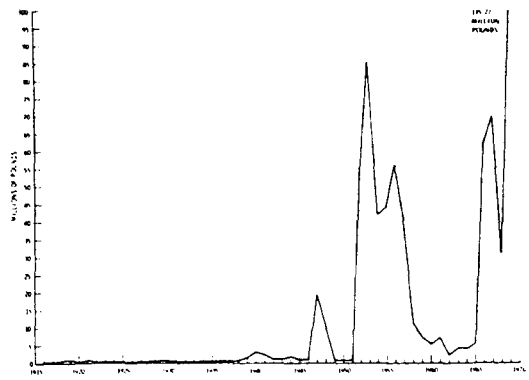
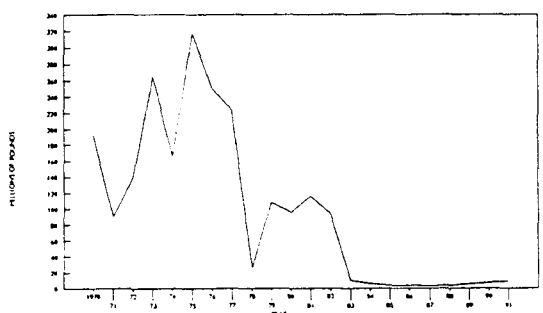
Anchovy harvested by the live bait fishery are not landed but kept alive for sale to anglers as bait. Transactions between buyers and sellers of live bait take place either at sea or at bait wells tied up at docks. Live-bait dealers generally supply bait to partyboats on a contract basis and receive a percentage of the fees paid by passengers. Bait is also sold by the "scoop" to anglers in private vessels.

Anchovy landed by the non-reduction (other than live bait) fishery are used as dead frozen bait, fresh fish for human consumption, canned fish for human consumption, animal food, and anchovy paste.

Reliable records of California landings of northern anchovy date from 1916. Landings were small until scarcity of Pacific sardine caused processors to begin canning anchovies in quantity during 1947, when landings increased to 9,464 tons. In order to lower the quantity of anchovies being reduced to fish meal, the California Fish and Game Commission required each processor to can a large proportion of the harvest (40-60 percent depending on can size). Anchovy landings declined with the temporary resurgence of sardine landings through 1951. Following the collapse of the sardine fishery in 1952, anchovy landings increased to 42,889 tons in 1953, but subsequently declined, largely due to low consumer demand for canned anchovy and increased sardine landings. Landings remained low through 1964. During the early years of the anchovy fisheries (1916-1964), anchovy were harvested almost exclusively by California fishermen. Mexico did not begin harvesting anchovy until 1962.



California commercial landings of northern anchovy, 1916-1969.



California commercial landings of northern anchovy, 1970-1991.

PELAGIC WETFISH

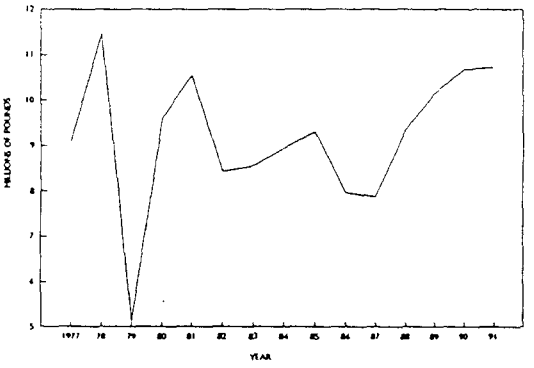
NORTHERN ANCHOVY

History of the Fishery

Northern anchovy (*Engraulis mordax*) are exploited by three separate fisheries in both California and Mexico. Anchovy landed by the reduction fishery are converted to meal, oil and soluble protein products that are sold mainly as protein supplements for poultry food but also as feed for farmed fish and other animals. Meal obtained from anchovy is about 65 percent protein compared to about 50-55 percent for meal from other fishes.

Beginning in 1965, the California Fish and Game Commission managed anchovy on the basis of a reduction quota. This quota has been taken by a fleet of approximately forty small purse seine vessels known collectively as the "wetfish" fleet, which fishes for other species in addition to anchovy. Anchovy landed for reduction in California increased from 171 tons in 1965 to 27,330 tons in 1966, and ranged from 13,786 to 92,893 tons per year during 1966-1972, and from 80,855 to 155,966 tons per year during 1973-1977. In response to a decrease in the price of fish meal, landings declined to an annual average of 51,223 tons during 1979-1982. Reduction landings have been extremely low since 1983, largely as a result of low prices offered to fisherman.

The non-reduction fleet in recent years has consisted of about eighteen boats that are distributed along the California coast to serve the principal sport fishing markets, mostly in southern California.



California landings of northern anchovy for live bait, 1977-1991.

The live bait boats fish for a variety of species, but anchovies comprise approximately 85 percent of the catch. Historically, the anchovy live bait catch ranged from 4,000 to 8,000 tons per year and averaged 5,748 tons annually in recent years. Non-reduction (other than for live bait) landings averaged about 2,189 tons per year from 1965 to 1989 and, since 1985, have exceeded reduction landings in California because of a major decline in the reduction fishery.

Anchovy landed in Mexico are used primarily for reduction, although a small amount is used as bait. Mexico's harvesting and processing capacity increased significantly in the late 1970's when several large seiners were added to the fishing fleet and a large reduction plant was constructed in Ensenada. Mexican landings reached a high of 284,975 tons in 1981, fell to 196,078 tons in 1982, and have ranged from 87,024 to 136,594 tons per year since 1983. The fishery ceased operation in 1991.

