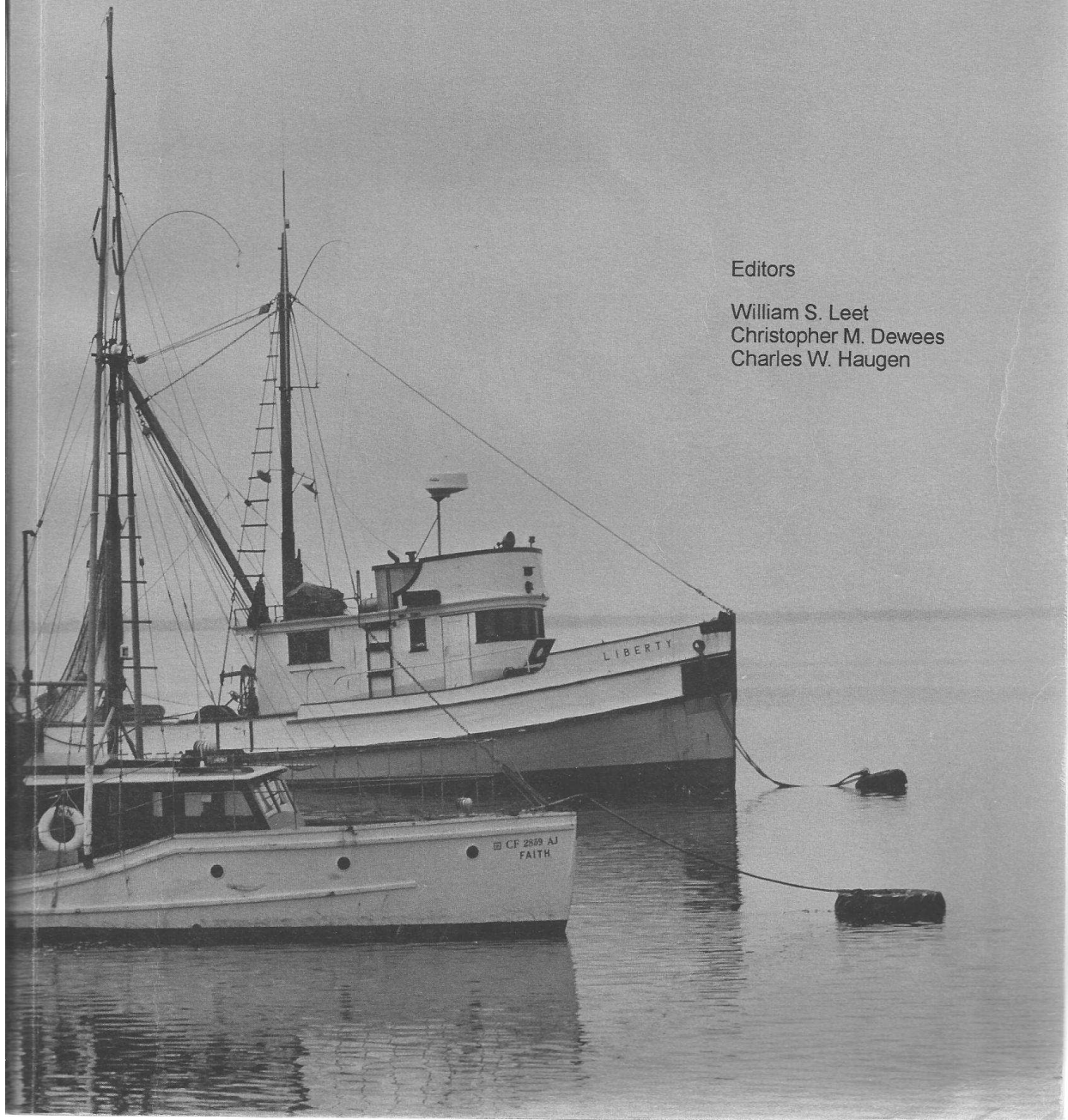


# CALIFORNIA'S LIVING MARINE RESOURCES AND THEIR UTILIZATION

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and restoration needs. In 1993, California will institute a catch report card requirement for all steelhead anglers. This requirement will provide much needed angler harvest information and also funds to be used for management, research, and specific restoration projects. Restoration of wild and native steelhead populations will be a major objective of the Steelhead Project.

