Pacific Angel Shark

History of the Fishery

Discarded as a nuisance species by halibut gillnet fishermen for several decades, the Pacific angel shark (*Squatina californica*) became one of the most sought after commercial shark species in the Santa Barbara Channel during the 1980s. Changes in consumer acceptance of sharks as high quality food fish and a concentrated marketing effort by an innovative processor working with local fishermen, stimulated development of the angel shark fishery in the Santa Barbara Channel area in 1976. Two key elements led to the rapid growth of this fishery: maintenance of quality and freshness of the shark by cleaning and dressing (removal of head and fins) at sea; and development of a method to fillet this irregularly shaped shark to satisfy retail distributors and consumers. Market development was linked to the popular but seasonal thresher shark, which is caught by the drift gillnet fleet in the summer and fall. As supplies of thresher shark diminished in the winter, angel shark was promoted as a viable substitute. Local demand grew rapidly as Santa Barbara and Ventura seafood retailers and restaurant owners found ready acceptance among consumers. Nearly every part of this shark, with the exception of skin, cartilage, and offal is utilized. The head and fins are sold as crab bait, large fillets are cut from the trunk, and portion-controlled pieces from the tail are used in fish and chips dishes. Small irregular-shaped pieces are used to make shark jerky. A yield of 50 percent of the dressed shark is generally expected.

The development of markets for angel shark was a significant benefit to halibut fishermen, providing them with a supplemental source of income. As demand increased for angel shark in the early 1980s, innovative fishermen developed nets to harvest them specifically. Because of their selectivity for market-sized angel shark, these nets caught only a few large California halibut. Nonetheless, 8.5-inch mesh monofilament gillnets designed for halibut continued to be used to take both species. After area closures were instituted in 1994, the directed gillnet fishery for these sharks ended and the smaller mesh halibut set gillnets again became the standard. Vessels used in the fishery are generally in the 25 to 40 foot range, suited for inshore coastal operations. Trawl vessels often caught a few angel sharks incidentally, but landings were insignificant compared to the set gillnet harvest. Trawl landings represented one percent of the total catch in 1990, rising to 17 percent in 1994.

Pacific Angel Shark, *Squatina californica*
Credit: DFG

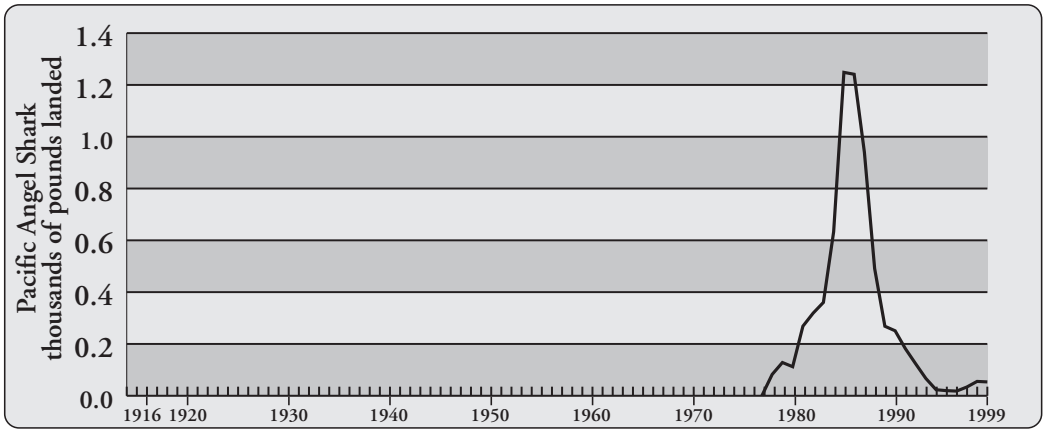
There has been little recreational interest in angel shark as nearshore anglers using hook-and-line catch relatively few compared to other more active sharks. One study logged only 12 angel sharks compared to over a thousand other sharks landed between 1997 and 2000. Nearly all of the angel sharks were caught at night.

In 1977, landings of dressed angel shark totaled 328 pounds. By 1981, landings rose to 258 thousand pounds, and by 1984, to 610 thousand pounds. Landings of angel shark exceeded one million pounds annually in 1985 and 1986, replacing the thresher shark as the number one species of shark taken for food in California.

