area. The purse seine fleet fishes year-round. Landings are typically slow during April and May, increase beginning in June, peak during the third quarter of the year, and decrease after September. As of June 2000, 63 purse seiners hold permits to participate in the NMFS limited entry fishery for coastal pelagic species, which is in effect south of 39° N. latitude (Pt. Arena, California). North of this area, there is open access to the fishery. These vessels participate not only in the Pacific mackerel fishery, but also take jack mackerel, Pacific sardine, northern anchovy, and market squid. Other types of gear take Pacific mackerel incidentally.

Pacific mackerel fisheries in California were managed by the state through 1999, and a fishery management plan (FMP) for coastal pelagic species, including Pacific mackerel, was implemented by the Pacific Fishery Management Council (PFMC) in January 2000. State regulations, enacted in 1985, had imposed a moratorium on directed fishing when the total biomass was less than 20,000 tons, and limited the incidental catch of Pacific mackerel to 18 percent during a moratorium. The fishing

Pacific Mackerel, *Scomber japonicus*
Credit: DFG

season for Pacific mackerel was set to extend from July 1 to June 30 of the following year. A seasonal quota, equal to 30 percent of the total biomass in excess of 20,000 tons had been allowed when the biomass was between 20,000 and 150,000 tons, and there was no quota when the total biomass was 150,000 tons or greater. From 1985 to 1991, the biomass exceeded 150,000 tons and no quota restrictions were in effect. The quotas from the period 1992 through 2000 averaged 24,445 tons, with a high at 47,200 tons set by the PFMC for the 1999-2000 fishing season.

Pacific mackerel have ranked among the top 11 most important sportfish caught in southern California waters, primarily because they are abundant rather than desirable. The recreational catch of Pacific mackerel averaged 1,500 tons per year from 1977 through 1991, and 700 tons per year from 1993 through 1999. During the commercial fishing moratorium, the sport fishery became the largest exploiter of Pacific mackerel in California. The recreational catch increased during the late 1970s and early 1980s, with more than one million fish per year caught from 1979 through 1981. Recent estimates of annual recreational catches indicate a steady decline since 1981 to about 200 tons of Pacific mackerel in southern California in 1999. The catches from commercial passenger fishing vessels (CPFVs) have declined from a peak in 1980 of over 1.31 million Pacific mackerel, and an average of over 700,000 fish per year during the 1980s, to an average of slightly over 330,000 fish per year through the 1990s. The reported CPFV catch in 1998 totaled only 136,614 fish.

Demand for Pacific mackerel in Baja California, Mexico increased after World War II. Mexican landings remained stable for several years, rose to 8,000 tons in 1963, then declined to a low of 100 tons in 1968. Catches remained insignificant until the mid-1970s. During the period 1990 to 1999, annual landings of Pacific mackerel in Ensenada peaked twice, first in 1990 at 39,426 tons, and again in 1998 at 55,916 tons. The average for Baja California annual landings during the 1990s was 20,108 tons per year. Mexican landings of Pacific and jack mackerels, Pacific sardines, northern anchovy, and round herrings, are primarily used for reduction into fishmeal, and approximately 20 percent used for human consumption.

Status of Biological Knowledge

Pacific mackerel occur worldwide in temperate and subtropical coastal waters. In the eastern Pacific, they range from Chile to the Gulf of Alaska, including the Gulf of California. They are common from Monterey Bay, California to Cape San Lucas, Baja California, but are most abundant south of Point Conception, California. Pacific mackerel usually occur within 20 miles of shore, but have been taken as far offshore as 250 miles.

Adults are found in water temperatures ranging from 50.0° to 72.0° F and larvae in 57.2° to 70.0° F. Adults occur from the surface to 1,000 feet deep. Sub-adult and adult Pacific mackerel in the northeastern Pacific move northward along the coast during the summer. The most northerly records occur during El Niño events. There is an inshore-offshore migration off California, with increased abundance inshore from July to November and increased abundance offshore from March to May. Pacific mackerel are typically found near shallow banks, and juveniles are commonly found off sandy beaches, around kelp beds, and in open bays.

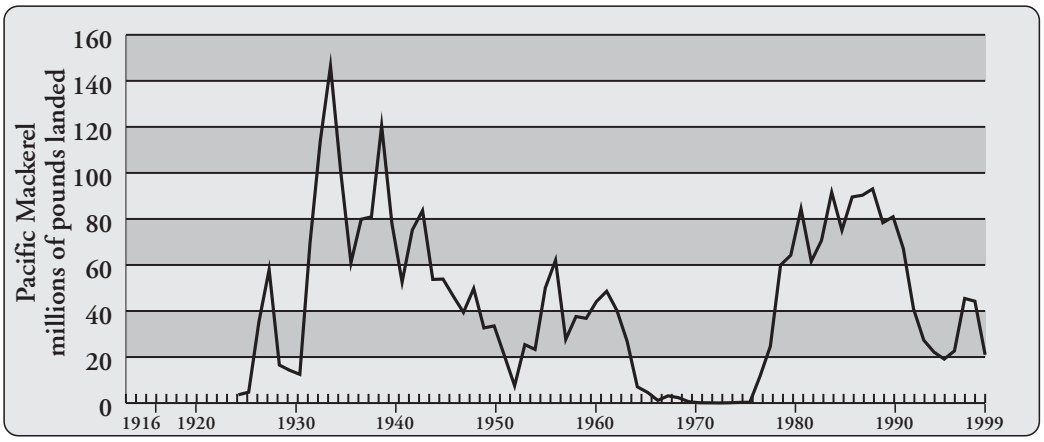
The largest recorded Pacific mackerel was 24.8 inches and weighed 6.4 pounds, although commercially harvested Pacific mackerel seldom exceed 16 inches and two pounds. Growth is believed to be density-dependent, as fish reach much higher weights-at-age when the population size is small. The oldest recorded age, determined by otolith reading, was 12 years, but most Pacific mackerel in the commercial catch are less than four years old. Some Pacific mackerel mature as one-year olds, although most are not sexually mature until age two or three. Pacific mackerel become available to the commercial fishery in their first year of life and are not fully recruited to the fishery until age four. However, substantial numbers of younger fish are taken by the commercial fishery and make up the bulk of the catch.

Recruitment of Pacific mackerel is variable and loosely linked to the size of the spawning biomass. Reproductive success is somewhat cyclical, with periods of roughly three to seven years. The annual rate of natural mortality is thought to be approximately 40 percent in the absence of fishing.

There are three spawning stocks in the northeastern Pacific – one in the Gulf of California, one near Cape San Lucas, and one along the Pacific coast north of Punta Abreojos, Baja California. Spawning occurs from Eureka, California to Cape San Lucas, two to 200 miles offshore, and in the Gulf of California.

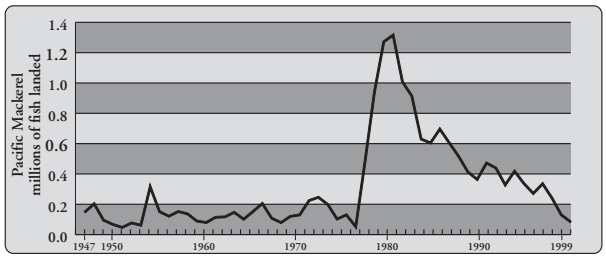
Off California, spawning occurs from late April to July at depths to 300 feet. Individual fish may spawn eight times or more per year and release at least 68,000 eggs per spawning. Off Baja California, spawning occurs from June through October.

Pacific mackerel larvae eat copepods and each other. Larvae normally begin to feed within 50 hours of hatching. Juvenile and adult Pacific mackerel feed primarily on small fishes, fish larvae, squid, and pelagic crustaceans such as euphausiids.



Commercial Landings 1916-1999, Pacific Mackerel
Data Source: DFG Catch Bulletins and commercial landing receipts. Pacific mackerel were aggregated as unclassified mackerel prior to 1926.

Pacific mackerel larvae are subject to predation from a number of invertebrate and vertebrate planktivores. Juvenile and adults are eaten by larger fishes, marine mammals, and seabirds. Pacific mackerel school as a defense against predation, often with other pelagic species, including jack mackerel and Pacific sardine. Principal predators include porpoises, California sea lions, brown pelicans, striped marlin, black marlin, sailfish, bluefin tuna, white seabass, yellowtail, giant sea bass, and various sharks.



Recreational Catch 1947-1999, Pacific Mackerel
Data source: DFG commercial passenger fishing vessel (CPFV) logbooks

Status of the Population

Historical estimates of Pacific mackerel biomass along the Pacific Coast indicate a decline in total biomass from 1932 until 1952. After a brief resurgence, the population reached a peak in 1962, then declined to less than 10,000 tons by 1966, and remained low until the late 1970s.

A series of successful year classes beginning in 1976 brought about a resurgence, and the age one-plus biomass peaked in 1982, at over one million tons. Since then, it has precipitously declined. Recent stock assessments indicate that biomass in the late 1990s was approximately 120,000 tons. Information derived from deposits of Pacific mackerel scales on the sea floor indicates that the prolonged period of high biomass during the late 1970s and 1980s was an unusual event that might be expected to occur about once every 60 years.

It is estimated that the maximum long-term yield of Pacific mackerel might be 29,000 to 32,000 tons under management systems similar to that in current use. It is difficult to assess the effects on the catch of recent warm temperatures, possible changes in availability of young fish, and the deteriorating markets. However, it is unlikely that the recent high harvest levels can be sustained.

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Sanddabs

History of the Fishery

Although not as important to California fisheries as other flatfishes, sanddabs are nevertheless highly prized by the commercial industry and recreational anglers for their excellent edibility. Four species of sanddabs are found in California waters – Pacific sanddab (*Citharichthys sordidus*), longfin sanddab (*Citharichthys xanthostigma*), speckled sanddab (*Citharichthys stigmaeus*), and gulf sanddab (*Citharichthys fragilis*). Commercial sanddab landings and recreational catches consist predominantly of the two largest species, Pacific sanddab and longfin sanddab. Pacific sanddab is the most abundant and makes up the bulk of the landings in central and northern California waters, whereas Pacific sanddab and longfin sanddab are caught in southern California. Because of their smaller size, speckled and gulf sanddabs are not important to the fisheries.

Recorded sanddab landings were highest (2.6 million pounds) in 1917. In 1918, landings decreased to 1.8 million pounds, and from 1919 to 1921 they remained less than 0.8 million pounds. In 1922, annual landings increased, reaching approximately two million pounds in 1925. From 1930 to 1974, annual landings were below a million pounds. Since 1975, landings have fluctuated between 1.4 million pounds and 0.6 million pounds annually. During the last decade, landings have been above the historical annual average, except for 1983 and 1984, the period of a strong El Niño event. Landings rebounded in 1985 and have increased since then. Approximately 1.44 million pounds were landed in 1990, but landings crashed in 1992 (also an El Niño year) to 0.6 million pounds, and then rebounded to more than 2.0 million pounds in 1997 and 1999. In the 1990s, ex-vessel value ranged from $0.46 to $0.80 per pound (1990 and 1999, respectively). Value increased from $0.46 to $0.70 per pound from 1990 to 1993, dropped to $0.51 per pound in 1995 and 1996, and then increase to a high of $0.80 per pound in 1999.

Since 1970, most of the commercial sanddab landings have been in northern and central California, with the largest landings at Eureka and San Francisco Bay and less at Monterey Bay. The commercial catch of sanddabs is mainly by otter trawls and some by hook-and-line, especially in the Monterey Bay area.

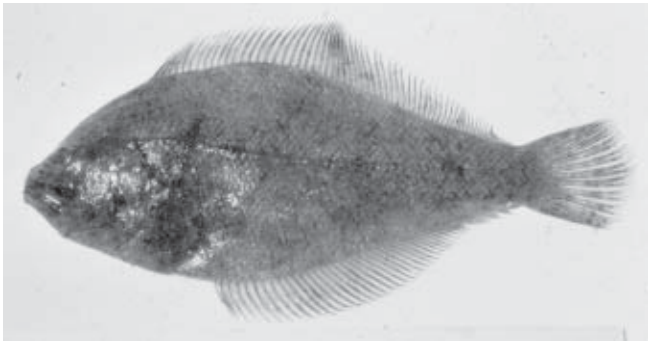
Many recreational anglers target them, mostly from small boats and commercial passenger fishing vessels (CPFVs). Sanddabs are one of a few fish groups for which there is no catch limit. Sanddab catches from CPFVs were small during the 1990s, with reported catches reaching 2,200 fish in 1990 and dropping to about 100 fish in 1998 (a strong El Niño year). About 70 percent of these were taken in southern California between Long Beach and Newport Beach. Sanddabs comprise an unknown, but probably large part of the unspecified flatfish catch, which has decreased from about 14,000 fish in 1990 to 4,000 fish in 1998.

As an El Niño event is more likely to have an immediate affect on the abundance of sanddab larvae than on harvestable adults, the immediate drop in sanddab catches during some El Niño years may be due in part to a shift in fishing effort to more desirable species.