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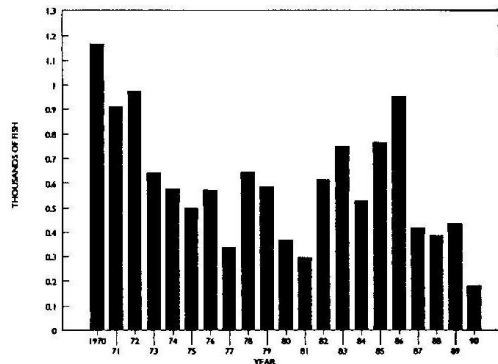
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## WHITE STURGEON

### History of the Fishery

Historically, the white sturgeon (*Acipenser transmontanus*) resource has been very important to Californians. Sturgeon scutes and skull plates are found in native American middens in the San Francisco Bay, Sacramento - San Joaquin Delta, and Elkhorn Slough areas, indicating that these large fish were important sources of tribal nutrition. An early commercial fishery developed for white sturgeon between the 1860's and 1901, stimulated by a growing acceptance of smoked sturgeon and caviar on the East Coast of North America. The California harvest was concentrated in the San Francisco Bay and Delta. Fishing gear included gillnets, longlines, and multiple unbaited hooks for snagging sturgeon. The commercial catch peaked at 1.65 million pounds in 1887, declined to 0.3 million pounds in 1895, and to 0.2 million pounds in 1901 when the commercial fishery was closed. Small commercial catches in a reopened fishery from 1909 to 1917 indicated that white sturgeon populations were still low, and commercial fishing ceased in 1917.

Sport fishing for white sturgeon was legalized in 1954, with a 40 inch total length minimum size and a one fish per day



California commercial passenger-carrying fishing vessel (CPFV) landings of sturgeon, 1970-1990.

per person limit. In 1956, snagging for sturgeon was outlawed, and the legal size minimum was raised to 50 inches through 1963. The small sport fishing catch increased dramatically in 1964 when the minimum size reverted to 40 inches and grass shrimp were discovered to be effective bait. By 1967, 2,258 sturgeon were landed by partyboat anglers. Possibly due to reduced stocks of other estuarine and coastal marine species such as striped bass, angling for white sturgeon has become very popular. Although exact sport catch data are not available, the California Department of Fish and Game estimates that harvest rate during the 1980's was 40 percent greater than it was during the previous two decades. In 1990, a 72 inch *maximum* size limit became law and the minimum size was increased by two inches per year until a new minimum size of 48 inches is reached (1993).



White sturgeon, *Acipenser transmontanus*.

### Status of Biological Knowledge

White sturgeon are generally found in estuaries, and their range extends along the Pacific Coast of North America from Ensenada, Mexico, to the Gulf of Alaska. However, spawning populations have been found only in large rivers from the Sacramento-San Joaquin system north. Indeed, most California white sturgeon are found in the Suisun Bay-San Pablo Bay-San Francisco Bay estuarine system. Some white sturgeon move into the Delta and lower Sacramento River during fall and early winter. Some of these fish move up the Sacramento River to the Colusa area or into the Feather River for spawning. A smaller number move up the San Joaquin River. The Klamath River supports the other California sub-population of white sturgeon. A few fish have shown extensive movements along the Pacific coast. Some tagged fish from San Pablo Bay have been caught in Oregon and Washington.

California white sturgeon grow very rapidly. Young sturgeon can reach 7.5-12 inches fork length in one year. This rapid growth slows somewhat and they reach 40 inches after six to twelve years. Subsequently, they grow one to 2.5 inches per year. Ages and growth rates of field-caught fish have been determined from the number and spacing of annular rings, visible in sections of first pectoral fin rays. Laboratory experiments have shown that young-of-the-year white sturgeon growth is affected by water temperature and dissolved oxygen concentration. They grow significantly faster at 68°F than at 59°F, but an increase to 77°F does not significantly increase growth rate. When dissolved oxygen concentrations drop to 56 percent of air saturation at any of these three temperatures, juvenile fish show a significant decrease in growth rate, presumably due to reduced food consumption. The white sturgeon's rapid growth rate has attracted the interest of some California aquaculturists, who grow sturgeon in freshwater tanks which have consistently moderate temperatures and high dissolved oxygen concentrations.

