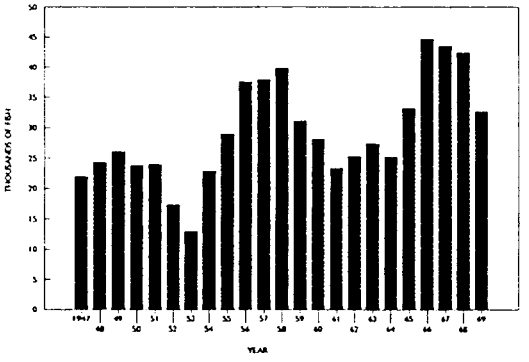
LINGCOD

History of the Fishery

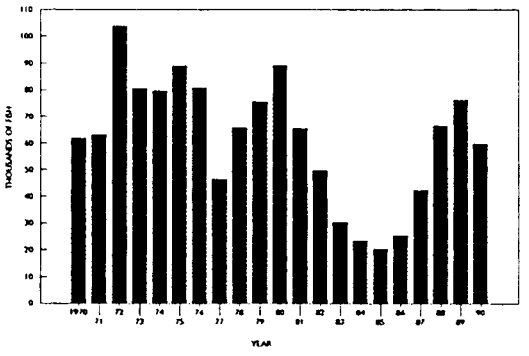
The lingcod (*Ophiodon elongatus*) is one of the largest northern California sport fishes. It is an aggressive predator that readily takes either a baited hook or an artificial lure, and it is a prized food fish. Although the raw flesh sometimes has a blue or green color, the flesh when cooked is white and of a mild flavor. From 1981 to 1986, lingcod provided more pounds of fish to

central and northern California recreational fishermen than any other species, including salmon. Only the rockfish group provides more pounds of fish to northern California recreational fishermen.

Annual landings averaged 51,250 lingcod from 1957 to 1961. At an average weight of eight pounds each, the annual yield was 410,000 pounds. The recreational fishery produced 20 to 25 percent by weight of all lingcod landed in those years. Twenty years later recreational fishermen were landing five times as many lingcod, but they were 20 percent smaller. From 1980 through 1986, annual landings averaged 254,000 fish per year. These fish averaged 6.2 pounds each yielding 1,575,000 pounds per year. The recreational fishermen's share has increased from a quarter to half of all lingcod landings.



California commercial passenger fishing vessel landings of lingcod, 1947-1969.

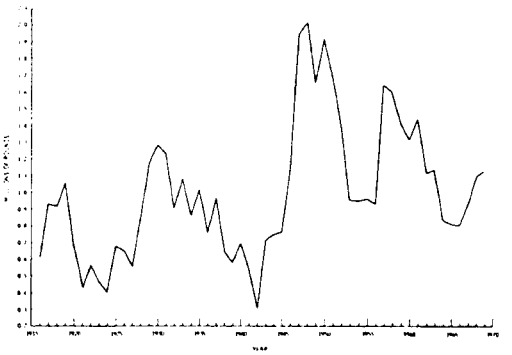


California commercial passenger-carrying fishing vessel landings of lingcod, 1970-1990.

Lingcod are most abundant north of Santa Barbara county, with eighty to ninety percent of the recreational landings being made north of San Luis Obispo County. Divers and recreational anglers both take lingcod. Divers use spears, and anglers use several styles of hook-and-line gear from a variety of fishing platforms. They may use either live or dead bait or artificial lures. Anchovies, squid, sanddabs, small rockfishes, kelp greenlings, and white croakers are used as live bait, while squid is the most common dead bait. Chrome plated jigs are the most popular artificial lures.

Recreational anglers catch lingcod while fishing from commercial passenger fishing vessels (CPFVs), privately owned boats (skiffs), piers, and the shore. In the late 1950's, 61 percent of the lingcod caught by recreational anglers were taken aboard CPFVs. However, the CPFV share of the landings declined to 33 percent in the early 1980's. Skiffs picked up the difference, increasing their share of lingcod landings from 32 to 58 percent. Shore and pier anglers and divers take a relatively small portion of lingcod landings; there appears to have been little change in their share.

Several steps have been taken to halt the decline in size of lingcod available to anglers. A 22-inch size limit was established in 1981, and the bag limit was reduced from ten to five fish one year later. These measures have slowed the decline but have not stopped it entirely.