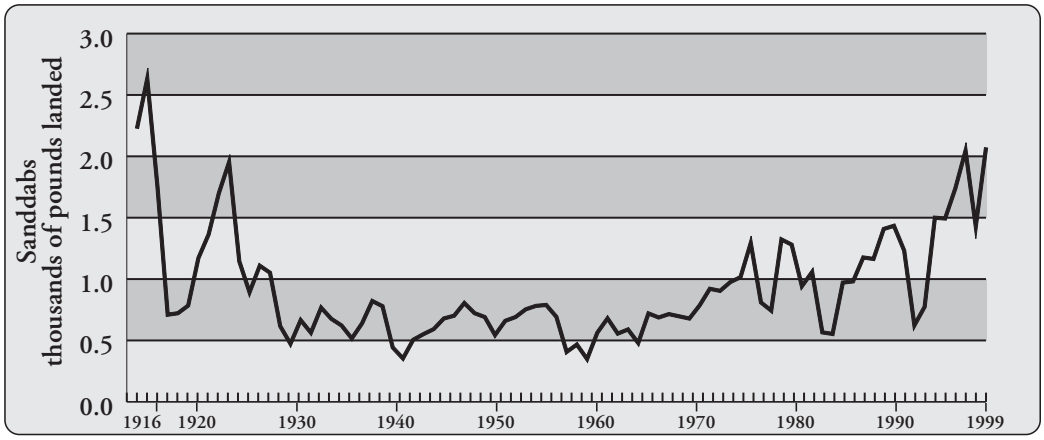
Status of Biological Knowledge

Sanddabs belong to the family Paralichthyidae (sometimes included as part of Bothidae - left-eye flounders). Biogeographically, Pacific sanddab and speckled sanddab are temperate species whereas longfin sanddab and gulf sanddab are warm-temperate to tropical species. Pacific sanddab ranges from the Bering Sea to Cape San Lucas, Baja California Sur, Mexico; speckled sanddab from Point Montague Island, Alaska to Magdalena Bay, Baja California Sur, Mexico; longfin sanddab from Monterey Bay to Costa Rica; and gulf sanddab from off Ventura, California to Cape San Lucas, Baja California Sur, and the Gulf of California. Speckled sanddab and Pacific sanddab occur throughout the state, with speckled sanddab occurring from the surface to a depth of 1,200 feet, and Pacific sanddab at 30 to 1,800 feet. Maximum depths of both species are suspect as the speckled sanddab seldom occurs deeper than 300 feet and Pacific sanddab seldom deeper than 600 feet. Longfin sanddab occurs at depths from seven to 660 feet, but usually less than 450 feet, and gulf sanddab from 59 to 1,140 feet. Most species are found on muddy to sandy mud bottoms but speckled sanddab occurs commonly on sandy bottoms.

Pacific sanddab is the largest species, reaching 16 inches, and up to two pounds. Most, however, are smaller than 10 inches and weigh, at most, 0.5 pound. The next largest species is longfin sanddab at 10 inches, followed by gulf sanddab at nine inches, and speckled sanddab at seven inches. Pacific sanddab live to a maximum of 10 years whereas speckled sanddab live to about 3.5 years. Pacific sanddabs mature at about three years, whereas the speck-



Pacific Sanddab, *Citharichthys sordidus*
Credit: DFG



Commercial Landings 1916-1999, Sanddabs
Data Source: DFG Catch Bulletins and commercial landing receipts.

led sanddab matures at one year. Spawning begins in July, peaks in August, and ends sometime in September for Pacific sanddab and extends from spring to fall for speckled sanddab. Females may spawn twice during a season. In contrast, most northern flatfish species spawn during late winter to early spring.

Sanddab larvae are pelagic and may be found near the surface and out to many miles offshore. Sanddab larvae transform and settle to the bottom at lengths of 0.6 to 1.6 inches. Juveniles and adults feed near or on the bottom on a variety of nektonic and benthic prey, including shrimp, crabs, marine worms, squid, octopus, eggs, and small fishes. Speckled sanddab feed largely on mysids and amphipods, but small Pacific sanddabs feed on copepods and polychaetes. Adults feed more on euphausiids and squid. Sanddabs, in turn, are preyed upon by larger fishes, diving birds, and marine mammals.

Status of the Population

Commercial landings indicate that sanddab populations are in good condition and currently are not being overharvested. The Pacific Fishery Management Council has not recommended a change in the minimal acceptable biological catch of incidentally caught "Other Flatfish" (which includes sanddabs) during the past decade, indicating a stable and likely reasonably utilized resource.

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Silversides

There are three species of silversides (family Atherinopsidae) in California ocean waters, grunion, topsmelt (*Atherinops affinis*), and jacksmelt (*Atherinopsis californiensis*). Information on grunion is presented in a separate section. Even though "smelt" is included in the common names of these species, silversides differ in part from true smelts (family Osmeridae) in having two dorsal fins (one with spines), while the true smelts have one dorsal fin and an adipose fin near the tail.

History of the Fishery

Silversides are marketed fresh for human consumption or bait. The commercial fishery for silversides has been conducted with gillnets, lampara nets, and round haul nets. Historically, set lines have been used in San Francisco Bay for jacksmelt, and during the 1920s beach nets, pulled ashore by horses, were used at Newport Beach. Commercial catches of jacksmelt have varied sharply over the past 80 years. The high year for this fishery was 1945, when more than two million pounds were taken. During the 1990s, the catch varied between 40,765 pounds in 1997 and 2,530 pounds in 1998 and 1999, with most of the catch being landed in the Los Angeles area. This is an occasional or incidental fishery, and fluctuations observed in catch records reflect demand, not true abundance. Principal commercial fishing areas are usually in harbors and bays such as San Pedro, Monterey, San Francisco, Tomales, and Humboldt. Commercial catches of topsmelt are not as large as those of jacksmelt because of the smaller size and more scattered distribution of topsmelt. There are no commercial or sport bag and possession limits on these species.

Jacksmelt and topsmelt make up a significant portion of the pier and shore sport catch throughout California, and private boat anglers fishing nearshore catch them occasionally. From 1958 to 1961, these two species comprised about 10 percent of the total hook-and-line sport catch by numbers (272,000 jacksmelt and 43,000 topsmelt) in central and northern California. These are among the most abundant fishes available to pier and shore anglers and represent a very important recreational fishery, especially for children. When taken with light fishing gear, they are easy to catch and excellent fighters.

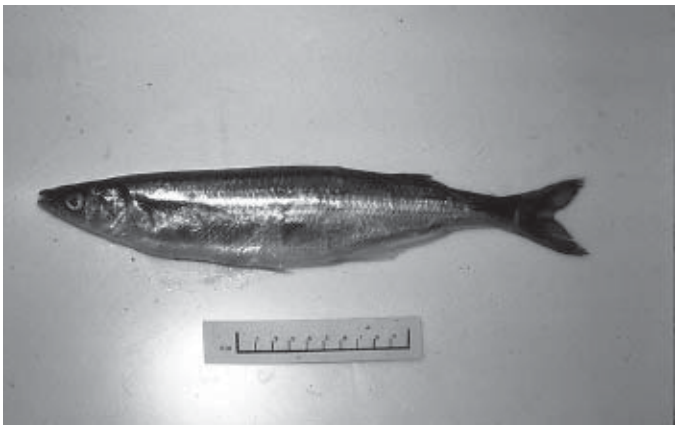
Jacksmelt are caught by a variety of sport fishing methods. A string of half-a-dozen bright red artificial flies or small hooks baited with shrimp or squid is the most successful terminal tackle used by pier anglers. Single baited hooks are also used from piers and by shore and skiff anglers. The larger jacksmelt is quite a game fish and will take a small spinner or lure cast out and retrieved with a series of quick jerks. Young jacksmelt and topsmelt are quickly attracted with breadcrumb chum thrown into the water. A rapid feeding activity takes place, making it easier to catch fish with hooks or hoop nets.

Status of Biological Knowledge

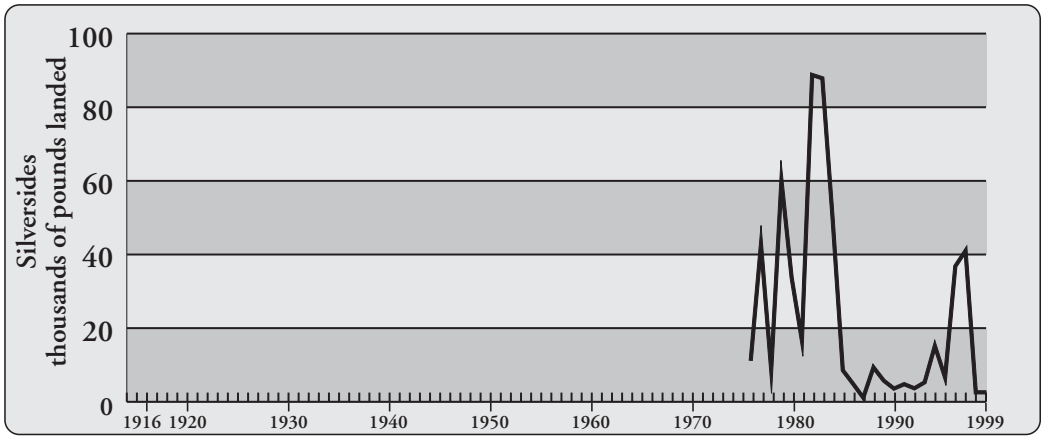
Topsmelt range from the Straits of Juan de Fuca, British Columbia, to the Gulf of California. They attain a total length of 14.5 inches, but individuals in sport catches are usually six to eight inches in length. There are seven subspecies of topsmelt, three of which are in California. These numerous subspecies demonstrate varied behavior and reflect the different environments occupied by this species: kelp beds, harbor areas, and sandy beach areas. They usually form loose schools but will congregate when feeding.

Topsmelt grow about 2.5 to four inches the first year, gain another two inches the next year, and grow proportionally less each year until they reach maximum size of about 14 inches. The largest topsmelt that has been aged was seven or eight years old. Some topsmelt spawn by their second year but most reach maturity during their third year. The spawning period is from April through October with a peak in May and June. This species attaches its eggs in a mass on eelgrass and low growing algae in harbors and bays, and possibly on kelp. The egg mass from each female is intertwined to the substrate by fine string-like filaments attached to each egg. Eggs may be deposited more than once in a spawning season. Topsmelt larvae are particularly abundant in tidal basins and the shallow edges of coastal bays. Juvenile topsmelt generally move into the open water of estuaries, bays, and coastal kelp beds.

The food of topsmelt consists primarily of plankton species including crustaceans. Intertidal inhabitants eat algae and fly larvae, as well as crustaceans. Bay forms have been observed working along muddy bottoms for food items. Topsmelt have the ability to withstand a wide range



Jacksmelt, *Atherinopsis californiensis*
Credit: DFG



Commercial Landings 1916-1999, Silversides
Data Source: DFG Catch Bulletins and commercial landing receipts. No commercial landing are reported for silversides prior to 1976.

of salinity concentrations. They are found in mesohaline waters and have been known to live in salt ponds with salinities as great as 72 parts per thousand – twice that of open ocean water.

Topsmelt are a very important species in bay and near-shore ecosystems in southern California. Collections of fishes by beach seine in bays are almost always numerically predominated by young topsmelt. Young-of-the-year topsmelt were found to contribute 85 percent of the total annual fish production in the shallow water areas of Upper Newport Bay. Topsmelt have been shown to be the most ubiquitous and numerically abundant fish species in submarine meadows of surfgrasses on the open coast. They are one of the five primary species brought to the breeding colonies of the least tern, an endangered seabird.

Jacksmelt form dense and larger schools than topsmelt and range over much of the inshore area of California. The geographic range is from Yaquina Bay, Oregon to Santa Maria Bay, Baja California. They are usually found in bays and within a few miles of shore in a salinity range from seawater to mesohaline. This species attains a length of 22 inches, with 17-inch fish commonly taken. Jacksmelt are relatively fast growing, reaching 4.5 to five inches in the first year and up to eight inches during the second year. Jacksmelt mature at two to three years or about eight inches. The oldest jacksmelt aged, a 16-inch male, was 11 years old. The spawning season is during winter, from October to April. Large masses of eggs, about the size of small BBs, are attached to eelgrass and algae by means of long filaments. Pinkish egg masses have been observed along with herring eggs during winter months in Elkhorn Slough and attached to eelgrass in Tomales Bay. Jacksmelt eggs have been observed to hatch in salinity as low as five parts per thousand. Jacksmelt can spawn several times during a spawning season.

The larvae and young are distributed near the surface in harbors, along sandy beaches, and in the kelp canopy, often mixed with the young of topsmelt. Their food habits are not well known, but it can be assumed that fish as fast as jacksmelt, that readily take a moving lure, are predatory animals. Small fish as well as crustaceans make up part of their diet.

The species is not desired by some sport anglers because of the presence of relatively large sized worms in the flesh. These are an intermediate stage of a spiny-head worm that is thought to be a parasite in sharks and pelicans. It probably is harmless to man, and definitely is harmless when the flesh is cooked.

Status of the Populations

Stock sizes of these two species have not been determined. At present, there are no indications that topsmelt or jacksmelt are being overfished in California. However, as these species occur in inshore waters, they are at risk of being affected by pollutants and loss of habitat through development.

Management Considerations

See the Management Considerations Appendix A for further information.

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Skates and Rays

History of the Fishery

Skates and rays are not specifically sought by commercial fishermen, but are taken incidentally, primarily by bottom trawlers in central and northern California waters. Of the species identified in the commercial catch the most common are the shovelnose guitarfish (*Rhinobatos productus*), bat ray (*Myliobatis californica*), big skate (*Raja binoculata*), and thornback (*Platyrhinoidis triseriata*). This does not represent the true catch composition, however, as 98 percent of the landings are listed as "unidentified skate." A few nearshore species, most commonly the bat ray and shovelnose guitarfish, are the target of small sport fisheries.

Only the wings of skates caught in the commercial fishery are marketed. The bodies are either discarded at sea or occasionally sold as bait for the rock crab fishery. Skate wings are sold fresh and frozen, predominantly in the Asian fresh fish markets in southern California. Wings are also dried or salted and dehydrated for the Asian markets. At times, skates have been processed for fishmeal, but most such enterprises experienced economic failure. Seafood restaurants and retail markets have been suspected of punching out rounds of skate wing to serve as cheap substitutes for scallops.

