

Bay Shrimp

History of Fishery

The commercial fishery for bay shrimp in San Francisco Bay began in the early 1860s, with some accounts indicating that the earliest participants used small-meshed bag seines. By 1871, Chinese immigrants established fishing camps along the shores of the bay and exported large quantities of dried shrimp meal (dried heads and shells) to China. These fishermen introduced what is now known as the Chinese shrimp net, a funnel-shaped net that is anchored in place and relies upon the tide to carry shrimp into the net. Fishing camps also existed in Tomales Bay between 1890 and 1895. At the height of the fishery in the 1890s, as many as 26 fishing camps operated up to 50 nets each in San Francisco Bay with daily landings of 400 to 8,000 pounds of shrimp, and annual landings exceeding five million pounds. Studies were required by the California Fish and Game Commission between 1897 and 1911 to address concerns that many young fish, particularly striped bass, were killed in the shrimp nets. The results of these studies prompted a May to August season closure and a prohibition of Chinese shrimp nets in 1911. The legislature modified this decision in 1915 allowing Chinese shrimp nets to be used in south San Francisco Bay. About this time, beam trawl nets began to be used by commercial shrimp harvesters in northern San Francisco Bay and San Pablo Bay. Annual landings gradually increased over the next two decades and peaked at 3.4 million pounds in 1935. Following this period, landings steadily declined in response to a decline in demand for fresh and dried shrimp as food. By the early 1960s, average annual landings declined to 1,500 pounds, and in 1964 no shrimp were landed.

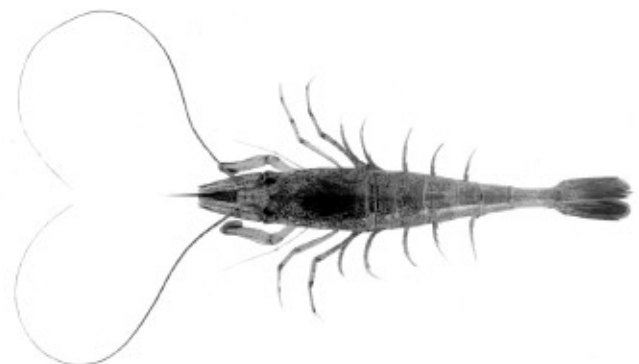
The current commercial fishery for bay shrimp developed in 1965 to supply live bait for sturgeon and striped bass sport fishing with a small percentage of the catch reserved for human consumption. Regulation changes in the 1980s eliminated fishing in most of Suisun Bay due to high incidental catch and associated mortality of small striped bass in shrimp trawls. Currently, neither a quota nor season closure is in effect for the commercial fishery, and landings are influenced primarily by demand. Regulations also allow for the catch of yellowfin (Oriental) goby, long jaw mudsucker, and staghorn sculpin with a commercial bay shrimp permit. Sport regulations allow the use of hand-powered shrimp trawls no greater than 18 by 24 inches at the mouth and a daily bag limit of five pounds. Any finfish caught in the sport fishery must be returned to the water. From 1965 to the present, the commercial fishery for bay shrimp has exclusively used beam trawls. These trawls are spread by either a wooden or galvanized steel pole, are 20 to 25 feet wide, and use a mesh of 7/8 inch to one inch in the cod end. Live tanks are used on all vessels, and shrimp are transported to local bait shops by

truck in either live tanks or iced-down wooden trays with burlap linings.

Since 1985, annual landings of bay shrimp have averaged 120,000 pounds and have ranged from 75,000 to 150,000 pounds. In 1999, 11 boats participated in the bay shrimp fishery. Eight of these boats fished exclusively in north San Francisco Bay and three fished exclusively in south San Francisco Bay. However, the total weight of bay shrimp landed was almost twice as high in the south San Francisco Bay versus north San Francisco Bay due to higher catch per boat, and higher catch per hour trawled. Primary fishing locations are Alviso Slough and Redwood Creek in south San Francisco Bay, north San Francisco Bay, northern San Pablo Bay, Petaluma Creek, and Carquinez Strait. Fishing generally occurs in waters less than 20 feet deep in channels of the estuary's shallow reaches.