California commercial landings of lingcod, 1916-1969.

California commercial landings of lingcod, 1970-1991.

The lingcod is also a valuable species in the fresh-fish market trade and is caught primarily north of Santa Barbara. It is frequently sold whole when landed in small quantities. A large lingcod makes an impressive addition to a display of fresh fish on a bed of ice. Hook-and-line caught lingcod are preferred for these displays, and fishermen receive a premium price for such fish because the fish's skin is not marred when they are

caught. Large catches of lingcod are usually filleted. Boneless portions can be cut from large fillets, and the flesh is slow to develop strong odors. These qualities contribute to the lingcod's commercial value. Commercial fishermen received $1,020,000 for the lingcod they sold in 1989.

Recorded commercial landings in California have ranged from a low of 400,000 pounds in 1924 to a high of 3.8 million pounds in 1974. Larger quantities are taken off Oregon, Washington, British Columbia, and Alaska. Most of the landings preceding World War II were caught by hook-and-line fishermen. Before 1946, commercial landings fluctuated between 1,288,000 pounds in 1930 and 314,000 pounds in 1942, averaging 758,000 pounds per year.

With the introduction of the balloon trawl during World War II, trawl gear became the most important source of lingcod landings. Landings increased to 2,056,000 pounds in 1948, and then declined to 800,000 pounds in 1966. Landings began to recover in the late 1960's, and climbed sharply in the early 1970's reaching a new high of 3,824,000 pounds in 1974. This increase in landings during the 1970's had at least two causes. Lingcod experienced exceptional reproductive success during the late 1960's, and gill nets became an important means of catching rockfish and lingcod at Monterey. Since 1970, a large portion of the commercial lingcod catches south of San Francisco have been taken in gill nets.

During the 1980's, two-thirds of the commercial lingcod landings were taken by trawlers. Eighteen percent were taken with unknown gear and at least 13 percent were taken with gill nets. On average only 2.7 percent of the lingcod sold in the 1980's were caught on hook and line. However, as salmon populations declined and gillnetting was restricted, many fishermen converted to fishing for rockfish and lingcod with hook and line. Hook-and-line landings of lingcod increased seven fold from 1985 to 1989, producing 30 percent of the commercial lingcod landings in 1989.

Trawling is generally prohibited within three miles of shore. Most of the adult males and many of the adult females and juveniles feed in these nearshore areas. Gillnetting for rockfish has recently been prohibited in state waters, further protecting both juvenile and adult lingcod.

Lingcod, *Ophiodon elongatus*.

Status of Biological Knowledge

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 Alaska Peninsula. Their center of abundance is off British Columbia, and they become less common toward the southern end of their range. Lingcod 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.

Adult lingcod are strongly residential, tending to remain near the reefs or rocky area where they live. Large-scale tagging studies in Canadian waters have found that the vast majority of mature lingcod are recaptured within six miles of where they were tagged. Individual fish do make long movements, however, and one fish that was tagged at Cordell Bank was recaptured nine months later at Coquille Bank, Oregon, over 430 miles away. Juveniles tend to disperse and travel over a wider range than adults.

Lingcod growth follows a typical pattern of rapid increases in length during the first years of life, followed by progressively smaller increases. Although there is large variation in length at age, the average one-year-old fish is 13 inches, and a two-year-old is 17 inches. After age two, females begin to grow faster than males. The average four-year-old female is 24 inches, an eight-year-old is 32 inches, and a 12-year-old is 35 inches. The average four-year-old male is 22 inches, an eight-year-old is 29 inches, and a 12-year-old is 32 inches. In California, the oldest lingcod on record is a 14-year-old, 37-inch female, while the longest is 43 inches. The maximum age recorded anywhere is 20 years, and a 59-inch British Columbia lingcod weighed 70 pounds.

Both sexes mature over a wide size range. In California, some females mature at 20 inches, half are mature at 23 inches, and all are mature by 28 inches. Some males mature at 14 inches, half are mature at 16 inches, and all are mature by 22 inches. Size at maturity is larger for lingcod in more northerly latitudes because these fish grow faster.