Historically, the economic value of the skate fishery compared to other seafood fisheries was relatively small. From 1958 to 1969 the ex-vessel price for skate wings ranged from $.01 to $.02 per pound. Prices increased from $.12 per pound in the 1970s to $.25 per pound in 1991. This increase has continued through the 1990s ranging as high as $1 or more and averaging around $.40. In 1999, the total ex-vessel value of skates and rays was approximately $340,000.

Central California (Monterey and San Francisco) shared the majority of the skate catch from 1948 through 1989, accounting for 41 to 100 percent of the annual landings and more than 70 percent of the total catch during the period. The northern California areas (Eureka, Crescent City, and Fort Bragg) have played an increasing role since about 1975. Over the period from 1989 through 1999, the northern California catch has increased dramatically, accounting for nearly 75 percent of the total catch. Areas south of Monterey remain relatively insignificant in terms of total landings.

From 1916 to 1990, skate landings, which ranged from 36,247 pounds (1916) to 631,240 pounds (1981), comprised two to 90 percent of the total elasmobranch catch (11.8 percent average). Like the shark fishery, which had peaks from 1937 to 1948, and more recently from 1976 to 1990, the skate catch has fluctuated widely during the last half century. In the past 10 years, however, skate and ray landings have increased nearly ten-fold in California, from around 228,566 pounds in 1989 to 1,912,695 pounds in 1999. This trend is most notable in the trawl fishery after 1994.

Some of the apparent increase may be due to increased landings of previously discarded catch. In 1994, the commercial groundfish fishery was divided into limited entry and open access components, each with new regulations and quotas. Groundfish quotas for both components were significantly reduced in the period from 1994 through 1999, leaving more space in the boats' holds for non-quota species. Trawl vessels have supplemented their groundfish landings with skate and ray bycatch. There is considerable uncertainty whether the total impact on the skate and ray resource has increased or if more of the catch is being retained and landed.

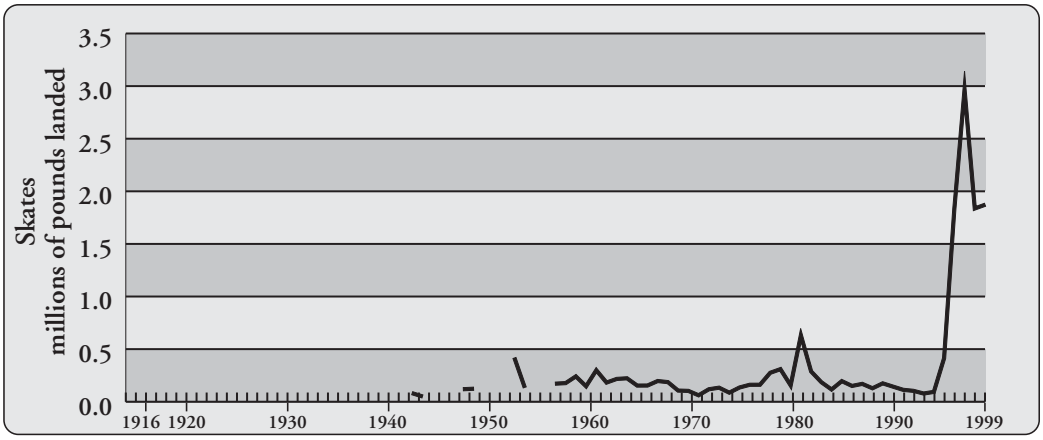
Status of Biological Knowledge

Skates and rays (batoids) can be distinguished from sharks by having pectoral fins which extend above and in front of the gills, attaching to the head and forming an expanded and flattened disc with gill slits located completely on the underside. They can be thought of as sharks flattened to accommodate a life spent on the sea floor. Twenty species of rays and skates have provisionally been recorded from California waters.

Rays and skates occur in all marine habitats, from protected bays and estuaries to open seas, ranging from the surface to 9,500 feet deep. While some species are common, others are known from only a few specimens. So far as is known, batoids follow the typical elasmobranch reproductive strategy in which sexual maturity is attained relatively late in life, brood size is relatively small, and fecundity is generally low. These characteristics make populations more susceptible to overfishing.

All batoids have internal fertilization, but two different modes of development exist. The skates are egg layers, or oviparous. Following fertilization, the yolk is enclosed in a

Longnose Skate, *Raja rhina*
Credit: DFG



Commercial Landings 1916-1999, Skates
Data Source: DFG Catch Bulletins and commercial landing receipts. Landings data are not available prior to 1943, 1945-1947, 1950, 1952, and 1955-1956.

tough, permeable egg case, which is deposited on the sea floor. The embryo develops within the egg case, feeding on nourishment stored in the attached yolk mass. Hatched egg cases (commonly known as "mermaid's purses") are washed ashore and frequently found by beachcombers. All other batoids are live bearing, or viviparous. The embryo is protected by, and develops within, a portion of the female's oviduct, which functions as a uterus. The gestation period for skates and rays varies widely; depending on the species it may range from two to 18 months.

Batoids feed on a variety of worms, mollusks, crustaceans, other invertebrates, and fishes. Some lie buried on the bottom to wait for prey, while others actively forage. As a group they have a large variety of feeding strategies, ranging from straining plankton (manta), to electric shock (electric ray), to excavation and suction (bat ray). In turn, marine mammals, sharks, and other large fishes prey upon batoids. An adult giant sea bass (*Stereolepis gigas*) was found to have three whole thornbacks in its stomach. Batoid predator avoidance adaptations include cryptic (camouflage) coloration and burying themselves in sand or mud. In some species, rows of sharp spines on the back and/or tail also serve as protection. Only a few of the batoid species are dangerous to humans. Electric rays are capable of producing a powerful shock, and stingrays can inflict serious wounds on unwary anglers and bathers.

The Skates and Softnose Skates - Families Rajidae and Arhynchobatidae

The skates are the largest group of batoid fishes. Nine species in three genera are presently known to occur in California waters. California's three commercially important skates are the California skate (*Raja inornata*), big skate (*R. binoculata*), and longnose skate (*R. rhina*).

The skates have a greatly flattened, usually rhomboidal shaped disc. Most species have enlarged thorns or sharp spines (denticles) on disc and tail. Adult males have rows of enlarged, hooked thorns along the front edge (malar thorns) and lateral edge (alar thorns) of the disc. The tail is slender, with two small dorsal fins located near the tip. The caudal fin is small or absent, and there are no stinging spines. Skates have paired electric organs along the sides of their tails, which generate weak, low-voltage electric currents believed to be used in intra-specific communication, possibly for mate recognition or to demonstrate aggression. These electric currents are not harmful to humans.

The California skate ranges from the Strait of Juan De Fuca to southern Baja California. It is common inshore in shallow bays at depths of 60 feet or less, but also occurs in deeper water to a depth of 2,200 feet. Females and males both reach sexual maturity at a total length of about 30 inches. They feed on shrimp and other invertebrates.

The big skate ranges from the Bering Sea to southern Baja California, but is relatively rare south of Point Conception. It occurs at depths from 10 to about 2,600 feet, being most common at moderate depths. It is the only known Californian skate with more than one embryo per egg case. The big skate grows to a length of up to eight feet, but usually does not exceed six feet and about 200 pounds. Females mature at 12 to 13 years and a length of 51 to 55 inches; males mature at seven to eight years and a length of 39 to 43 inches. It feeds on crustaceans and fishes.

The longnose skate also ranges from the Bering Sea to central Baja California, and is usually found on the bottom at depths from 80 to 2,250 feet. It attains a maximum length of about 4.5 feet. Females mature at eight years and a length of 28 inches; males mature at five years and a length of 24 inches.

Other skate species include the sandpaper skate (*Bathyraja interrupta*) and starry skate (*Raja stellulata*) occurring in moderate depths and the deep-sea skate (*B.*

abyssicola), roughtail skate (*B. tachura*), and white skate (*B. spinosissima*) occurring in deep water up to 9,500 feet (deep skate). One other species, the broad skate (*Amblyraja badia*) is very rare with only two records from California.

The Guitarfishes and Thornbacks - Families Rhinobatidae and Platyrhinidae

The guitarfishes derive their name from their similarity in shape to the musical instrument; head tapered or round, flattened, and somewhat broader than their sturdy, shark-like tail. Thornbacks share this general body shape, but have rows of spines down the dorsal surface. Guitarfishes and thornbacks are usually found on the bottom and close inshore. All are viviparous, the embryos being nourished by nutrients stored in their yolksac. They have small, blunt teeth used for crushing, and feed on invertebrates such as worms, crustaceans, and mollusks, as well as small fishes, and are generally harmless to humans. Three species are known from California waters.

The shovelnose guitarfish (*Rhinobatos productus*) has a sharply pointed snout and a tapered, somewhat shovel-shaped disc. It ranges from San Francisco to the Gulf of California, but is rare north of Monterey Bay. It is found in shallow coastal waters, bays, sloughs and estuaries over sandy or muddy bottoms to a depth of about 50 feet. Mating occurs during the summer months in southern California and the females give birth to live young the following spring or summer. Newborn guitarfish are six inches long, with up to 28 pups per litter. Females reach a length of 5.5 feet and a weight of about 40 pounds; males are smaller. The banded guitarfish (*Zapteryx exasperata*) has a more rounded snout and dark banding across the disc. It inhabits rocky reefs and gravel beds and occurs rarely in southern California.

The thornback (*Platyrhinoidis triseriata*) is identified by three parallel rows of large, curved spines running down the back and base of its tail to just past the first dorsal fin. Adults reach a length of 2.5 to three feet. Thornbacks occur in shallow water to depths of 150 feet resting on sandy bottoms partially or completely buried. Thornbacks are common in the southern part of the state and Baja California, becoming more rare to the north.

The Electric Rays - Family Torpedinidae

Electric rays are found worldwide in all tropical and warm-temperate seas. They have a greatly expanded sub-circular disc that is fleshy toward the margins, and specialized to accommodate the two kidney-shaped electric organs. These organs are modified muscles capable of producing a powerful electrical shock. Only one species is known from California waters.

The Pacific electric ray (*Torpedo californica*) ranges from northern British Columbia to central Baja California, at depths from 10 to 1,400 feet. Commonly found over sandy bottoms, it also occurs in rocky areas and kelp beds. Females reach a length of over 4.5 feet, while males may reach three feet. It feeds exclusively on fish, including anchovies, herring, kelp bass, mackerel, and halibut. One four-foot female ray was observed to consume a two-foot silver salmon. Unlike most predatory fish, however, it does not initially seize its prey with its mouth, but first immobilizes it with electric discharges. It then manipulates the prey toward its mouth, using its remarkably dexterous disc, before swallowing it.

Sometimes aggressive when approached or provoked by divers, it may swim toward them with pectoral fins curled downward in a challenging manner. While its electric shock may be quite powerful, reaching up to 60 volts in larger individuals, it does not extend a great distance from the ray's body. The shock is apparently not fatal to humans, but often snaps the backbone of prey fish.

The Myliobatidiform Rays (Stingrays) - Families Urolophidae, Myliobatidae, Dasyatidae, Gymnuridae, and Mobulidae

The stingrays are a large and rather diverse group, most of which have a greatly flattened disc and whiplike tail with one or more serrated stinging spines that are readily replaced when they become old or worn. This group includes both the smallest and largest batoids. Most are bottom-dwellers, occurring in shallow inshore waters, bays, estuaries and sloughs, but some are also found in deeper waters. At least one species of stingray and all mantas and mobulas are epipelagic, occurring in the upper water column of the open ocean.

The stingrays bear live young and are unique among the elasmobranchs in their method of nourishing the developing embryo. A nutritive fluid called uterine milk is secreted from hair like processes called trophonemata, which line the oviduct wall. Adults feed on soft benthic invertebrates, mollusks, crustaceans, and benthic, midwater, and schooling nektonic fishes.

Rays are usually popular when displayed in public aquaria; bat rays are especially suited for shallow petting tanks. Although used by cultures throughout the world for food, myliobatidiform rays are of little interest to California commercial fishermen, who mostly consider them a nuisance. Because most species have a stinging spine, care should be taken when handling them.

The round stingray (*Urolophus halleri*), our most common stingray, has a nearly round disc and short, stout tail with well-developed caudal fin and stinging spine. It ranges from northern California to Panama, but is most abundant south of Point Conception. A benthic species

with restricted habitat requirements, this ray is limited to a relatively shallow coastal zone at depths from three to 100 feet, occurring primarily in water less than 50 feet deep. It can be found off beaches and in protected bays, sloughs, channels and inlets, where it inhabits loose sand or mud bottoms.

The round stingray's stinging spine is located far enough back on its tail to afford a powerful stinging reflex. When large numbers of round stingrays congregate off beaches, injuries to bathers can result. This danger can usually be avoided, however, by shuffling one's feet or pushing a stick along the bottom. Injuries from the spine may also result when rays are removed from nets or hooks. While the wounds do not appear to be fatal, they can be severely painful, and can cause vomiting, diarrhea, sweating, cramps, and difficulty breathing.

The bat ray (*Myliobatis californica*) is a common seasonal inhabitant of shallow inshore waters from Oregon to the Gulf of California. It occurs in muddy or sandy bays and sloughs as well as rocky areas and in kelp beds from near the surface to depths of 150 feet.

Gestation is estimated to take from nine to 12 months, with two to 12 young per litter. Size range at birth is 8.7 to 13.8 inches disc width (wingtip to wingtip). Onset of sexual maturity in males occurs at an age of two to three years and a disc width of 17.7 to 24.5 inches; maturity in females occurs at five to seven years and disc width of 35 to 40 inches.