Fishing effort throughout the early development and expansion phase was concentrated off Santa Barbara and Ventura counties and around the northern Channel Islands, especially Santa Cruz and Santa Rosa Islands. Landings began to decline in 1987, dropping to 940 thousand pounds with an ex-vessel value of $542,000 and further declining to 248 thousand pounds ($166,000) in 1990. A minimum size limit adopted by the DFG in 1986 contributed to a decrease in landings in the following years.

A second major decline in landings occurred in 1991 when a voter initiative was passed banning the use of gill and trammel nets within three miles of the southern California mainland coast and within one mile around the Channel Islands. Many gill-netters switched to other fisheries and a few dropped out entirely or retired. In 1990, a total of 144 vessels (including a few trawlers) landed angel shark and by 1994, the number was reduced 50 percent to 72. These boats landed 23 thousand pounds, a decline of 91 percent from the catch in 1990. Of the 72 vessels reporting landings, nine boats landed the major share (61 percent). The closures, in effect, established a large "no-take" reserve for angel shark in southern California, since gillnetting, considered to be the most viable fishing method for this species, was eliminated in the primary nearshore angel shark habitat.

Another factor affecting the fishery and contributing to the decline in landings was the sale of the primary angel shark processing plant in 1991 and its subsequent closure in 1992. This led California seafood wholesalers and retailers to search for alternative sources of angel shark, as the



Commercial Landings 1916-1999, Pacific Angel Shark
Data Source: DFG Catch Bulletins and commercial landings receipts. No commercial landing are reported for Pacific angel shark prior to 1977.

demand in California remained high, especially for use as fish and chips in seafood restaurants.

Prior to the 1994 fishing area closures, a gillnet fishery for angel sharks began in the upper reaches of the Gulf of California and a processing plant was established in Puerto Peñasco, Mexico. By 1993, imports of angel shark fillets were being used to meet the market demand in California. One buyer estimated imported fillets increased from 65 thousand pounds in 1994, to approximately 90 thousand pounds in 1999. Since 1997, a share of these sharks has been caught off Ensenada and Cedros Island near Guerrero Negro. The frozen and glazed imported fillets represent a weight of approximately one-quarter of the whole shark, so the actual landing figure was closer to 360 thousand pounds in 1999 from Mexican waters.

California landings dwindled to 19 thousand pounds in 1995 and 18 thousand pounds in 1996, but began to increase again between 1997 (33 thousand pounds) and 1999 (53 thousand pounds). Adding the Mexican imports (from two processing operations) to the California landings provides a better estimate of the California market demand and consumption of angel shark, which in 1999 totaled over 413 thousand pounds. Mexican imports now provide at least 87 percent of the total market share of the state.

The ex-vessel price for angel shark in 1977 was 15 cents per pound. The price rose to 35 cents per pound in 1982 ($1.60 to $1.70 per pound at retail markets) as demand increased for the firm, white-fleshed shark. With continued market demand and lower landings, ex-vessel prices in 1991 rose to 75 cents per pound dressed (head off) and in 1999 averaged 91 cents per pound. The standard ex-vessel price in 2000 is reported to be over $1 per pound. Retail prices have increased to between $4 and $6 per pound.

Cooperative fisheries research began in 1979 to obtain information on angel shark distributions, migrations, growth rates, and eventually, reproductive rates. Members of the commercial fishing industry helped initiate the investigations, which, with the participation and cooperation of university research and extension personnel, helped fisheries managers develop a management plan in 1986. Development of regulatory guidelines for this fishery is an example of a "co-management" approach involving a partnership of managers and resource users. The drop in landings after 1986 was partially attributed to a new size limit, though fisheries biologists and fishermen agree that management regulations were initiated too late to maintain a sustainable yield angel shark fishery with the harvest levels experienced in the mid-1980s.

Status of Biological Knowledge

The Pacific angel shark is reported to occur only in the eastern Pacific Ocean from southeastern Alaska to the Gulf of California and from Ecuador to Chile. A gap in distribution separating subpopulations of *S. californica* occurs between the equator and 20° North latitude. The southern population was earlier reported as a separate species, *S. armata*.