Lingcod have a unique form of reproduction which includes spawning migrations into nearshore habitats, reproductive territoriality by males, spawning of an egg mass to form the nest, and the presence of a guardian male at the nest until the eggs hatch. In California waters, spawning begins by November and continues until March, with a peak in December and January. Males move into the spawning grounds first to establish territories, and it appears that larger males select the most suitable nesting sites. Preferred nest sites are rocky areas in shallow water (low tide line to 100 feet) where there are strong currents. A relatively strong current is necessary to oxygenate the egg mass and prevent death of the embryos. Often, egg masses are located on rocky ledges with an opening directly behind the eggs to allow water to pass over the nest. Laboratory studies show that a current with a velocity of four to six inches per second is necessary to provide adequate oxygen levels throughout the egg mass.

Lingcod probably spawn at night. After a female chooses a male and a nesting 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 24-inch female can produce 50,000 eggs, a 32-inch female 124,000 eggs, and a 36-inch female 170,000 eggs. Egg masses of three to 68 quarts have been reported.

After spawning, males remain to guard the nests from predation until hatching is complete. Males position them-

selves within three feet of the nest and drive away potential predators. On occasion, males have been found guarding two nests if they were close together. If the male is removed, a new male will sometimes assume the guardian role. Males have very aggressive behavior during nest guarding and, therefore, are particularly vulnerable to fishing at this time. An unguarded egg mass is invariably eaten by predators. The eggs generally hatch about seven weeks after they are laid, but incubation can last from five to 11 weeks. Eggs on the outside of the egg mass hatch first. Hatching may continue for 24 to 48 hours, after which the guardian male leaves.

Newly hatched larvae (0.25-0.5 inch) occur in January and February in Humboldt Bay and San Francisco Bay. In Canadian waters, the first appearance of these larvae is in early March. From March until June, lingcod grow about 0.04 inch per day, transforming into pelagic juveniles. Juvenile lingcod may be caught off central California from April (at two inches in length) to June (at three inches) in pelagic trawls in the upper 100 feet of the surface waters. After June, these juveniles disappear from surface waters and migrate to bottom habitats, frequently around kelp and eelgrass beds. Lingcod appear in typically adult habitats at about 12 inches.

Larval lingcod feed primarily on various life stages of copepods. 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. When the stomachs of nest-guarding males are examined, they are invariably found to be empty.

Most predation on lingcod occurs during the egg stage, and predation becomes less common with age. The presence of a nest- guarding male prevents fish predators, often other greenlings and surfperches, from consuming the entire egg mass; when the guardian male is removed, the entire egg mass is lost. Invertebrate predators such as predatory snails commonly feed on egg masses and are not repulsed by guardian males. On rare occasions, pelagic juvenile lingcod (1.5 to 2.6 inches) are found in the stomachs of chinook salmon from the Gulf of the Farallones. It can be assumed that other predators of juvenile fish, such as seabirds, particularly the common murre, and marine mammals, prey on juvenile lingcod at a similar rate. Small benthic lingcod are not usual prey of nearshore predators. Because of their large size, large juvenile and adult lingcod escape all but the occasional predator.

Status of Population

Fishing success is currently our only long-term indicator of changes in the abundance of lingcod. Commercial and recreational landings exhibit regular fluctuations with a periodicity of about ten years; commercial landings having peaked seven times in the past 73 years.

Recreational fishing success has exhibited regular fluctuations over the past 40 years, with each peak falling within two years of a peak in commercial landings. Peak landings of lingcod have been preceded by reports of sightings of small lingcod. SCUBA divers occasionally see large numbers of small lingcod less than one year old. Sightings were reported three to five years before each of the last three peaks. The years of exceptional lingcod abundance are probably the result of especially good survival of lingcod larvae. Although divers saw some small lingcod in 1988 and 1990, they were much less abundant than the 1984 cohort that produced the peak sport and commercial landings of 1989.

The population is still strong and is still providing landings of a size similar to those made early in this century. There is no long term trend in commercial landings. There has, however, been a five-fold increase in recreational landings in the past two decades and a 20 percent decline in the average weight of recreationally-caught lingcod. The decline in average weight is accompanied by a considerable reduction in longevity of lingcod. This trend must be stopped to ensure the existence of a spawning biomass large enough to produce an abundance of larvae when oceanic conditions are conducive to their survival.

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