Female bat rays reach a greater size than males, attaining a maximum disc width of 70.9 inches and weight of 210 pounds. The largest reported male is 40 inches wide at a weight of 37 pounds. Bat rays grow slowly, reach sexual maturity relatively late, have few young, and seem to be fairly long-lived. A 60-inch disc width female was estimated to be 24 years old.

Bat rays feed on clams, abalones, oysters, marine snails, worms, shrimps, and crabs. Bat ray predation on oysters is a major reason for the fencing seen around commercial oyster beds. Pieces of backbone (centra), tooth plates, and sting fragments have been identified from coastal shell-mounds, suggesting that bat rays were a regular diet item of early California natives.

The diamond stingray (*Dasyatis brevis*) is found in shallow waters to a depth of 55 feet. It ranges from southern California (with a possible record from British Columbia) to Peru inhabiting sand and mud bottoms, often around kelp beds. Maximum reported size is 38.5 inches disc width.

A truly open ocean species, the pelagic stingray (*Pteroplatytrygon violacea*) is commonly found swimming in open water well above the bottom. Found worldwide in warm-temperate and tropical waters the pelagic stingray reaches a maximum disc width of 32 inches. It is a frequent incidental catch of drift longline gear.

The California butterfly ray (*Gymnura marmorata*) inhabits its shallow bays and sandy beaches. It has a very wide disc, reaching widths up to five feet. The butterfly ray is found from Point Conception to Peru, including the Gulf of California.

Found worldwide in tropical seas the Pacific manta (*Manta birostris*) is seen on rare occasions in southern California. The manta can reach a maximum width of 25 feet. Its close relative, the mobula (*Mobula japonica*), which occurs in temperate waters of the Pacific, is also rarely seen in southern California. Mobulas are smaller than mantas, reaching a maximum width of four to seven feet. Mantas and mobulas are unique among the batoids in being filter feeders. They pass huge volumes of water across complex filter plates at the gills, straining out small pelagic crustaceans and schooling fishes.

Status of the Populations

Based on existing data, little can be said about the current or past population levels of California's skates and rays. While landings are increasing dramatically, this may or may not reflect an actual threat to the resource. Fish that were discarded in the past, dead and alive, are now being retained and landed. The increase in landings, however, certainly warrants close monitoring. Although some skate species may have higher growth rates than other elasmobranchs, compared with bony fishes they have slow growth rates, late age at maturity, and low fecundity. Other regions have already witnessed decreases in skate and ray populations. In Japan and the Irish Sea, landings have decreased and overfishing has apparently occurred.

The impact of sport fisheries on skates and rays is relatively unknown. Data from 48 shark derbies in Elkhorn Slough from 1950 to 1990 show, however, that shovelnose guitarfish, which in the 1950s and 1960s were the second, and in some years the most abundantly caught elasmobranch, virtually disappeared from the catch in later years. In the 1990s, there was a two-thirds decrease in the catch-per-unit effort for bat rays compared to the 1950s catch rates in these derbies. Pacific States Marine Fisheries Commission recreational fisheries sampling, however, shows continued catches of bat rays, big skates, shovelnose guitarfish, and thornback. The total numbers caught are hard to determine from the numbers of sampled skates and rays, as sampled catch numbers vary widely from year to year.

Management Considerations

See the Management Considerations Appendix A for further information.

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Spotfin Croaker

History of the Fishery

The spotfin croaker (*Roncador stearnsii*) is a nearshore croaker reserved for the recreational fishery. It has been illegal to take them with nets since 1909, and illegal to buy or sell them since 1915. Anglers can experience good fishing when there are croaker "runs" and when "croaker holes" are found. Most of the spotfin croaker catch consists of smaller fish (one to three pounds). Its fighting spirit and delicate taste make it a prized sport fish.

Spotfin croaker can be taken throughout the year, but fishing is best in late summer. Most spotfin croaker are caught from shore on piers and jetties along beaches and in bays; they are occasionally taken by private and rental boats but are rarely taken by commercial passenger fishing vessels. Anglers use conventional and spinning gear. The best baits are marine worms, clams, and mussels.

Annual landings of spotfin croaker have fluctuated greatly. Marine Recreational Fishery Statistics Survey (MRFSS) annual catch estimates for 1980 through 1998 ranged between 1,000 and 46,000 fish; the average was 14,900. Catch-per-unit effort has remained relatively low and stable since 1980, but started to increase in the late 1990s.

Status of Biological Knowledge

The spotfin croaker is a medium-bodied croaker with a bluish gray back, brassy sides, and a silver to white belly. It has a large, distinctive black spot at the base of its pectoral fin. The spotfin croaker ranges from Point Conception, California to Mazatlan, Mexico. In California, it is most common south of Los Angeles Harbor. It lives along beaches and in bays over sandy to muddy bottoms at depths from four to 50 feet. Most spotfin croaker are found in 30 feet of water or less, preferring depressions and holes near shore. These "croaker holes" are well known to surf anglers. Spotfin croaker aggregate in small groups or schools of usually fewer than 50 fish; however, schools containing several hundred fish are occasionally encountered.

Spotfin Croaker, *Roncador stearnsii*
Credit: DFG

Spotfin croaker can grow to 27 inches and weigh 14 pounds. A fish weighing 10.5 pounds was eight or nine years old, and a 26.5-inch long individual was at least 15 years of age. During the breeding season, females develop blackish streaks on their bellies, while larger males have golden pectoral and pelvic fins, and are commonly called golden croaker. Apparently, most males are mature at nine inches (two years), and most females are mature at 12.5 inches (three years); all are mature at 14.5 inches (four years). Spawning occurs from June to September. It probably occurs offshore, since few ripe fish have been captured in the surf zone. Small (two- to four-inch) spotfin croaker have been captured inside the surf zone to 30 feet of water.

The spotfin croaker is a bottom feeder. The diet of juveniles consists of small crustaceans and clam siphons. Larger individuals use their strong pharyngeal teeth to crush shells and consume whole clams, mussels, and polychaetes.

A limited tagging program showed that the spotfin croaker moves around considerably, especially from bay to bay, without a discernible pattern. Fish tagged in Los Angeles Harbor were later recaptured as far south as Oceanside.

Status of the Population

Southern California is on the northern fringe of the spotfin croaker population. Their population size, recruitment, and mortality are unknown. Modifications of bay and nearshore environments, including development, land fills, and dredging, have had an adverse effect on the habitats of this species. Beach seine hauls along the open coast from 1994 through 1997 yielded many fewer spotfin croaker than during a similar study from 1953 through 1956. However, catch-per-unit effort estimates from MRFSS data and gillnet sets inside bays and along the open coast indicate that spotfin croaker populations were increasing in the late 1990s.

Management Considerations

See the Management Considerations Appendix A for further information.

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Surfperches

General

The surfperches, family Embiotocidae, are a small abundant assemblage of 23 species found predominantly in temperate eastern North Pacific waters, two which are found in the Sea of Japan. Nineteen of the 20 species found in California occur in inshore coastal waters. Tuleperch (*Hysterocarpus traski*) occupies freshwater and estuarine habitats. Collectively, the 19 marine species are found in a variety of habitats, including beaches, rocky substrate, intertidal and subtidal kelp beds. A few species inhabit several of the habitat types. Included in this group are the pile perch (*Rhacochilus vacca*), rubberlip surfperch (*Rhacochilus toxotes*), shiner perch (*Cymatogaster aggregata*), walleye surfperch (*Hyperprosopon argenteum*), and the white surfperch (*Phanerodon furcatus*). The majority of surfperches occupy only one type of habitat. Species most commonly found along beaches include the barred surfperch (*Amphistichus argenteus*), calico surfperch (*Amphistichus koelzi*), redtail surfperch (*Amphistichus rhodoterus*), silver surfperch (*Hyperprosopon ellipticum*), and the spotfin surfperch (*Hyperprosopon anale*). Black perch (*Embiotoca jacksoni*), dwarf perch (*Micrometrus minimus*), kelp perch (*Brachyistius frenatus*), rainbow perch (*Hypsurus caryi*), reef perch (*Micrometrus aurora*), sharpnose seaperch (*Phanerodon atripes*), and striped seaperch (*Embiotoca lateralis*) tend to be associated with rocky substrate and kelp beds. The pink seaperch (*Zalembius rosaceus*) inhabits deep water and is seldom taken in the sport catch.

The surfperch fishery in California includes both sport and commercial components. The sport fishery is enjoyed by anglers of all ages who fish for surfperch from piers, jetties, sandy beaches, and boats. The recreational catch of surfperch for 1999 totaled 489,000 fish, with the majority being caught in central and northern California. The average sport catch for 1993 through 1999 was 864,000 fish with a high of 1,119,000 fish in 1998.

Surfperch are easy to catch, which makes them highly sought. They can be caught using light gear and a variety of baits such as clams, tubeworms, or sand crabs. A spinning or casting outfit using 10 to 15 pound test monofilament line, and a standard two-hook surf leader with size six hooks, is ideal for shore based surfperch fishing.

Barred Surfperch, *Amphistichus argenteus*
Credit: DFG

Annual commercial landings of surfperches have also been highly variable. While the market for fresh "perch" fillets is relatively small, the total catch for the fishery was 49,000 pounds in 1999. The California Department of Fish and Game did not distinguish between species in their statistics until 1987, simply listing the category as surfperch. Currently, there is a large commercial fishery for various surfperches in the southern part of the state and a moderate fishery focusing on redtail surfperch in northern California.

Surfperches can be identified by their elliptical, compressed body form and forked tail. Most are marked with bars or stripes. They have a continuous dorsal fin with nine to 11 spines and 19-28 soft rays. The anal fin has three spines with 15-35 soft rays.

The diet of surfperches consists of isopods (*e.g.*, rock lice) of all sizes, and gastropod mollusks (*e.g.*, snails); various amphipods (*e.g.*, skeleton shrimp), polychaete worms, brittle stars, and small crabs, also are included. Surfperches are usually bottom grazers, but apparently will feed midwater when competitors are absent.

Surfperch reproduction is viviparous, their young being highly developed and free swimming at birth. Newborn males of a few species are reproductively mature.

Much information is lacking on this group. Although the taxonomy has been recently refined, life history and habitat requirements are areas in need of more research.

Barred Surfperch

History of the Fishery

The commercial fishery for barred surfperch is minor compared to the sport fishery. Its popularity as a sport fish stems from abundant numbers and accessibility. The average catch for the 1993-1999 period was 176,000 fish in southern California, and 202,000 fish in the remainder of the state. In the southern California sport fishery for barred surfperch, 99 percent were caught from beaches and jetties. Similarly, 99 percent of central and northern California's catch also came from shore. The best months for fishing are December, January, and February with the majority of large individuals being gravid females. Sand crabs are the best bait for barred surfperch, especially female sand crabs carrying orange colored eggs. Small jigs and spinners also work well. Although barred surfperch are excellent sport fish for the light tackle angler, they are sometimes considered a pest to anglers pursuing other fish such as California halibut or corbina.

Status of Biological Knowledge

Barred surfperch have eight to 10 rust-colored, irregular bars on their sides with spots in between. The background color is usually silver or white, and the back can take on a blue or grayish coloration. Similar species are the calico surfperch and the redtail surfperch, but the barred surfperch can be distinguished from the redtail and calico because it lacks red coloration in its fins.

Barred surfperch are found in small schools along sandy beaches and near jetties, piers, and other sources of food and cover. They range from Bodega Bay in northern California to north central Baja California. While the majority are found in the surf zone, some have been caught in water as deep as 240 feet. The largest individual ever taken was a female that weighed 4.5 pounds and was 17 inches in length. Most fish are in the one- to two-pound range and are highly prized by anglers.

Barred surfperch mate during the fall and winter months, and young are released during spring and summer. Males and females both darken considerably during courtship, and males make "figure-eights" around females before mating. A female can produce from four to 113 young, depending on her size. Females undergo a five-month gestation period, and juveniles are born at about 1.75 inches in length. Juveniles are miniature replicas of the parents and are independent at birth. The young usually live relatively close to where they were born.

Status of the Population

During the last seven years, the sport fishery in southern California has yielded up to 306,000 barred surfperch (1998), while central and northern California together produced upwards of 252,000 fish annually. No estimates have been made of the size or current status of the barred surfperch population.

Calico Surfperch

History of the Fishery

The calico surfperch is of moderate sport value along the California coast. Due to its striking similarity and frequent misidentification with the redtail surfperch, calico surfperch, until recently, have been considered of minor importance in the sport catch. The mean sport catch from 1993-1999 was 16,000 fish. There is no targeted commercial catch but small numbers are taken in the directed redtail surfperch fishery. The calico fishery has historically included fishing from piers, sandy beaches, and skiffs.

Status of Biological Knowledge

The calico surfperch can be identified by its silvery surface, which is covered by olive-green mottling and broken bars down each side. The calico reaches a length of 12 inches and rarely weighs more than one pound.

The range of the calico surfperch is from north central Washington to northern Baja California. The primary habitat of the calico is sandy beaches, although they can occasionally be found over rocky substrate. The vertical distribution of the calico includes depths from the surface down to 30 feet.

Calico Surfperch, *Amphistichus koelzi*
Credit: DFG

Status of the Population

At this time, little information is available on the population status of the calico surfperch.

Pile Perch

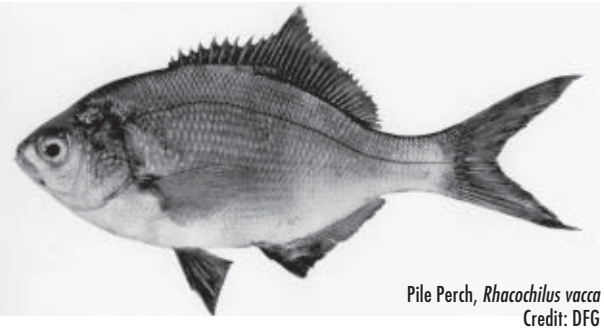
History of the Fishery

Pile perch sustain a limited commercial fishery in Del Mar, California, and Papalote Bay, Baja California, but do not contribute substantially to annual commercial landings in the state.