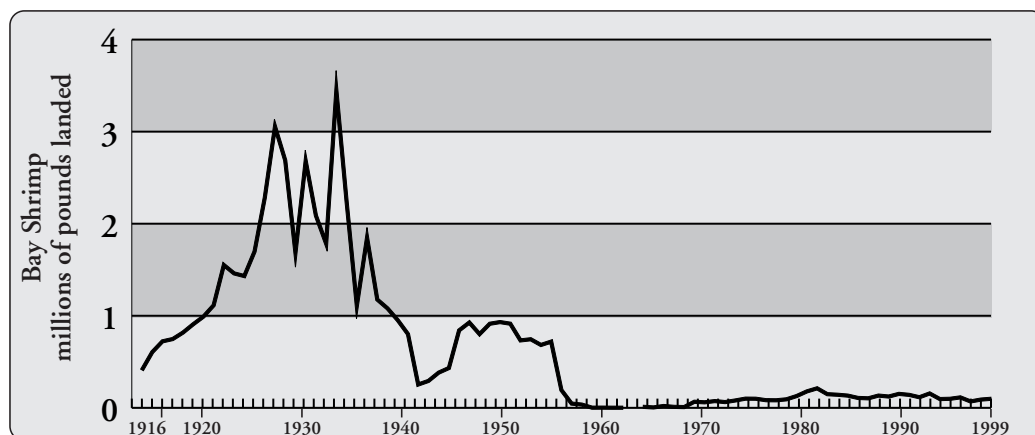
The bay shrimp fishery exhibits a distinct seasonal pattern both in pounds landed, and catch-per-unit (CPUE) of effort as measured in pounds caught per hour trawled, with fluctuations typically on the order of five to eight-fold for both variables. Since 1996, March and April have had the lowest average monthly landings at 3,000 pounds as well as the lowest CPUE. Peak CPUE and total catch typically occurs in the months of June through November. Peak monthly catch for the past four years ranged from 10,000 to 12,000 pounds. Such seasonal variations in CPUE are most likely a result of fluctuations in salinity. However, seasonal variations in total pounds landed may reflect corresponding fluctuations in demand for bay shrimp by sport anglers.

The current value of bay shrimp landed each year is approximately \$350,000, with the average pound of bay shrimp selling for \$3.50 ex-vessel price. Additionally, over the past decade the bay shrimp fishery has caught between 9,000 and 2,000 pounds of staghorn sculpin and yellowfin goby per year at a total value ranging between \$4,000 and \$25,000.



California Bay Shrimp, *Crangon franciscorum*
Credit: DFG

**Commercial Landings
1916-1999, Bay Shrimp**
Data Source: DFG Catch
Bulletins, log books,
and commercial
landing receipts.



Status of Biological Knowledge

The bay shrimp (grass shrimp) fishery is composed of four species: the California bay shrimp (*Crangon franciscorum*), the blacktail bay shrimp (*Crangon nigricauda*), the blackspotted bay shrimp (*Crangon nigromaculata*) and the oriental shrimp (*Palaemon macrodactylus*). The crangonid shrimp ("crangonid" is a taxonomic family) are easily distinguished from other shrimp by a very short rostrum that usually does not extend beyond the eyestalks, a dorsally flattened body, and poorly developed chelipeds. All four species prefer a soft substrate such as mud or sand, but can occasionally be found over rocky substrates and in the rocky intertidal.

The California bay shrimp, is the primary component of commercial shrimp landings. It is the dominant caridean shrimp ("caridean" is a taxonomic group between order and family) in most Pacific Coast estuaries, and the most common species in the San Francisco estuary. The California bay shrimp ranges from Alaska to San Diego to a depth of at least 180 feet. It is the largest of the bay shrimp species. Adult females and males may reach total lengths of 3.2 inches and 2.4 inches, respectively, in California, while a maximum size of 4.3 inches has been reported in the Columbia River. Life span varies by estuary. In the San Francisco estuary, males are estimated to attain a maximum age of 1.5 years and females may live up to 2.5 years. This species has been reported to be a protandrous hermaphrodite, with males changing to females.

Their larvae develop into the post-larvae stage in about 30 to 40 days. Both sexes reach maturity in about nine to 12 months. Males mature at approximately 1.3 to 1.5 inches, while females mature at about 1.9 to 2.1 inches. Though gravid females have been observed in all months of the year, they are most abundant in December through June. Spawning occurs near the mouth of the estuary in the summer months. During winter and spring, spawning takes

place in nearshore areas outside of the estuary. During fertilization, female California bay shrimp, and other crangonid shrimp, extrude their eggs into their brood pouch (on their abdominal region). The fertilized eggs are held in the brood pouch throughout development (approximately 8 to 12 weeks) until they hatch.

California bay shrimp tolerate a wide range of salinity and temperature. During a 17-year interagency study in the San Francisco estuary, 90 percent of collected specimens were found in waters with salinity ranging from 2.8 to 25.9 parts per thousand (ppt) (mean 13.9 ppt). In the same area, mean temperature was 64.8°F with 90 percent collected between 55.8 and 70.3°F. Juveniles may be found throughout the estuary where salinity is greater than one part per thousand, although they prefer shallow (less than 16 feet), low salinity waters and migrate to deeper, higher salinity waters as they grow. The annual abundance of juveniles is strongly correlated with fresh water outflow in the winter and spring; lowest abundance occurs in years with low outflow.