Angel sharks are relatively small, bottom-dwelling elasmobranchs, attaining maximum length of five feet and a weight of 60 pounds. In the Santa Barbara Channel, commercially caught specimens generally range in size between three and four feet, although minimum size limits now allow the take of females 42 inches and above and males 40 inches or more. Angel sharks range in depth from three to over 600 feet. Fishermen working the northern Channel Islands reported that most of their catches were between 30 and 240 feet. After the inshore area closures were set in 1994, fishing shifted to deeper waters between 100 and 300 feet.

Pacific angel shark are usually found lying partially buried on flat, sandy bottoms and in sand channels between rocky reefs during the day, but they may become active at night. Tagged specimens near Santa Catalina Island were found to move from a few feet to four nautical miles per night. However, individual sharks have been observed to remain in the same place with no apparent movement for up to 10 days.

Sonic tagging studies conducted at Santa Catalina Island indicated that 11 sharks with transmitter tags remained near the Island for up to 90 days, although movement around the island was extensive. Of 30 conventionally tagged fish all but one angel shark remained in the same general vicinity in which they were tagged. The lone exception was a shark tagged on the coast and captured three and a half years later at Santa Cruz Island. Without further evidence from tag and recovery data, resource managers assume that isolated stocks may exist near islands, separated from the mainland and other islands by deep water channels (including San Clemente, San Nicolas, Santa Barbara, and Santa Catalina Islands). A 1997 report on the genetic variability of angel sharks, from two of the northern Channel Islands (Santa Rosa and Santa Cruz Islands) and a more southern island (San Clemente Island) showed that there were significant allele frequency differences between sharks from the northern and southern areas. This electrophoretic study provides a strong indication that genetically isolated populations of angel sharks exist in California.

Several techniques have been utilized in an effort to age angel sharks, but to date aging this species has been unsuccessful. Researchers have observed that angel sharks are born with six to seven bands in their vertebral centra, but growth curves based on size and band counts were found to be atypical. Both centrum edge histology and size-frequency analyses have proven inconclusive. Sharks grown in the laboratory, along with field-tagged, tetracycline-injected returns, indicated no periodic basis for band deposition in the vertebrae, but indicated that calcified band deposition is more related to rapid somatic growth.

Sexual maturity in both males and females occurs between 35 and 39 inches total length. Embryos present per female range between one and 11, with a mean of six pups produced annually from March to June. A 10-month gestation period was estimated for this species.

Major prey items of angel shark include queenfish and blacksmith in the summer and market squid in the winter. Fishermen in the Santa Barbara Channel report that mackerel and Pacific sardines are found in angel shark stomachs during the fall and early winter, along with squid, which predominates during the winter and spring.

Status of the Population

The rapid increase in angel shark landings between 1983 and 1986 led to concern that stocks were being over-exploited. Over 79,000 individual angel sharks were reported taken during the 1985-1986 season. Considering the low fecundity and apparent lack of significant migrations of angel sharks, the need to develop a management plan became critical. A minimum retention size limit was proposed by DFG in 1987 and became law in 1989. Because these sharks are nearly always retrieved alive, limiting retention size is a viable regulation. However, landings had decreased before the inception of the regulation, indicating a declining population along the Santa Barbara-Ventura County coastline and around the northern Channel Islands. The minimum size restriction is believed to have been effective in decreasing the numbers of immature sharks harvested and also to have decreased harvest pressure on exploited stocks. The area closures had a much more severe effect on the fishing community and led to the unintended consequence of shifting the fishery to Mexico where, at present, no management of the species exists. Large numbers of gillnet "pangas" on both sides of the Baja Peninsula now fish angel sharks for Mexican markets and for export to California.

No population studies have been conducted on angel shark since the nearshore fishery ended in 1994. A comparative research survey of nearshore fish assemblages around Santa Catalina Island and along the mainland (Santa Barbara to Newport Beach) between 1996 and 1998 indicated that *Squatina* was a commonly caught species at many of the 10 sampling stations. The researchers reported that the survey showed a greater abundance and proportionately larger biomass for nearshore sharks than any other southern California study. Further, they note that gillnets are much more efficient for sampling mobile and elusive fishes than trawls and diver surveys. In terms of biomass, angel sharks ranked third at Santa Catalina Island and ninth at the mainland sites. There have been no recent studies of *Squatina* populations at the northern Channel Islands.

Management Considerations

See the Management Considerations Appendix A for further information.

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