They are of interest as a sport fish throughout the state, with an average of 16,000 perch caught between 1993 and 1999. Many are caught from piers, jetties, beaches, or skiffs. Pile perch may be caught year-round on any number of popular baits, including clams, sand shrimps, and worms.

Status of Biological Knowledge

Pile perch can be identified by the silvery sides with a dark vertical bar about midbody, and a unique dorsal fin with the first few soft dorsal rays longer than any of the others, giving the fin a peaked appearance. They are equipped with strong, well-developed teeth, enabling them to feed on hard shelled mollusks, crabs, and other



Pile Perch, *Rhacochilus vacca*
Credit: DFG

crustaceans. Their specialized dentation differs enough from rubberlip surfperch to convince some ichthyologists to place them in their own genus (*Damalichthys*).

Pile perch are found between southeastern Alaska and northern Baja California, including Guadalupe Island. They usually live along rocky shores, from the surface down to 150 feet, and grow to around 17.5 inches in length.

Fecundity increases with age and size of the females. Average fecundity at first reproduction is 11.7 young, and sometimes exceeds 60 in older females. Adult longevity of pile surfperch is seven to 10 years.

Status of the Population

Because accurate landings data for pile perch are lacking, little can be concluded about the current population status in California.

Redtail Surfperch

History of the Fishery

Redtail surfperch sustain a sport fishery from central California to Vancouver Island, British Columbia. They support a commercial fishery only in northern California, especially in the inshore waters of the Eureka/Crescent City area where over 99 percent of the catch is taken. These fish are taken primarily from sandy beaches or the mouths of rivers and streams entering the sea, but also can be caught from jetties and piers inside harbors and bays. Humboldt and Del Norte counties in northern California are the primary locations of the winter redtail commercial fishery. Fishing is mostly from open beaches using hook-and-line gear. The best catches are in March and April when the fish are concentrated for spawning. Commercial fishing is closed from May 1 to July 15. The annual commercial harvest averaged 37,000 pounds over the last 10 years, with a high catch in 1990 in excess of 62,000 pounds and a low catch of around 27,000 pounds in 1998.

Sport fishing for redtails occurs in the same areas where they are commercially taken. They are taken year-round by hook-and-line, but are usually targeted during the spawning season. The sport catch since 1993 has ranged from a low of 10,000 fish in 1998, to a high of 56,000 in 1994.

Status of Biological Knowledge

Redtail surfperch are distinguished by the nine or ten vertical, orange-to-brassy bars alternating at the lateral line and the light red pelvic, anal, and caudal fins. The body is moderately deep and laterally compressed, with a light green back and silver sides and belly. During the 1990s, adult female redtail averaged 10.5 inches and weighed 1.1 pounds, while the males averaged 9.8 inches and weighed 0.8 pounds. The largest recorded California redtail was a female that was 16.5 inches long and weighed 3.7 pounds. The largest recorded individual was 16.5 inches long and weighed 3.7 pounds. Females produce eight to 45 young about one year after fertilization, sometime between May and August.

Redtail surfperch are found from Vancouver Island, Canada, to Monterey Bay, California, but the fishery is centered north of the San Francisco Bay area.

Status of the Population

There are no estimates of the size of the redtail surfperch stocks in California coastal waters. The commercial catch averaged 50,000 pounds during the 1970s, 48,000 pounds during the 1980s and 38,000 pounds during the 1990s, which suggests a decreasing population. Another indicator of problems with the population is the decrease in weight from an average per fish weight of 1.8 pounds during the late 1950s and early 1960s, to 0.9 pounds during the 1990s.

Redtail Surfperch, *Amphistichus rhodoterus*
Credit: DFG

Rubberlip Surfperch

History of the Fishery

The rubberlip surfperch is one of the many important surfperch sport fish along the California coast. It is caught along jetties and piers, and also taken by skiff anglers nearshore or in kelp beds. The sport catch over the last seven years ranged from 13,000 fish in 1993 to 44,000 fish in 1997 with an average of 19,000. The commercial fishery is very small with landings of less than 1,000 pounds annually from southern California.

Status of Biological Knowledge

The large, thick lips of the rubberlip distinguish it from other surfperches. Its coloration varies from olive-to brassy-brown on the sides, with one or two dusky bars on adult fish. The pectoral fins are yellow to orange, and the pelvic fins are usually black. The maximum length of rubberlip seaperch is 18.5 inches, making the rubberlip the largest of the surfperches.

Rubberlip surfperch are found from Russian Gulch State Beach (Mendocino County), California, to central Baja California, including Guadalupe Island. These fish range from inshore waters to depths of 150 feet.

Although no data have been collected on age at sexual maturity, gravid rubberlip surfperch have been caught from April to June. Time of birth is estimated to be midsummer.

Rubberlip Surfperch, *Rhacochilus toxotes*
Credit: DFG

Status of the Population

No recent estimates have been made of the rubberlip perch population its size is unknown at this time.

Striped Seaperch

History of the Fishery

Striped seaperch is one of the eight to 10 species that make up the small commercial "perch" fishery. However, it is a minor component when compared to such species as the barred surfperch. Conversely, striped seaperch do comprise a substantial portion of the state's sport fishery. The mean take of striped seaperch for the last seven years was 65,000 fish, almost wholly from central and northern California. These perch are easily taken from piers, jetties, beaches, and skiffs, and are favorites of anglers due to their beautiful coloration.

Striped Seaperch, *Embiotoca lateralis*
Credit: DFG

Status of Biological Knowledge

Striped seaperch can be easily identified by the red, blue, and yellow lines that run laterally along the length of the body. Maximum length is 15 inches. These fish are sexually mature in their third year of life and produce about 18 young per female. At age seven, the average number of young produced per female is 32. The maximum life expectancy for this fish is approximately 10 years.

Striped seaperch are found from southeastern Alaska to northern Baja California.

Status of Population

Population estimates of striped seaperch have not been made, but recent landing figures indicate that this species should be able to sustain a healthy sport catch.

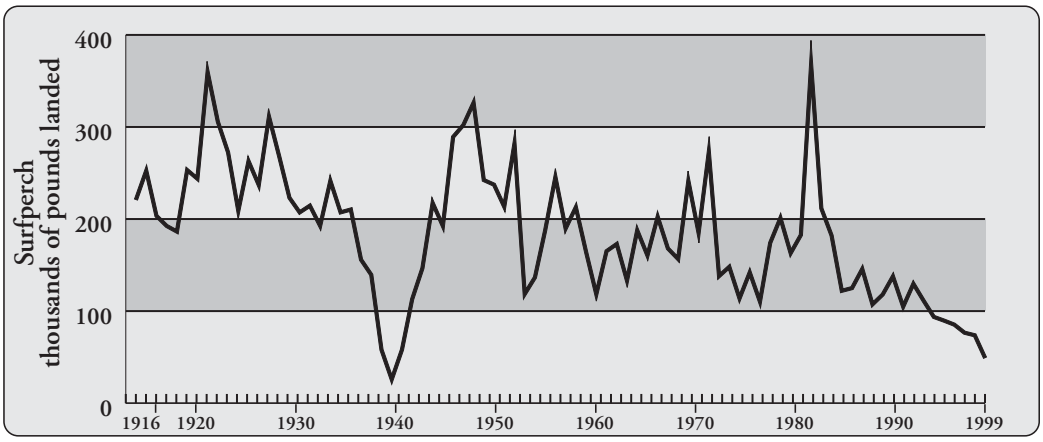
Walleye Surfperch

History of the Fishery

Sport anglers enjoy fishing for walleyes. In 1993, anglers caught 164,000 individuals, well over 90 percent being caught from shore, jetties, and piers. Walleyes can be taken on sand crabs and other invertebrates, as well as on small spinners and jigs. They are excellent to eat.

Status of Biological Knowledge

Walleye surfperch are silver to bluish above, with very faint pink bars that fade quickly after death. Most notable are the large eyes and black tipped pelvic fins. Similar species are the spotfin surfperch and the silver surfperch. However, the spotfin has black spots on its dorsal and anal fins, while the silver lacks any black coloration.



Commercial Landings 1916-1999, Surfperches
Data Source: DFG Catch Bulletins and commercial landing receipts.

Walleye surfperch are found in large schools along sandy beaches, jetties, kelp beds, and other habitats with rich invertebrate life. They range from Vancouver Island, British Columbia, to central Baja California, including Guadalupe Island. They reach a length of 12 inches and are found to depth of 60 feet.

Walleye surfperch mate from November to December and, after a five-month gestation period, give birth in mid-April. Males engage in an aggressive "swooping" courtship before mating. Females, depending on size, will have five to 12 young that are about 1.5 inches at birth. The young are miniature replicas of the parent and mature the fall or winter following their birth.

Status of the Population

The recent sport take has averaged 112,000 fish per year. However, the total stock size is unknown at this time.

Surfperch: Discussion

Surfperches are important both commercially and as sport fish. Most of the California coastal species are taken in the sport catch and the majority of the catch is taken when spawning aggregations are present. Female surfperches are intentionally targeted by sport anglers because they are larger than males. Sport anglers also grade their catch, which probably results in an even greater take of mature females with a resulting decline in the fishery. The redtail and barred surfperches are the most notable in the commercial catch and may be important to local economies. Total commercial surfperch landings have fluctuated over the years, but over the long-term have declined by 25 percent since the 1950s. Recent research has indicated that some of the decline is associated with the increases in water temperature.

Surfperch habitats have been, and will continue to be, areas of conflict. As humans develop the shoreline, areas inhabited by surfperches may become polluted or destroyed. Although surfperches may adapt to structures such as jetties and piers, it should not be assumed that they can continue to adapt to all the changes that are forced upon them.

Action is needed if surfperch populations are to be restored.

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White Croaker

History of the Fishery

Although not a highly prized species, the white croaker (*Genyonemus lineatus*) has been an important constituent of commercial and sport fisheries in California. Before 1980, most of the catch was in southern California. However, since 1980, the majority of the catch has been in central California. The changes in fishing methodology and area of greatest landings since 1980 are due primarily to the entrance of Southeast Asian refugees (mainly Vietnamese) into this fishery. Many of these refugees who settled in California's coastal areas were gillnet fishermen in their homelands and sought to earn their living here by that method of fishing. The underutilized white croaker resource (especially in central California) and moderate start-up costs required for gillnetting (small to medium-size boats and moderate gear costs) offered many of them an opportunity to enter the commercial fishing business. In contrast, most of the sport catch is in southern California. Anglers fishing from piers, breakwaters, and private boats account for about 90 percent of the catch.

Prior to 1980, white croaker landings averaged 658,000 pounds annually and exceeded one million pounds in several years. Peak landings in 1952 (88 percent in southern California) were probably in response to the total collapse of the sardine fishery that year. From 1980 through 1991, total landings have averaged 1.1 million pounds and were above one million pounds in all but four years. Since 1991, landings have averaged 461,000 pounds and have steadily declined to an all time low of 142,500 pounds in 1998.

Before 1980, the commercial catch of white croakers was primarily by round haul net (mainly lampara), although some were taken by trawl, gillnet, and hook-and-line. After 1980, most white croakers have been taken by gillnet and hook-and-line. Most of the commercial catch is sold in the fresh fish market, although a small amount is used for live bait. "Kingfish" is the most common name seen in markets. Also, small quantities of another croaker, the queenfish, are included in the commercial landing records, mostly for southern California.

Landings of white croaker by recreational anglers aboard commercial passenger fishing vessels, were highest in the late 1940s and early 1950s, averaging about 70,000 fish per year. Since 1954, however, they have averaged well below 30,000 fish per year, with one exceptional peak in 1988 of about 120,000 fish. Landings from 1990 through 1998 have averaged about 12,000 fish per year, with approximately 96 percent of the landings from southern California.

White Croaker, *Genyonemus lineatus*
Credit: DFG

Status of Biological Knowledge

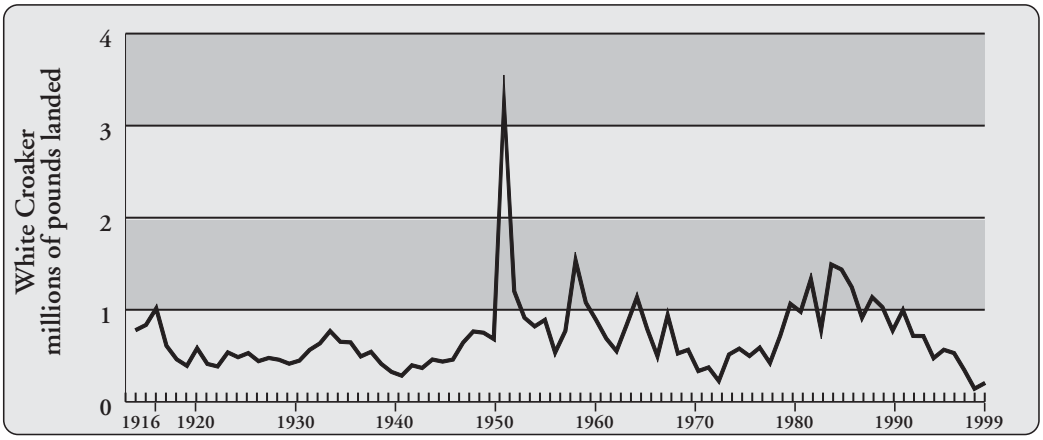
White croaker is one of eight species of drums, from the family Sciaenidae, recorded off of California. *Genyonemus* is a combination of two Greek words, *genys*, meaning lower jaw, and *nemus*, meaning barbell. The species name *lineatus* is a Latin word meaning striped. White croaker are often sold in fish markets under the name kingfish, and they are often called tomcod, tommy, roncador, or ronkie by sportfishermen.