The largest sturgeon were caught before 1900 when size records were vague. However, the largest of these fish was probably more than 13 feet long and weighed more than 1,300 pounds, making white sturgeon the largest freshwater-inhabiting fish in North America! This fish may have been 100 years old. The largest white sturgeon captured in California waters during the past 40 years (a 9.2 foot, 460 pound, 47 year-old female) was inadvertently caught in a Sacramento River fish trap in 1955. In a U.C. Davis study of white sturgeon during the 1980's, many fish were caught, measured, examined for sex and stage of maturity, and released. Median male size was 3.6 feet and median female size was 4.6 feet in San Francisco Bay.

Compared with most freshwater or anadromous fishes, white sturgeon are quite old when they become sexually mature, but they evidence impressive fecundity at this large size. In the U.C. Davis study during the 1980's, sexually mature males were 3.6-6.0 feet long (10-15 years old), whereas mature females were generally 4.6-6.6 feet (12-20 years old) in San Francisco Bay. However, high natural variability in the size at sexual maturity was noted, especially among female white sturgeon. For example, the smallest pre-spawning female white sturgeon weighed only 25 pounds, whereas a 120 pound female was caught which, from gonadal analysis, was determined to have not yet spawned in her life! Preliminary studies indicate that white sturgeon females probably do not spawn every year. Several years may lapse between successive spawnings in an individual female. In the study on San Francisco Bay fish, approximately 50 percent of the males captured were approaching spawning condition for that year, compared with only about 15 percent of the captured females. Fecundity scales with female size. Smaller females (under five feet) contain about 100,000 eggs, whereas the 9.2-foot record female contained 4.7 million eggs!

Spawning occurs in the Sacramento River between mid-March and early June when water temperatures are 50-75°C. Little is known about spawning behavior. White sturgeon spawn their eggs onto deep gravel riffles or rocky holes in the upper Sacramento and Feather Rivers. The fertilized eggs are very adhesive and hatch after one or two weeks on the bottom.

Larvae stay close to the bottom and are washed into the upper reaches of the Sacramento-San Joaquin estuary. Young juvenile sturgeon become increasingly tolerant of brackish water as they grow and develop.

White sturgeon feed on a wide variety of bottom-dwelling, estuarine animals. Sturgeon feed by suction with their ventral, protrusible mouths. Dense aggregations of taste buds on their four barbels presumably assist in identification of food on the bottom. When their mouths are blocked by food, white sturgeon can ventilate their gills by flushing water in via the dorsal part of the gill slit and out via the ventral part. Young sturgeon (eight inches) feed primarily on small crustaceans such as amphipods and opossum shrimp. As they develop, they take a wider variety of benthic invertebrates, including various species of clams, crabs, and shrimp. Larger sturgeons' diets include fish such as herring, striped bass, anchovy, smelt, starry flounder, salmon, and trout. White sturgeon in San Francisco Bay gorge themselves on herring roe, when it is available during the winter.

Little is known about predators on white sturgeon. Smaller fish are undoubtedly taken by various fish and bird predators, although the five lines of bony scutes along their bodies probably make them less desirable prey than other estuarine species. Anglers undoubtedly mount the largest predatory effort on the adult fish.

#### Status of Population

The nineteenth century history of white sturgeon fishing in California waters shows this species' vulnerability to overfishing. Delayed sexual maturity and infrequent spawning by the females exacerbates this vulnerability compared to most bony fishes. California Department of Fish and Game gillnet surveys during the 1980's in San Pablo Bay showed that angler harvest was high, and new size limits (including initiation of a first-ever maximum size limit in 1990) reflect the Department's management concerns. Their analysis of the supply-demand relationship indicates that the "white sturgeon cannot sustain the current 10 percent annual harvest rate."

Besides mortality associated with fishing, white sturgeon populations are influenced very much by recruitment of young fish. California Department of Fish and Game surveys of young and adult fish spanning the 1975-1986 period show that recruitment of young fish is directly proportional to freshwater outflow through the Sacramento-San Joaquin estuary. Thus, recruitment is highest in years with high rainfall and runoff, although the mechanism driving this phenomenon is not yet known.

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## STRIPED BASS

### History of the Fishery

In 1879, 132 young striped bass (*Morone saxatilis*) from the Navesink River, New Jersey were released into the Sacramento-San Joaquin Estuary at Carquinez Strait. A second plant of 300 fish from the Shrewsbury River, New Jersey followed in 1882. Shortly after these introductions, striped bass experienced a population explosion in the estuary. Commercial harvesting started in the early 1880's and, by the turn of the century, exceeded one million pounds annually. The greatest recorded commercial catch, over two million pounds, occurred in 1903. Subsequently, annual catches declined due to increased restrictions on the fishery.

