

Ocean Shrimp

History of the Fishery

The commercial fishery for ocean shrimp (*Pandalus jordani*), also called pink shrimp, started in 1952 after commercial quantities were found by DFG research vessels in 1950 and 1951. The California Fish and Game Commission established regulations for the new fishery in 1952, including net type with mesh restrictions and a season. The first catches were made later that same year. Three regulation areas were also designated and catch quotas established for each. The three regulatory areas were Area A, Oregon border to False Cape; Area B, False Cape to Pigeon Point; and Area C, Pigeon Point to the Mexican border. In 1956, Area B was divided into two areas; B-1 extended from False Cape to Point Arena and B-2 from Point Arena to Pigeon Point.

Catch quotas governed the shrimp take from 1952 to 1976. Quotas were based on recommendations by DFG and were set each year by the Fish and Game Commission. In 1976, all quotas were dropped in favor of four criteria believed to protect the resource. The criteria were: 1) a season from April 15 through October 31, designed to protect egg-bearing females; 2) a net mesh size of 1 3/8 inches, to allow escapement of small zero- and one-year-old shrimp; 3) a count per pound of 170 or less, intended to protect one-year-old shrimp; and 4) a minimum catch rate of 350 pounds per hour to protect shrimp when the population is at a low level. If these requirements were not met, the DFG had the option to close the fishery. In 1981, the regulations were changed again to bring them into accord with an agreement with Oregon Department of Fish and Wildlife and Washington Department of Fisheries to have coast-wide uniform regulations. The new regulations included a season from April 1 through October 31, a maximum count per pound of 160, and a minimum mesh size of 1 3/8 inches measured inside the knots. These regulations are still in effect. From 1952 to 1963, shrimp

fishermen were limited to the use of beam trawls with a minimum mesh size of 1.5 inches between the knots. In 1963, shrimpers were permitted to use otter trawls with the same size mesh. The mesh size was reduced from 1.5 inches to 1 3/8 inches in Areas A, B-1, and B-2 in 1975.

Prior to 1974, all shrimp boats in California pulled a single rig of one net and two doors, but starting with the 1974 season, vessels towing a double rig from outriggers, one on each side of the boat, entered the fishery. The double-rigged vessels are approximately 1.6 times more effective than single-rigged vessels.

During the first year of the fishery, only six boats participated. The number of boats increased to 27 by 1960, then averaged 24 boats per season over the next 16 years. The record catch in 1977 started a rapid influx of boats into the shrimp fishery and reached a high of 104 vessels during 1980, but the number declined to 33 during 1983 when the catch fell to a low of 1,176,000 pounds. As the catch recovered from that El Niño-induced low, many boats reentered the fishery. The number of vessels per season averaged 88 from 1983 through 1999. A record-high 155 boats shrimped during the 1994 fishery, the first year of a moratorium on new shrimp permits — probably the cause of the large increase in the number of vessels.

California landings have averaged 4,843,000 pounds annually from 1952 through the 1999 season, ranging from a low of 206,000 pounds in 1952 to a high of 18,683,000 pounds in 1992. Average landings have increased each decade since the start of the fishery in the 1950s: 969,000 pounds in the 1950s, 1,810,000 pounds in the 1960s, 5,679,000 pounds in the 1970s, 5,871,000 pounds in the 1980s and 9,127,000 pounds in the 1990s. Area A has been the most consistent producer and, since 1954, has had the highest annual landings. The only exception was the El Niño year of 1983, when Area C had the highest landings. Since the inception of the fishery, 86.8 percent of the shrimp have been landed in Area A ports, 5.4 percent in Area B-1, 2.9 percent in Area B-2, and 4.9 percent in Area C.

The price paid to the fishermen (ex-vessel price) has ranged from a low of \$0.07 per pound in 1955 to a high of \$0.87 per pound in 1987. The ex-vessel price remained fairly constant at \$0.10 per pound during the 1950s and 1960s, increased in price from \$0.12 per pound to around \$0.30 per pound in the 1970s, and since has fluctuated around \$0.50 per pound.

The largest portion of ocean shrimp landed in California is picked and individually quick-frozen. Small amounts are sold fresh whole, as cooked picked meat or packed in vacuum cans. Most of California's shrimp catch was hand picked until 1969, when machines were introduced in the Eureka area. Shrimp machines have enabled the shrimp



Catch of Ocean Shrimp, *Pandalus jordani*
Credit: DFG

industry to pick much smaller shrimp than was possible with hand picking.

Status of Biological Knowledge

Ocean shrimp are found from Unalaska in the Aleutian Islands to off San Diego, California, at depths from 150 to 1200 feet. In California, this species is generally found from depths of 240 to 750 feet. Spawning probably occurs throughout the range, but commercial harvest is limited to the area between Vancouver Island, British Columbia, and Point Arguello, California.

Concentrations of shrimp generally remain in well-defined areas or beds from year to year. These areas are associated with green mud and muddy-sand bottoms. Although there is some evidence of minor onshore-offshore and coast-wide movement within the confines of a bed throughout the year, no convincing evidence of migratory behavior has been produced. Horizontal movements probably are governed by feeding activities and prevailing currents. Ocean shrimp also exhibit vertical migrations. These movements toward the surface during periods of darkness appear to be associated with feeding on plankton. Adults from the different beds probably intermix rarely, but the planktonic larvae undoubtedly intermingle, as there are no indications of genetically distinct subpopulations. Genetic stock identification work on ocean shrimp has failed to isolate any genetic differences between ocean shrimp from off the coasts of California, Oregon, Washington and British Columbia.