White croakers have subfusiform compressed bodies, inferior mouths with a subterminal lower jaw, falcate pectoral fins, thoracic pelvic fins, and a truncate caudal fin. They are typically silvery to brassy colored, with a small, but prominent black spot at the base of each pectoral fin and a cluster of minute barbells on the membranes underneath the lower jaw.

The white croaker is an abundant, nearshore species in California, usually found over soft, sandy-mud substrata. They range from Vancouver Island, British Columbia to Magdalena Bay, Baja California, but are not abundant north of Point Reyes, California. They usually swim in schools, and are found from the surf zone to depths as great as 780 feet and in shallow bays, sloughs, and lagoons. Most of the time, they occupy nearshore areas at depths of 10 to 100 feet, but sometimes are fairly abundant to a depth of 300 feet.

The maximum recorded length for white croaker is 16.3 inches; however, fish larger than about 12 inches rarely occur. Fish up to four pounds have been reported, but those weighing over two pounds are extremely rare. White croakers live to about 15 years and over 50 percent of both sexes are sexually mature by one year (about 5 1/2 inches for males, six inches for females). By three or four years and 7.5 inches, all white croakers are mature.

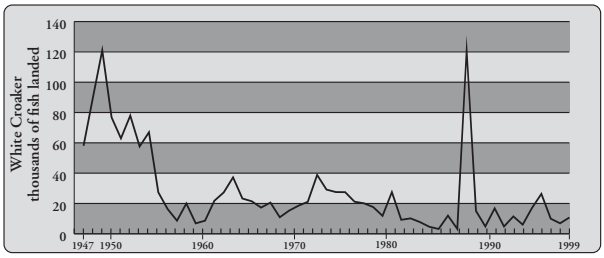
In southern California, white croakers spawn mainly from November through April, with peak months being January through March. In central California, they spawn all year and may have winter and summer spawning peaks (ovary weights were found to be highest in January and September and lowest in May). Females may spawn about once every five days and about 18 to 24 times each season, depending upon their size and age. Batches of eggs range from an estimated 800 eggs in a six-inch female to 37,200 in a 10-inch female. The fertilized eggs are pelagic and



Commercial Landings 1916-1999, White Croaker
Data Source: DFG Catch Bulletins and commercial landing receipts.

occur in depth ranges from about 25 to 120 feet. The larvae initially are pelagic and most abundant in ocean depth ranges from about 50 to 75 feet. As the larvae grow, they descend toward the bottom and migrate towards shore. Juveniles occur near the bottom where ocean depth is about 10 to 20 feet. As they mature, they migrate to somewhat deeper water.

White croaker are omnivores, their diet including a variety of worms, shrimps, crabs, squid, octopuses, clams, small fishes, and other items, living or dead. They feed primarily at night and on the bottom, although some midwater feeding occurs during the day. They are preyed upon by seals, sea lions, halibut, giant sea bass, bluefin tuna, and other fishes.



Recreational Catch 1947-1999, White Croaker
CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

White croakers that live near marine waste discharges may concentrate toxic materials such as pesticides (DDT, DDE, etc.), polychlorinated biphenyls (PCB's), metals (zinc, selenium, mercury, etc.), and petroleum products in their bodies at levels that are considered hazardous for human consumption. Some white croakers in these areas are diseased and malformed and some show reproductive impairment. Current health guidelines advise against human consumption of white croakers from southern California waters in Santa Monica Bay, off the Palos Verdes Peninsula, and the Los Angeles-Long Beach Harbor area.

Status of the Population

The size of the white croaker population is not known. Although previous catch data indicated that the overall population was healthy and sustaining itself under fishing pressure, recent declines in commercial catches imply that future monitoring may be needed.

Management Considerations

See the Management Considerations Appendix A for further information.

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California Department of Fish and Game

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White Seabass

History of the Fishery

White seabass (*Atractoscion nobilis*) have been favored by California anglers and consumers for at least a century. Coastal Indian middens have yielded many seabass ear bones (otoliths) suggesting that this fish was highly regarded for food and possibly used for ceremonial purposes.

Commercial landings of white seabass have fluctuated widely over the nearly 85 years of record keeping. Almost three million pounds were reported in 1922, 599,000 in 1937, 3.5 million in 1959, and 58,000 in 1997. Since 1959 the trend has been one of decline, although landings have been over 100,000 pounds for the years 1984 through 1991 and 1998-1999. Although there was a commercial fishery in the San Francisco area from the late 1800s to the mid-1920s, landings of fish caught north of Point Conception rarely exceeded 20 percent of the total California catch.

Today, catches of white seabass are concentrated along the coast from Point Conception to San Diego and around the Channel Islands. The frequency of fish caught north of Point Conception has increased in the past few years, although the pounds landed still represent less than 20 percent of the total California catch. Before 1982, California commercial fishermen landed thousands of pounds of white seabass taken in Mexico. Often these landings comprised more than 80 percent of the annual catch. Since then, the Mexican government has denied access permits to U.S. fishermen, and the fishery is concentrated in California.

During the early years of the fishery, commercial catches were made using gillnets, hook-and-line, and round haul nets such as lamparas and purse seines. Purse seining was curtailed in the late 1920s because decreasing catches made it uneconomical. Since all round haul nets were prohibited in the early 1940s, gillnets have been the major commercial fishing gear. Set gillnet fishing for white seabass within state waters was completely disallowed beginning in 1994. Therefore, drift gillnetting is the primary fishing method utilized today. Some commercial hook-and-line fishing takes place during the early spring, when large seabass are available.

White Seabass, *Atractoscion nobilis*
Credit: DFG

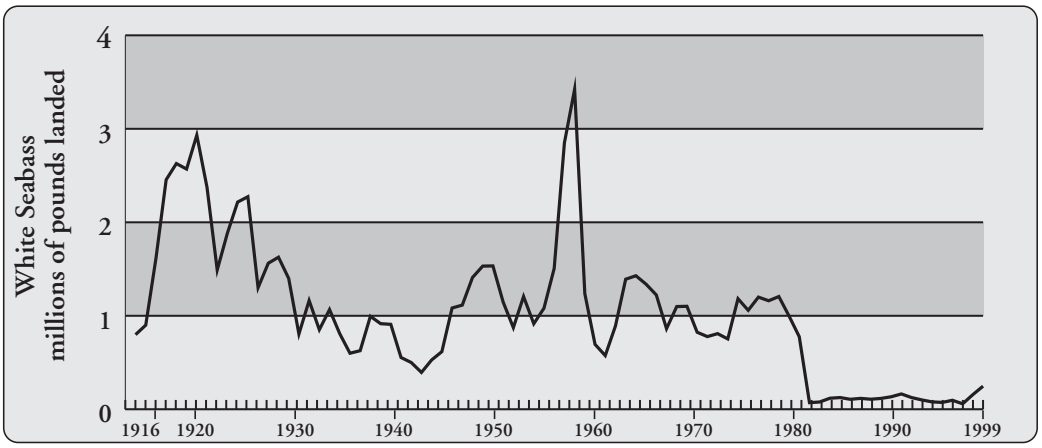
Although the legal size limit for white seabass is 28 inches (about seven pounds), the average commercially caught fish is nearly 40 inches (about 20 pounds). Because of consumer demand, seabass has always commanded relatively high prices. In 2000, commercial fishermen were typically paid $2.25 per pound for whole fish. At the retail level the fish are sold fresh, primarily as fillets and steaks.

Recreational fishing for white seabass began around the turn of the century. Because of their size and elusive nature, seabass are popular with anglers. Historical records show that anglers on commercial passenger fishing vessels (CPFVs), fishing in California waters, landed an average of 33,400 fish annually from 1947 through 1959. The catch steadily declined to an average of 10,400 fish in the 1960s, 3,400 fish in the 1970s, and 1,200 fish in the 1980s, but increased to 3,000 fish in the 1990s. In fact, the 1999 recreational catch of white seabass from California waters was greater than 11,000 fish and appears to be as high for 2000. Additional seabass are caught by anglers aboard private boats, but accurate catches by private boat anglers are difficult to estimate.

Today, sport anglers catch white seabass that are generally between seven and 25 pounds. This was not true in the past. While the 28-inch size limit also applies to recreational anglers, most of the catch prior to the 1990s (kept and released) was between 20 and 24 inches. In a survey of private boaters at launch ramp facilities from 1978 through 1982, biologists found that only six to 16 percent of the white seabass kept were of legal size. In a similar survey aboard CPFVs from 1985 through 1987, biologists reported that 16 to 25 percent of the seabass caught were legal. However, this has changed dramatically with the apparent increase in the abundance of legal-size white seabass. During the period from 1995 through 1999, data collected from private boat anglers revealed 77 percent of the fish were legal size while data from CPFV anglers showed 80 percent of the fish were legal size.

White seabass are more often caught with live bait than with dead bait or lures, but all are effective when the fish are actively feeding. Seabass can sometimes be brought to the surface by heavy chumming with live bait. Anglers fishing around Santa Catalina Island have reported consistently good catches using blacksmith and silversides as bait. However, when available, live squid and Pacific sardines are popular baits. Spearfishing for large seabass by free divers (without SCUBA) is successful in kelp beds.

Regulations covering white seabass have been in effect since 1931, and have included a minimum size limit, closed seasons, bag limits, and fishing gear restrictions. Such regulations are in effect today, with slight variations. A



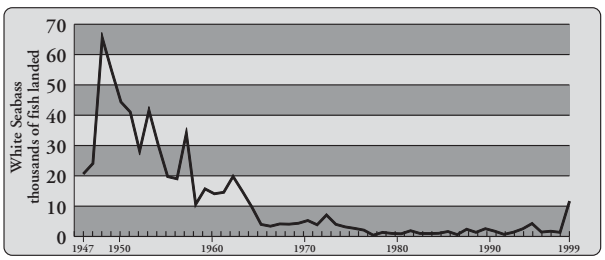
Commercial Landings 1916-1999, White Seabass
Data Source: DFG Catch Bulletins and commercial landing receipts.

fishery management plan for white seabass is presently being adopted and the need for additional regulations will be considered.

Status of Biological Knowledge

White seabass is the largest member of the croaker family (Sciaenidae) in California. Fish weighing nearly 90 pounds with lengths of five feet have been recorded, but individuals larger than 60 pounds are seldom seen. White seabass range from Magdelena Bay, Baja California, Mexico to the San Francisco area. They are also found in the northern Gulf of California. During the strong El Niño of 1957-1959, seabass were reported as far north as Juneau, Alaska and British Columbia, Canada.

The center of the white seabass population presently appears to be off central Baja California. Recent genetic research of seabass populations shows that some mixing of fish from California and Mexico does occur. However, there may be local subpopulations of fish that do not mix regularly. While the question of population continuity remains unresolved, there is evidence that each summer the fish move northward with warming ocean temperatures (as demonstrated by catches). Biologists believe the movement is probably spawning-related.



Recreational Catch 1947-1999, White Seabass
CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

Spawning occurs from April to August, with a peak in the late spring to early summer. Fecundity (egg productivity) for this species has not been determined, but a maturity study in the late 1920s reported that females begin maturing when four years old (nearly 24 inches), and some males were sexually mature at three years (20 inches). All white seabass have probably spawned at least once by age six (nearly 32 inches).

The eggs, which are the largest of any croaker on the west coast (approximately 0.05 inch in diameter), are planktonic. The larvae, which are darkly colored, have been collected from Santa Rosa Island, California to Magdelena Bay, Baja California. Most are found in the inshore areas of Sebastian Viscaino and San Juanico Bays, Baja California, indicating that major spawning occurs off central Baja California.

Young-of-the-year white seabass, ranging in length from 0.25 inch to 2.25 inches, inhabit the open coast in waters 12 to 30 feet deep. They associate with bits and pieces of drifting algae in areas of sandy ocean bottom. Some time between the ages of one and three years old, they move into protected bays where they utilize eelgrass communities for cover and forage. Older juveniles are caught off piers and jetties and around beds of giant kelp. Adult seabass occupy a wide range of habitats including kelp beds, reefs, offshore banks, and the open ocean. Adult white seabass eat Pacific mackerel, Pacific sardines, squid, pelagic red crabs, and Pacific herring.

Laboratory spawning of white seabass was first induced in 1982. Beginning in 1983, the California Department of Fish and Game initiated the Ocean Resources Enhancement and Hatchery Program (OREHP) to test the feasibility of raising seabass for population enhancement. That goal was achieved in the first 10 years of the program and the goals of the program have been expanded to test the feasibility of enhancing marine fish populations through the stocking of cultured fish. By 1999, more than 375,000 juvenile

white seabass had been released off southern California, and it is estimated that 17,500 of those may have survived to legal size or larger. Additionally, valuable life history information has been gathered during this program through ecological surveys, tagging, and genetic studies. However, more work is necessary to determine if artificial propagation is successful in enhancing the seabass population.

Status of the Population

The range of the white seabass population has contracted since the early part of this century, and few are found regularly north of Point Conception. Few data are available concerning the status of seabass in Mexico, and it is difficult to determine whether the decline in California waters indicates an overall population decline.