The U.S. northern anchovy fisheries have been managed by the Pacific Fishery Management Council since 1978. Current regulations impose no numeric limit on live bait catch and provide a 7,711 ton quota for other non-reduction uses. The regulations also specify an optimum yield for the reduction fishery ranging from zero to 220,000 tons depending on the size of the spawning population.

Although the northern anchovy is harvested by fisheries in Mexican as well as U.S. waters, there is no bilateral management agreement with Mexico. In the absence of such an agreement, fishery managers in the U.S. assume that U.S. fisherman are entitled to 70 percent of the total optimum yield and quotas are set on this basis. The assumption is based on an estimate that 70 percent of the shared northern anchovy resource is, on average, found in U.S. waters. The Mexican fishery is managed independently and is not restricted by a quota.

Economics explain a great deal about the current dynamics of anchovy fisheries in California, because the fisheries are more limited by prices and markets than by biological constraints. The price paid to fisherman for anchovy landed as live bait has been about $618 per ton. On this basis, revenues in the live bait fishery during 1989 were about $3.1 million. Although prices and revenues for live bait tend to be surprisingly high, annual catches have been modest because of market limitations.

During 1980 to 1988, the price paid for anchovy landed for non-reduction purposes other than live bait averaged about $261 per ton. As with live bait, market limitations have resulted in modest annual catches despite relatively high prices paid to fishermen.

The average price for anchovy landed by the U.S. reduction fishery during 1974 to 1988 was about $55 per ton, but the price paid during 1988 was only $29 per ton. Low prices, as well as market problems, have prevented a significant U.S. reduction fishery in recent years.

Northern anchovy, *Engraulis mordax*.

Status of Biological Knowledge

Northern anchovy are distributed from the Queen Charlotte Islands, British Columbia to Magdalena Bay, Baja California. The population is divided into northern, central, and southern subpopulations or stocks. The central subpopulation ranges from approximately San Francisco, California to Punta Baja, Baja California, with the bulk being located in the Southern California Bight.

Northern anchovies are small, short-lived fish typically found in schools near the surface. They rarely exceed four years of age and seven inches total length, although individuals as old as seven years and nine inches have been recorded. There is a great deal of regional variation in age composition (number of fish in each age group) and size at age with older fish and larger fish found at relatively offshore and northerly locations. In warm years relatively old and large fish are found farther north than during cool years. These patterns are probably due to northern and offshore migration of large fish, regional differences in growth rate, and water temperatures. Northern anchovies in the central subpopulation are typically found in waters that range from 54° to 71° F.

Information about changes in anchovy abundance during 1780 to 1970 is available from scales counted in sediment cores from the Santa Barbara basin. These data indicate significant anchovy populations existed throughout the time period and that biomass levels during the late 1960's were modest relative to those during most of the 19th and early 20th centuries.

The age at which northern anchovy become vulnerable to California fisheries depends on the location of the fishery and type of fishery. Fish become vulnerable to the inshore live bait fishery at an earlier age than they become vulnerable to the reduction fishery. However substantial numbers of zero and one year old fish are taken by both fisheries in most years.

Anchovy are all sexually mature at age two. The fraction of one-year-olds that is sexually mature in a given year depends on water temperature and has been observed to range from 47 to 100 percent. They spawn during every month of the year but spawning increases during late winter and early spring and peaks during February to April. Spawning has been observed over a temperature range of 54° to 71° F. Individual females spawn batches of eggs throughout the spawning season at intervals as short as seven to ten days. The eggs are found near the surface, and require two to four days to hatch, depending on water temperatures. Eggs and larvae are both found near the surface.

Northern anchovy are subject to intense predation throughout all life stages. Anchovy eggs and larvae fall prey to an assortment of invertebrate and vertebrate planktivores. As juveniles in nearshore areas, anchovies are vulnerable to a variety of predators, including birds and some recreationally and commercially important species of fish. As adults offshore, anchovies are fed upon by numerous marine fishes (some of which have recreational and commercial value), mammals, and birds, including the endangered California brown pelican. A link between brown pelican breeding success and anchovy abundance has been documented.

Northern anchovy eat plankton either by filter feeding or biting, depending on size of the food. Adult anchovy are known to filter anchovy eggs and it is possible that this type of cannibalism is an important factor in regulating population size.

Status of Population

Biomass of northern anchovy in the central subpopulation averaged 440,000 tons during 1964 to 1970, increased rapidly to 2,029,000 tons in 1974 and then declined to 543,000 tons in 1978. Since 1978, biomass levels have tended to decline slowly. Anchovy biomass during 1989 was 338,000 tons.

Maximum sustained yield of northern anchovy in the central subpopulation is estimated to be about 241,000 tons per year at a total biomass level of about 646,000 tons. However this harvest is a long-term average, and annual fluctuations are large.

Although total anchovy harvests and exploitation rates since 1983 have been below the theoretical levels for maximum sustained yield and historical levels, abundance continues to decline slowly. Annual harvests in the near future are expected to be lower because the Mexican reduction fishery has reportedly become unprofitable and has ceased operations. The size of the anchovy resource is now being determined mostly by natural influences.

Lawrence D. Jacobson
National Marine Fisheries Service

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