Ocean shrimp feed mostly at night on planktonic animals. The stomach contents of shrimp taken at night indicated that the most common food items were euphausiids and copepods, while the stomachs of shrimp collected during daytime contained little food. Identifiable food items included polychaete worms, sponges, diatoms, amphipods, and isopods.

Many species of fish prey on ocean shrimp. Major fish predators include Pacific hake, arrowtooth flounder, sablefish, petrale sole and several species of rockfish.

Ocean shrimp are protandric hermaphrodites; that is, during their first year and a half of life most will function as males, then pass through a transitional phase to become females. During some years, large percentages (up to 60 percent) of the one-year-old shrimp become females and never mate as males. Female shrimp usually carry between 1,000 and 3,000 eggs. Small individuals in their second year have been found carrying as few as 900 eggs, whereas larger shrimp in their third or fourth year of life have been found with up to 3,900 eggs. Mating takes place during September and October, and the external fertilization of the eggs takes place when the females

begin extruding eggs in October. The female carries the eggs between the posterior swimming appendages until the larvae hatch. The peak of hatching occurs during late March and early April. Ocean shrimp go through a larval period that lasts 2.5 to three months. The developing juvenile shrimp occupy successively deeper depths as they develop, and often begin to show in commercial catches by late summer. Shrimp grow in steps by molting or shedding their shells. Growth rates for ocean shrimp vary according to region and also by sex and year class. There is a clear pattern of seasonal growth despite the variations mentioned, with very rapid growth during spring and summer and slower growth over the winter. The growth rate decreases as the shrimp age. Shrimp growth rates increased markedly in Oregon after 1979, suggesting a density dependent growth response to fishing. Ocean shrimp may reach 5.5 inches in total length, but the average catch size is about four inches. In California, few shrimp survive beyond their fourth year.

Studies on natural mortality estimate that the survival between fishing seasons (over winter) is 46 percent, 76 percent, and 43 percent for ocean shrimp during their first, second, and third winters of life, respectively.

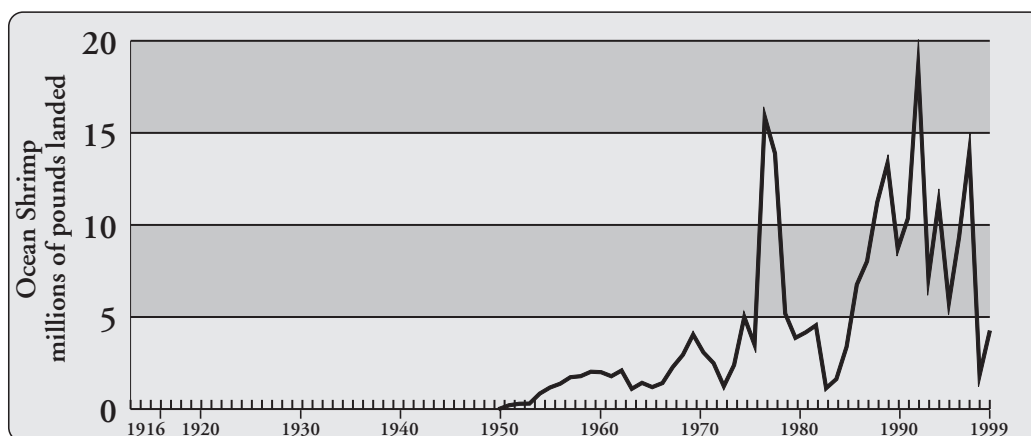
Status of the Population

Population estimates of the various shrimp beds were obtained by department sea surveys from 1959 to 1964; catch quotas were set at one quarter of the estimated population. Area A sea survey continued until 1969. The highest Area A population estimate from sea surveys was 10,700,000 pounds in the fall of 1967. Because the cost of sea surveys was quite high, another method of estimating population was needed. A mathematical population model, designed by department statisticians, was used to estimate the population size and set the quota from 1969 until 1976, when the model was dropped and no further attempts to estimate the population were made.

It was established that the ocean shrimp population abundance off California is determined by environmental conditions, which causes natural fluctuations in recruitment that are apparently unrelated or minimally related to commercial fishing effort. Since the abandonment of quotas, the shrimp population, as evidenced by the commercial catch, has gone through two extreme highs (1977 - 15,600,000 pounds; 1992 - 18,683,000 pounds) and two lows (1983 - 1,200,000 pounds - primarily in Area C; 1998 - 1,836,000 pounds). The population appears to be headed up again since the 1998 low.

Investigations of the population dynamics of shrimp off Oregon suggest shrimp are inherently resistant to overfishing. Annual recruitment success has been shown to be

Commercial Landings
1916-1999, Ocean Shrimp
 Data Source: DFG Catch
 Bulletins and commercial
 landing receipts. No commercial
 landing are reported for ocean
 shrimp prior to 1952.



linked to the strength and timing of the spring transition in coastal currents immediately following larval release. An early, strong transition produces large year classes. Shrimp are short-lived and exhibit flexible rates of sex change that act to maintain a roughly balanced sex composition, despite highly variable mortality rates. Other evidence also suggests that shrimp exhibit density-dependent growth. In combination, these biological traits increase the fishing pressure a stock can withstand without suffering decline. Nonetheless, some evidence has been presented recently suggesting shrimp are periodically "recruitment-overfished" in a manner that delays the stock's rebound from El Niño-related recruitment failures. However, overfishing in such a short-lived resource has relatively minor impacts on yield and changes in management await additional research on how fishing is altering yield.

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