Population estimates have not been made. Fishery biologists have been concerned about the decline in landings since the late 1920s. Today, this concern still exists within the scientific community, commercial fishing industry, and with the angling public. Human-induced changes, such as pollution, overfishing, and habitat destruction have probably contributed to this long-term population decline. However, natural environmental changes can also influence the population. The large numbers of small seabass caught in recent years suggests that the warm water period beginning with the 1982-1983 El Niño helped to increase young fish survival. Young fish surveys conducted in southern California, as part of OREHP, showed a dramatic increase in the number of fish taken in research gillnet sets. During research work in 1997 over 600 juvenile fish were captured, in 1998 approximately 700 fish were taken, and in 1999 slightly over 1,300 juveniles were captured. Anecdotal evidence from commercial and sport fishers confirms this dramatic increase in juvenile white seabass. It is unknown whether this increase in juveniles will subsequently enhance the adult spawning population.

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California Department of Fish and Game

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Yellowfin Croaker

History of the Fishery

The yellowfin croaker (*Umbrina roncador*) is a nearshore croaker that has been reserved for the recreational fishery since 1915. It is primarily caught by anglers fishing from sandy beaches, piers, jetties, harbors and bays from Santa Barbara south to the U.S.- Mexico border. This croaker is among the most common fish caught from many of southern California's piers and sandy beaches during summer months. It is important to many anglers because they can be readily caught from shore with minimal investment in fishing gear and time. Yellowfin croaker are typically caught with light spinning gear using a variety of popular baits, including live and dead anchovies, mussels, blood worms, and ghost shrimp. About 80 percent of the catch occurs from May-October. Anglers fishing from piers and breakwaters account for 35 percent of the total catch, whereas anglers fishing from private skiffs and beaches account for 35 percent and 25 percent, respectively. The commercial passenger fishing vessel (CPFV) fleet accounts for approximately five percent of the total catch. CPFV catches fluctuated from a high of over 8,000 fish in 1947 to less than 100 fish in 1958. Catches are relatively low because the CPFV fleet rarely targets shallow (< 25 feet) sandy areas where yellowfin croaker are most abundant.

Status of Biological Knowledge

Yellowfin croaker have a series of yellow-brown stripes on their back, mostly yellow fins, and a pronounced chin barbel. Yellowfin croaker range from Point Conception to the Gulf of California, but are most abundant south of the Palos Verdes Peninsula. They occur in small schools over soft bottom habitats from shore to 125 feet, but are most commonly found in waters less than 30 feet. Yellowfin croaker are also common in harbors and bays and occasionally frequent kelp beds.

Yellowfin Croaker, *Umbrina roncador*
Credit: DFG

Although very little is known about their basic life history, it appears that spawning occurs during summer months. Young-of-the-year have been found near the entrance of embayments during late fall and offshore in 30 feet of water during winter. They have been reported to reach 18 inches in length and weigh over five pounds, however fish over two pounds are uncommon. The current California state record is three pounds and 14 ounces. Preliminary ageing estimates indicate that a 10-inch fish is about 4 years old and a 15-inch fish is about 10 years old. Yellowfin croaker are opportunistic predators that feed during day and night. Their diet consists of a broad variety of prey, however California grunion eggs, mysids, and pelecypods are the most important components. Small fish feed primarily on mysids, whereas large fish concentrate on bivalves. Yellowfin croaker eggs, larvae, and small juveniles are preyed upon by many fishes; larger individuals are preyed upon by seals, sea lions, halibut and other large fishes.

Status of the Population

No population estimates exist for yellowfin croaker, and stock structure has not been examined. The population appears healthy despite potentially damaging impacts associated with recreational fishing, contaminants from urban run-off, and shoreline habitat modifications such as development, dredging, filling, and erosion control projects. In fact, the population may be increasing; catch-per-unit-effort data from the Marine Recreational Fishery Statistics Survey have increased during each of the past five years. In addition, a fishery independent study found a much greater abundance of yellowfin croaker in the mid-1990s than a similar study conducted during the mid-1950s. Increased sea surface temperatures caused by several El Niño events during the 1990s have probably benefited yellowfin croaker, since they are a warm temperate species whose center of abundance is in warmer waters off Baja California. However, without regular monitoring of catch and effort data it is difficult to accurately assess the status of the fishery.

Management Considerations

See the Management Considerations Appendix A for further information.

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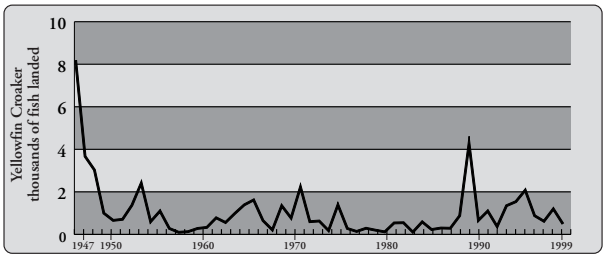

Recreational Catch 1947-1999, Yellowfin Croaker

CPFV = commercial passenger fishing vessel (party boat); Recreational catch as reported by CPFV logbooks, logbooks not reported prior to 1947.

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Yellowtail

History of the Fishery

Sport and commercial fisheries for yellowtail (*Seriola lalandi*) have existed off California since the late 1800s. Commercial or subsistence fishing is the older of the two, with modern hook-and-line sport fishing getting its start in 1898 at Santa Catalina Island. Prior to 1898, sportsmen used handlines, a practice which faded with the advent of hickory rods, functional reels, and linen line. Both the sport and commercial fisheries in California are confined to the area south of Point Conception. The fishery usually occurs in nearshore areas, often adjacent to kelp beds. During the summer, fish may be found offshore under floating mats of kelp.

Commercial landings of yellowtail have fluctuated greatly in the past, ranging from a high of 11.5 million pounds in 1918 to a low of 9,769 pounds in 1995. Market conditions appear to dictate landings more than does the health of the resource. When market demand for fresh yellowtail was high or the canneries needed fish because tuna were unavailable, the price to the fisherman was great enough to encourage trips for the fish.

The commercial fishery for yellowtail was restricted to small live bait boats working off southern California or the Coronado Islands, Baja California, Mexico, until 1933. At that time, purse seiners began fishing in Mexican waters, as the supply of yellowtail off California had decreased and it was illegal to seine them north of the international border. Gillnet boats also started landing yellowtail taken incidentally to white seabass landed commercially in California. However, nearshore gillnet fishing was banned beginning in 1994. This greatly reduced the amount of fish landed by commercial fishers since only hook-and-line gear and gillnets fished outside three miles are legal methods of take.

Data from commercial passenger fishing vessel (CPFV) logs provide a general indication of the magnitude of the sport fishery for yellowtail in southern California. During years when the water was warm, CPFVs have landed over 450,000 fish. When the water was cold, yellowtail catches were sometimes less than 10,000 fish. Prior to the early 1950s, CPFVs were responsible for most of the sport catch. However, in the 1950s private boaters began taking a significant number of fish. During some years, private boaters land more yellowtail than do CPFV anglers. For instance, during 1997, private boat anglers fishing off California, landed 472,000 fish compared to 163,000 recorded by CPFV anglers. The increase in the number of private boat anglers may impact the yellowtail resource more than continued effort by CPFV anglers or commercial fishermen.

Yellowtail, *Seriola lalandi*
Credit: DFG

Major fishing areas for CPFV and private boat anglers include the Channel Islands, Santa Monica Bay, Dana Point to Oceanside, La Jolla, San Clemente Island, Santa Catalina Island, and the Coronado Islands. Long-range CPFVs fish primarily from Cedros Island south. They often concentrate on the offshore banks, especially in the Magdalena Bay area. The commercial fishery is conducted in the same areas as the sport fishery.

Status of Biological Knowledge

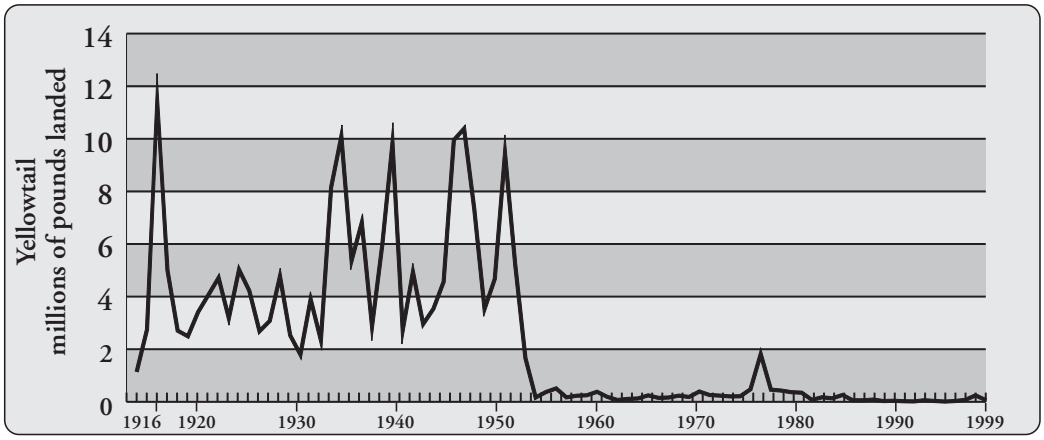
Yellowtail are found from British Columbia, Canada to Mazatlan, Mexico. They are present in the Gulf of California, occurring as far north as the Bay of Los Angeles.

Most yellowtail spawn during the summer months, June through September. During this period, adults move offshore and form spawning aggregations. Some two-year-old females may spawn, but all females over three years of age are capable of spawning. Young fish spawn only once during the season, while those seven years of age (20 pounds) and older are capable of multiple spawnings. A 20-pound fish is capable of producing 940,000 eggs during a single season.

Yellowtail are opportunistic daytime feeders. Off southern California, yellowtail stomachs contain sardines, anchovies, jack mackerel, Pacific mackerel, and squid. Fish taken off Mexico frequently are full of pelagic red crabs.

Age and growth studies conducted on yellowtail indicate the fish are relatively slow growing. They gain approximately three to four pounds a year during most of their lives, although very large individuals may gain only one to two pounds per year. Growth can vary considerably from year to year and also between and within geographical areas. The largest recorded individual weighed 80 pounds. The average sizes at selected ages are: age one, 20 inches and 3.8 pounds; age two, 25 inches and 7.4 pounds; age three, 28 inches and 9.9 pounds; age four, 31 inches and 13.2 pounds; age five, 33 inches and 15.9 pounds; age 10, 44 inches and 35 pounds.

Within southern California and at the Coronado Islands, sport anglers generally land yellowtail that weigh four to 12 pounds. Long-range CPFV anglers fishing off central Baja California usually catch 12 to 18 pound fish. Com-

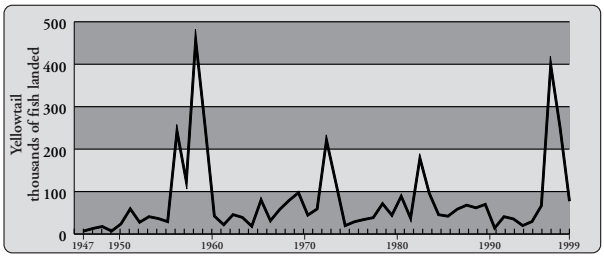


Commercial Landings 1916-1999, Yellowtail
Data Source: DFG Catch Bulletins and commercial landing receipts. Yellowtail landings include fish caught in waters south of the state but landed in California.

mercial gillnet fishermen generally land 10 to 20 pound yellowtail because of the selective nature of the nets. Commercial hook-and-line fishermen usually land four to 12 pound fish, although none can be less than 28 inches long, measured in fork length.

Results of a tagging study conducted by the California Department of Fish and Game indicate there are two stocks of yellowtail off Baja and southern California. One group occurs south of Cedros Island, Baja California, while the second group occupies the area from Cedros Island northward. There is some interchange of fish between the two groups around Cedros Island. Because of limited mixing between the two stocks, the southern California fishery is wholly dependent on fish recruited from the northern population.

The number of yellowtail available to southern California fishermen in any given year is dependent on whether warm water conditions exist off northern Baja California. Excellent yellowtail catches have occurred during years when water temperatures were at least three to five degrees F above normal in the spring. Conversely, periods of cool water produce low catches. When fish are available, they usually are found nearshore in the spring and fall but offshore during the summer months.



Recreational Catch 1947-1999, Yellowtail
Data Source: DFG, Commercial Passenger Fishing Vessel logbooks.

Status of Population

While no population estimate is available for the northern stock of yellowtail, the resource appears to be healthy. The stock is probably not as large as it was in the early 1950s, but it can support significant sport and commercial fisheries when oceanic conditions are favorable.

Data collected during the 1970s and early 1980s indicate that the northern population has undergone a shift in fish size. Two and three year olds now dominate the catch, whereas six to nine year olds made up the majority of the catch in the past. The shift in size could be an indicator of either population stress or good recruitment.

Because more of the northern stock is available to sport anglers during warm water conditions, CPFV catches during El Niño events provide an indication of the health of the resource. The El Niño event of 1997, which proved to be the strongest of many events beginning with 1983, pushed many young yellowtail north into southern California. The 1996 year class dominated the sport fishery during the summer of 1997 as one-year-old fish. The 1996 year class remained off southern California during the winter of 1998 and again dominated the fishery as two-year-olds. During 1998, the commercial fishery harvested almost a quarter million pounds of yellowtail since most of the 1996 year class fish reached legal size midway through the summer. This commercial catch represented a four-fold increase from 1997. With the cooling of ocean waters off southern California in 1999 and 2000, sport and commercial yellowtail catches dropped. However, the 1996 year class continued to dominate the sport fishery during both years. Based on data from the MRFSS, the 1996 year class was the strongest in recent history. Over 1.0 million yellowtail from the 1996 year class were landed by CPFV and private boat anglers between 1997 and 2000.