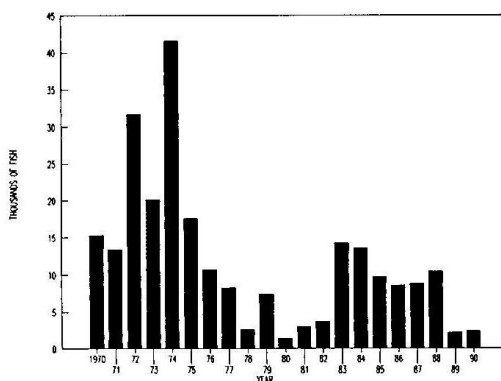
In 1935 the commercial fishery for striped bass was closed, although the stock was not depleted. The closure stemmed largely from a social conflict between sport and commercial fishing interests which culminated in the closure of the commercial gill net fisheries for chinook salmon and American shad in 1957. Thousands of striped bass which could not be legally marketed were killed annually in nets fished for these two species. Closure of the salmon and shad fisheries reduced fishing mortality for striped bass, but the magnitude of the reduction cannot be estimated because the precise extent of the incidental harvest is unknown. Some illegal netting continues today.

The striped bass sport fishery has become the most important fishery in the Sacramento-San Joaquin Estuary and one of the most important fisheries on the Pacific coast. From 1969 to 1989 there has been a general decline in catch associated with a decline in striped bass abundance. Over this period, the annual catch varied from about 403,000 fish in 1975 to 68,000 fish in 1989. During the early 1960's the annual catch of striped bass was even larger, probably around 750,000 fish. In 1985 an economist estimated the annual value of the striped bass fishery to exceed 45 million dollars.

Striped bass angling occurs year-round, but fishing localities vary seasonally in accordance with the striped bass migratory pattern. Tag recoveries indicate that many adults inhabit salt water—San Pablo Bay, San Francisco Bay, and the Pacific Ocean—in the summer. The proportion entering the ocean varies from year to year. These fish begin returning to the delta in the fall.

The distribution of fishing effort and catch has changed substantially over the years. Before the late 1950's there was little fishing in San Francisco Bay and the Pacific Ocean. Most of the catch came from San Pablo and Suisun bays, the delta,

and rivers upstream. From the late 1950's to early 1980's, however, postspawning striped bass generally migrated farther downstream and stayed there longer. Thus, fishing improved in San Francisco Bay and the Pacific Ocean and declined in the delta. Also, the use of the Sacramento River as a spawning area appeared to have increased, improving fishing there in the spring. Now the migrations have shifted upstream again with Suisun Bay and the delta providing the bulk of the catch in the 1980's. While significant environmental changes have occurred, data are insufficient to develop conclusions regarding causes of these changes in striped bass migrations.



California commercial passenger-carrying fishing vessel (CPFV) landings of striped bass, 1970-1990.

Based on tag returns from 1969-1979, private boat anglers accounted for an average of about 65 percent, shore anglers for 21 percent, and commercial passenger fishing vessels for 14 percent of the annual striped bass catch. During creel checks over this same period, predominantly in the bay area, the average length of censused fish ranged from about 23 inches in 1979 to 28 inches in 1977. Average catch per hour ranged from about 0.1 to 0.3 fish.

Striped bass are generally caught by bait fishing or trolling, although under some conditions fly fishing or casting plugs or jigs is effective. Common dead baits include threadfin shad, anchovies, cut sardines, staghorn sculpins (bullheads), gobies (mudsuckers), shrimp, blood worms, and pile worms. Drift fishing with live anchovies or shiner perch is popular in San Francisco Bay and the Pacific ocean, and live golden shiner minnows sometimes are used in the Delta. Trolling methods are specialized. Many types of plugs, jigs, and spoons are used in trolling, frequently in double combinations.

Present fishing regulations include an 18-inch minimum length and a daily bag limit of two fish. From 1956 to 1981, the minimum length was 16 inches and the bag limit was three fish. Prior to 1956, regulations were more liberal. A 12-inch minimum length and five-fish bag limit generally was in effect.

Exploitation rates have been estimated almost annually since 1958. They have varied from nine percent (1989) to 28 percent (1963) except for an unusually high 37 percent in 1958. Exploitation in the Sacramento-San Joaquin Estuary is lower