Like other members of the genus, they are considered opportunistic feeders, and primary prey items may change with size of the shrimp. Smaller California bay shrimp (< 1.2 inches total length, TL) consume mostly foraminiferans, ostracods, and copepods; intermediate size shrimp prey upon amphipods and bivalves, and larger shrimp (> 2.4 inches TL) consume mostly bivalves, caridean shrimp, and polychaetes. Myoid shrimp are some common prey items in parts of the San Francisco estuary. Little is known about the ecology of larval and postlarval crangonids. However, diatoms and small zooplankton such as copepods are probably an important part of the larval diet.

The blacktail bay shrimp, ranges from Alaska to Baja California and is found in estuaries and nearshore ocean areas to a depth of at least 190 feet. This species is less tolerant of low salinities than California bay shrimp. In the San Francisco estuary, 80 percent of collected

specimens were found in waters with salinity ranging from 18.0 to 31.7 ppt (mean 25.9 ppt). In the same area, mean temperature was 60.6°F with 80 percent collected between 51.3° and 66.7°F. Juveniles tolerate lower salinities and higher temperatures than adults. Adult females and males may reach total lengths of 2.5 and 2.4 inches, respectively. Males may live up to one year and females may live up to 1.5 years. Both sexes are reported to mature by the end of the first year; males are thought to spawn once and die. Male blacktails mature at approximately 1.1 inches, while females mature at about 1.5 to 1.6 inches. Juvenile shrimp usually peak in abundance from May through August, but in some years there is a second fall-winter peak. Blacktail bay shrimp feed mostly on amphipods.

The blackspotted bay shrimp is a very minor component of the catch. It ranges from the Gulf of the Farallones to Baja California, and is more common in the nearshore ocean area than in estuaries. It is found on sandy bottoms at depths ranging from 15 to 575 feet and reaches a maximum size of 2.8 inches TL. Females mature at about 1.7 inches and males mature at about 1.1 inches. Blackspotted bay shrimp tolerate a smaller salinity range and lower temperatures than the other two common crangonids. They are generally limited to areas with high salinity and cool temperatures, with 80 percent of the specimens collected at salinities ranging from 25.9 to 31.9 ppt and temperatures ranging from 51.6° to 64.0° F in the long-term interagency study. Abundance increased during the 1987-1992 drought. The Oriental shrimp, was introduced to the San Francisco estuary from Asia in the 1950s and is now a significant component of the commercial catch. This species reaches a total length of about 3.0 inches and appears to complete its entire life-cycle in estuarine waters. It is common in lower salinity areas, including south San Francisco Bay and areas upstream from San Pablo Bay. The center of its distribution is either Suisun Bay or the west delta. It is more tolerant of lower salinity than the crangonid shrimp and is abundant over a broad range of salinities. In San Francisco Bay, 80 percent of collected specimens have been found in waters with salinity ranging from 1.9 to 28.1 ppt (mean 13.5 ppt) and temperatures ranging from 54.1° to 71.° F (mean 64.4° F). Abundance of oriental shrimp did not appear to be affected by the 1987-1992 drought. Gravid female oriental shrimp occur most frequently from May to August, with larvae hatching during summer and early fall.

An additional species of *Crangon*, *C. munitella*, has been collected on rare occasions within the estuary. For example, from 1980 to 1996 the DFG's Bay-Delta Project caught more than 2.2 million California bay shrimp in otter trawls, while observing only 26 *C. munitella*.

A sixth species of bay shrimp, *Exopalaemon carinicauda*, was reported from San Francisco Bay in 1993. This species seems to have been introduced accidentally from Korea. It is distinguished from other shrimp by its long, toothed rostrum, large chelae, and dorsal ridges. Its abundance and distribution in the estuary, and the impact of this species on the ecosystem are unknown.

Bay shrimp are an important component in the diets of nearshore and estuarine fishes. Twenty-four predator species have been identified in the estuary and 20 in the adjacent ocean environment. Major predators include green and white sturgeon, striped bass, leopard shark, brown smoothhound shark, big skate, white croaker, staghorn sculpin, starry flounder, English sole, pile and rubberlip surfperch, Pacific tomcod and brown rockfish.

Status of the Populations

The absolute abundance of bay shrimp has not been estimated nor has the impact of commercial fishing on these populations. However, annual abundance indices of bay shrimp indicate that abundance can vary widely from year to year. For example, annual abundance indices of adult California and blacktail bay shrimp varied by more than a factor of 10 from 1980 to 1996. Studies indicate that the abundance of California bay shrimp increases with increased river inflow to the estuary, probably because of the increased low-salinity habitat which is favorable for the rearing of juveniles. In contrast, abundance of blacktail bay shrimp increased during years of low river inflow, although not to levels capable of replacing California bay shrimp in abundance.

Management Considerations

See the Management Considerations Appendix A for further information.

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