The department initiated a minimum size limit on sport caught yellowtail during 1998 in an effort to reduce the catch of one-year-old fish. The 10 fish limit was retained, but a 28-inch FL size limit was adopted with sport anglers allowed to retain five fish less than 28 inches FL.

Management Considerations

See the Management Considerations Appendix A for further information.

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Pinnipeds

History

There are six pinniped species inhabiting the California coast and offshore islands: the California sea lion (*Zalophus californianus californianus*), Steller (or northern) sea lion (*Eumetopias jubatus*), Pacific harbor seal (*Phoca vitulina richardsi*), northern elephant seal (*Mirounga angustirostris*), northern fur seal (*Callorhinus ursinus*) and Guadalupe fur seal (*Arctocephalus townsendi*). The ribbon seal (*Phoca fasciata*) and the hooded seal (*Cystophora cristata*) have been reported in California waters, but these were extremely rare events and they are not considered normal California visitors.

The California sea lion and Pacific harbor seal are probably the best known and most often seen pinnipeds in California waters. Californians and visitors from around the world enjoy watching the playful behavior of these animals cavorting in the water near shore or hauled out to rest on buoys, rocks, and other solid objects. They also enjoy seeing them in public display aquaria or as performers in animal shows at zoos and parks. Pinnipeds are amusing and intelligent entertainers, but there is another aspect of the pinniped story which is related to their diet of fish and their expanding populations.

In recent years, California sea lions and, to a lesser degree, Pacific harbor seals have gained notoriety by taking over portions of marinas, bathing beaches and by eating endangered or threatened salmon and steelhead moving upstream to spawn. Marina operators and boat owners consider them a major nuisance, and potentially dangerous. Some seals react aggressively when people approach. Some who fish commercially or for sport believe that pinnipeds compete for fish and are costly pests consuming tons of valuable fish, destroying valuable fishing gear and interfering with fishing operations. They complain that any sea lion is attracted to fishing operations and that the mere presence of a sea lion scares fish away from the fishing area. Research biologists speculate that most of those problems are caused by a relatively few "rogue" pinnipeds. The rogues have learned that a fish caught in a net or hooked on a line is an easier meal than a free-swimming fish, and some actually target these fisheries on a regular basis. A major concern is that this behavior will spread as the pinniped populations grow.

Resolving pinniped conflicts with human activities is a controversial issue. Faced with decreasing catches, increasing marine mammal populations, and increasing fishery interactions, some sport and commercial fishermen contend that some pinniped populations have reached the point where population control and management efforts should be implemented. This would include the lethal removal of nuisance animals. Others will argue for protection of pinnipeds in spite of the damage and economic losses they cause.

It is unclear whether foraging by pinnipeds is impacting the abundance of marine species harvested by man. Current research data are insufficient to answer this question. Ecological interactions between pinnipeds and fishery resources are complex and poorly understood. Food habits studies on California sea lions and Pacific harbor seals indicate a broad range of prey species are consumed. The opportunistic feeding nature of pinnipeds means food habits can change dramatically between areas and years in response to changes in the abundance of different prey species. Research in this area is difficult because of the great complexities of interactions. Though we do know their diets often include fish such as anchovies, mackerel, herring, hake, rockfish, salmon, and cephalopods, such as squid and octopus.

In the 1860s and 1870s, many pinnipeds were killed for their oil or body parts and many females were captured for displays or animal acts. Pinnipeds were hunted commercially until 1938, when California law gave them complete protection from hunting. Nevertheless, sport and commercial fishermen were free to kill sea lions and harbor seals that were destroying gear or otherwise interfering with fishing operations. In 1972, the Marine Mammal Protection Act was passed by Congress prohibiting the take (pursuit, harassment, capture, or kill) of marine mammals except under special permitted conditions. The act was renewed and revised in 1994. From its inception, the act specified that marine mammals should be protected as functioning elements of the ecosystem. The 1994 amendments to the act established a new system to reduce the injuries and mortality of marine mammals involved incidentally in commercial fishing operations to insignificant levels approaching zero.

Research has been conducted in the past on methods of reducing the impacts that pinnipeds have on certain fisheries (*e.g.*, various taste aversion substances and acoustic harassment devices), but with little success. In most cases, the animals appeared to acclimate to the deterrents, and sometimes used the purported scare devices as "dinner bells" signifying active fishing boats and an easy food source. Long-term solutions remain illusive.

Status of Biological Knowledge

California Sea Lion

The California sea lion ranges from British Columbia south to Tres Marias Islands off Mexico. Breeding grounds are mainly on offshore islands from the Channel Islands south into Mexico. Breeding takes place in June and early July

California Sea Lion, *Zalophus californianus*
Credit: Phil Schuyler

within a few days after the females give birth. The pups are weaned at six months to a year or more. Males and females reach sexual maturity between four and five years, although males normally do not achieve territorial status until age eight or nine. Males weigh between 500 and 1,000 pounds and reach seven to eight feet in length. Females weigh between 200 and 600 pounds and reach six feet. Adult males have a pronounced sagittal crest (a ridge on top of the skull extending from the forehead to the rear of the skull), a characteristic distinguishing this species from the Steller sea lion. Food of the California sea lion consists largely of squid, octopus, and a variety of fishes (anchovies, mackerel, herring, rockfish, hake, and salmon).

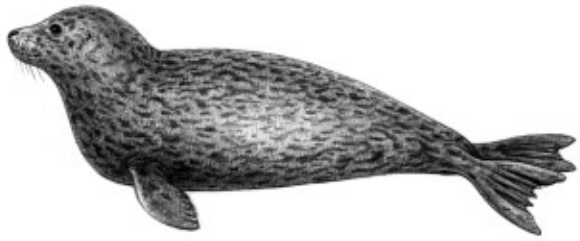
Steller Sea Lion

The Steller sea lion's distribution partially overlaps that of the California sea lion. It ranges from the Bering Strait off Alaska to southern California. Breeding grounds extend from the Pribilof Islands to Año Nuevo Island. The largest breeding colonies in California are at Point St. George, Año Nuevo, and the Farallon Islands. Breeding is in late June, after which the animals migrate northward. This species is a tawny or yellowish-brown color in contrast to the darker reddish color of the California sea lion. Grown males are 1,500 to 2,200 pounds and reach a length of 13 feet. Females usually weigh between 600 and 900 pounds and reach a length of nine feet. Food of the Steller sea lion consists primarily of squid and fish.

Steller Sea Lion, *Eumetopias jubatus*
Credit: Phil Schuyler

Pacific Harbor Seal

The Pacific harbor seal ranges along the northwest coast of America from the Gulf of Alaska to Cedros Island off Baja California. In California, harbor seals are abundant along the entire coast. Adult male Pacific harbor seals reach a length of six feet and weight of up to 240 pounds,



Pacific Harbor Seal, *Phoca vitulina richardsi*
Credit: Phil Schuyler

while females reach 5.5 feet and 275 pounds (when pregnant). The coloration patterns of adults vary from black with white spots to white with black spots. Breeding season varies with latitude, starting in March to May on the Channel Islands of southern California and continuing later up the coast. Age at sexual maturity is three to four years for females and five years for males. Newborn pups are approximately 32 inches long and weigh about 22 pounds. They are weaned at five to six weeks at an average weight of 50 pounds. Adult females ovulate and mate at the end of weaning, with a two-month delayed implantation of the developing embryo. Their diet consists of fish such as flounders, herring, tomcod, hake, and lampreys, and cephalopods such as squid and octopus.

Northern Fur Seal

The northern fur seal is one of the best-known seals in the world because of its valuable fur, for which it was hunted to near extinction. Historical populations, centered on the Pribilof Islands, Alaska, are estimated at two million animals, but in 1911, when international treaties were established to protect and manage this species, there were fewer than 125,000 animals. San Miguel Island, off Santa Barbara, California, hosts a small breeding colony and is the southernmost extent of its range. It is a remnant of a much larger population that existed in California in the early 1800s. The peak breeding and pupping period is in July. After breeding, the males migrate out to sea where they spend as many as 10 months. The pups are weaned at four months of age and are left to travel in the northward migrations on their own. Fur seals are distinguished from sea lions by their pelage, composed of a very dense undercoat and a thinner, coarser layer

Northern Fur Seal, *Callorhinus ursinus*
Credit: Phil Schuyler

of guard hairs, and by their relatively long flippers. The northern fur seal is closely related to the Guadalupe fur seal and is distinguished from its close relative by its very short muzzle. Males reach a length of eight feet and weigh up to 700 pounds. Females are only four to five feet long and weigh about 130 pounds. Sexual maturity is attained between three and seven years, with longevity reported to be up to 26 years.

Guadalupe Fur Seal

The Guadalupe fur seal was presumed extinct until 1926, when a group of 60 animals was discovered on Guadalupe Island, Mexico. The population is recovering slowly from near extinction brought about by sealers in the last century. This is a rare pinniped in California waters, seen

Guadalupe Fur Seal, *Arctocephalus townsendi*
Credit: Phil Schuyler

only occasionally at islands in the Southern California Bight and the Farallon Islands. They breed only on Guadalupe Island. They are identified by a "collie-like," long pointed muzzle. Males reach up to six feet in length; females are slightly smaller.

Northern Elephant Seal

The comeback of the northern elephant seal, the largest of all the seals, is one of the great success stories for an animal threatened with extinction. Male elephant seals reach a length of 15 to 16 feet and weight of about 4,000 to 5,000 pounds. Females reach a length of 11 feet and weigh about 1,700 pounds. The male develops a bulbous enlargement of the snout from which, along with its size, it gets its common name. Breeding colonies exist on San Miguel Island, Santa Barbara Island, San Nicolas Island, San Simeon Island, Año Nuevo Island, Southeast Farallon Island, and Point Reyes Peninsula. They have also begun hauling out at several other mainland sites where historically they did not haul out. The breeding season is from December through March. Breeding groups, or "harems," consist of one male and eight to 40 females. The gestation

Northern Elephant Seal, *Mirounga angurstirostris*
Credit: Phil Schuyler

period is about 11.5 months. Pups are weaned by four weeks but remain on the rookery another eight to 10 weeks, sleeping during the day and gradually starting to enter the water at night. Departure from the rookery occurs at an age of approximately three months. Females begin breeding as young as two years of age. Males reach sexual maturity at five years; but older, larger males prevent young and socially immature males from mating until they are at least eight or nine years old. Males and females both live about 14 years.

Elephant seals do most of their feeding at night and probably in deep water as evidenced by the fact that they have been caught in nets at 2,000-foot depths. Time-depth recorder experiments show that elephant seals can dive to 5,200 feet, and stay beneath the surface for up to an hour. Stomach content analyses indicate that they feed on small sharks, rays, ratfish, rockfish, and squid.

Status of the Populations

The Marine Mammal Protection Act recognizes marine mammals as components of the marine ecosystem and requires maintenance of stocks above levels at which they would lose their function in the ecosystem. In practice, marine mammal management is directed toward maintaining the optimum sustainable population size (OSP) for each species within its geographical range. To be optimal, the population size should be between the rate at which maximum growth occurs and the carrying capacity of the environment. A variety of procedures are used to assess population status.

California Sea Lion

California sea lions breeding on U.S. rookeries are assumed to comprise a single stock. The population of newborn pups is determined from an aerial census. The size of the entire population is estimated from the number of new births and the proportion of pups in the population. Their status was last assessed in 2000. At that time, the population size was estimated at 204,000 to 214,000 animals. Recent estimates place the population growth rate at 6.2 percent per year. Fishery mortality is increasing.

Steller Sea Lion

Population estimates for northern sea lions are based on counts of animals hauled-out during the breeding season. A decline of this species is occurring throughout its range, including the Gulf of Alaska and Aleutian Islands, which support 75 percent of the world's population. The current West Coast population of northern sea lions is estimated at 39,031 animals, which is less than half of the population level from 1956 to 1960. The dramatic decline in numbers of Steller sea lions throughout most of its range has prompted its listing as endangered under the Endangered Species Act and depleted under the Marine Mammal Protection Act.

Pacific Harbor Seal

From aerial census data, the harbor seal population along the California coast appears to be increasing, and concurrently, the number of occupied sites has increased. From the last aerial survey (1995), the population was estimated at 30,293 animals after using correction factors. The population appears to be growing and fishery mortality is declining.

Northern Fur Seal

The eastern North Pacific population of fur seals is estimated at over one million animals. The population at San Miguel Island was estimated in 1999 at 4,336 animals after correction factors. The San Miguel Island population has increased steadily since the 1970s. An annual increase of eight percent occurred from 1965 through 1996. However, the eastern North Pacific stock of fur seals is formally listed as depleted under the Marine Mammal Protection Act.

Guadalupe Fur Seal

The historical distribution and abundance of the Guadalupe fur seal are unknown because commercial sealers and other observers failed to distinguish between it and the northern fur seal in their records. This species, once thought to be extinct, has an estimated population of 7,408 animals. The population is growing at approximately 13.7 percent per year. Although the primary breeding colony is on Guadalupe Island, recent sightings of adult and juvenile seals on some of the Channel Islands suggest that recolonization of that area may occur in the future. The Guadalupe fur seal is listed as threatened under the Endangered Species Act and depleted under the Marine Mammal Protection Act.

Northern Elephant Seal

The exploitation and subsequent recovery of the northern elephant seal population is a remarkable story. Biologists estimate that only 100 to 500 animals were left on Guadalupe Island before protective legislation was passed. They claim that the entire current population may have originated from this small group of animals. Based on pup counts, the California breeding stock was estimated at 84,000 animals in 1996. The apparent growth rate since 1980 has been about eight percent annually. Annual surveys indicate that this species has reoccupied most or

all of its historical rookeries and hauling grounds. The population is continuing to grow and fishery mortality is relatively constant.

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