Pacific Hake

History of the Fishery

The Pacific hake (*Merluccius productus*), also known as Pacific whiting, makes up more than 50 percent of the potential annual harvest of West Coast groundfish off Washington, Oregon, and California and is the largest groundfish resource managed under the Pacific Fishery Council's Groundfish Management Plan. Pacific hake was considered an underutilized domestic species until 1991, the first year the entire harvest was captured and processed by the U.S. seafood industry.

A member of the cod family, Pacific hake is a delicate fish that requires careful handling to achieve a marketable product. The fish must be chilled, processed, and frozen soon after the harvest. Also, Pacific hake are infected with a myxosporidian parasite that can appear as black spots within the flesh. Protease enzymes associated with the parasite can cause degradation of the flesh if the fish are not handled properly.

The Pacific hake fishery is a high-volume, low-value fishery (ex-vessel prices have ranged from $0.025-$0.08 per pound). Its product contains, on average, about 15 percent protein and three percent fat. Domestic production had been primarily geared towards the frozen headed and gutted market, shipped in high volume on a penny-a-pound margin. However, with the growth of the domestic fishery in the 1990s, there has been significant growth in the production of surimi (fish paste), Individual Quick Frozen (IQF) fillets, and frozen blocks. Today 60 to 80 percent of production is surimi, 10 to 20 percent headed and gutted, 10 to 20 percent fillets. A significant proportion of the waste products is processed into fishmeal and fertilizers including hydrolosate and compost-based products.

Economic contributions to the Pacific Coast states of hake harvesting/processing vary according to product form and harvest/processing mode. Each pound harvested and processed in headed-and-gutted form contributes about $0.38 per round pound. For surimi, the state contribution is between $0.27 and $0.32 per round pound. In 1999, the hake fishery generated an estimated cumulative economic impact to West Coast states of between $134 and $185 million dollars.

The fishery has been multi-national in character, having been exploited commercially since before 1900 by the U.S. fishing industry and since 1966 by foreign fleets. A small domestic fishery has existed for coastal hake since at least 1879. Most catches prior to 1960 were made incidental to the pursuit of more valuable trawl-caught species and were either discarded or delivered to reduction plants producing animal food and fishmeal. The average annual California catch from 1959 to 1966 was 248 tons.

In 1964, the National Marine Fisheries Service (NMFS) demonstrated that large catches of hake (to 60,000 pounds per half-hour haul) could be achieved off coastal Washington and Oregon using newly developed depth telemetry systems on midwater trawlers. This fishery grew from 484 tons in 1964 to 15,883 tons in 1967.

Knowledge of the large hake resource off the West Coast attracted a large fleet of Soviet trawlers and accompanying support vessels in 1966. Between 1973 and 1976, Poland, the Federal Republic of Germany (West Germany), the German Democratic Republic (East Germany), and Bulgaria entered the fishery. Japan also participated in the fishery before 1977; their peak harvest was 9,104 tons in 1974. The estimated catches of Pacific hake during this period of expansion ranged from 130,000 tons to 262,000 tons. Catches peaked in 1976 and were subsequently reduced due to restrictions on foreign effort imposed by the Magnuson Fisheries Conservation and Management Act (MFCMA) of 1976.

Two types of fishing operations involving foreign vessels were conducted off Washington, Oregon, and northern California after the implementation of the MFCMA in 1977. In one fishery (the foreign trawl fishery or "directed fishery"), fish were caught and processed by foreign vessels. In a second fishery, known as the joint venture (JV) fishery, U.S. trawl vessels deliver their catch to foreign processing vessels at sea.

The joint venture fishery for Pacific hake started in 1978 between foreign nations and the United States and Canada. Consistent with the intent of the MFCMA to encourage development of domestic fisheries, landings of hake declined in the foreign directed fishery while increasing in the JV fishery. In 1978, the foreign catch amounted to 98 percent of the total hake catch in the U.S. management zone. The foreign catch declined to 11 percent of the total by 1988, and in 1989 there was no foreign catch. U.S. fishermen harvested the entire annual hake quota in 1989, eliminating the foreign directed fishery, and in 1991

Pacific Hake, *Merluccius productus*
Credit: DFG

domestic processors were able to process the entire catch thereby eliminating the JV fishery.

The phase out of foreign fisheries opened development to domestic fisheries. This took the form of domestic factory trawlers, which catch and process their catch, motherships which take fish at sea from catcher vessels, and the development of shoreside processing plants. Development was accelerated by the discovery of enzyme inhibitors that made it possible to utilize hake for surimi.

The domestic at-sea and shore-based fisheries grew through the 1990s with the at-sea sector harvest increasing from 4,700 tons in 1990 to 197,000 in 1991. The Pacific Fisheries Management Council (PFMC) reduced the at sea harvest in following years to allow growth in the shoreside sector. Prior to 1991, shore-based deliveries of Pacific hake were relatively small with an annual harvest of less than 10,000 tons. Between 1985-1991, the shore-based fishery concentrated off northern California with processing plants at Eureka and Crescent City. As the domestic shoreside fishery grew, additional processing plants were opened in Oregon and Washington. Shoreside deliveries increased from 8,115 tons in 1990 to 87,862 in 1998. In California, landings have increased from 41 tons in 1980 to about 11,000 tons in 1999.

In the early 1990s, fishing seasons began April 15. Since 1998, PFMC has used a season-ending, forward-counting protocol to estimate the season opening for the shore-based sector only (the offshore sector still opens May 15). Using October 15 as the season ending date, the PFMC estimates daily harvesting and processing capacity and shore-based quotas to determine the season opening date. The greater the quota or the lower the daily capacity, the earlier the season opening. Before 1995, the season opened April 15, between 1995 and 1998 the season opened May 15, (mostly to avoid salmon bycatch), and since 1998 the season has opened June 15. The shift in season opening date has had a significant effect on improving economic benefits (recovery, quality, price, and growth).

In 1996, the Makah Tribe in Washington requested an allocation of hake as part of its treaty entitlement. NMFS allocated 15,000 tons of the domestic TAC to the Makahs, increasing it to 25,000 in 1997 and 1998, and to 32,000 in 1999. The fish are harvested by Makah trawl vessels and delivered to a floating processor mothership. The fishery is limited to the Makah's "usual and accustomed" fishing grounds off the northern Washington coast.

In 1997, the PFMC adopted a sector allocation formula dividing U.S. non-tribal hake harvest guideline between factory trawlers (34 percent), vessels delivering to at-sea processors (24 percent), and vessels delivering to shore-based processing plants (42 percent). Shortly after this allocation agreement was approved by the PFMC, fishing companies with factory trawler permits established the Pacific Whiting Conservation Cooperative (PWCC). The primary role of the PWCC is to allocate the factor trawler quota between its members. Benefits of the PWCC include more efficient allocation of resources by fishing companies, improvements in processing efficiency and product quality, and a reduction in waste and bycatch rates relative to the former "derby" fishery in which all vessels competed for a fleet-wide quota.

The rapid development that took place in the 1990s has resulted in full utilization of the combined U.S. and Canadian hake catch. The 1994 combined catch reached 359,000 tons, the largest yield since the inception of the fishery. Since 1994, the total hake harvest has declined slightly, as biomass declined from high levels, and averaged 312,000 tons from 1996 to 1999.

Status of Biological Knowledge

Pacific hake are distributed from the Gulf of Alaska to the Gulf of California. Four major stocks have been identified within this area. The most abundant and widely distributed stock (which is the subject of this report) spawns between central California and northern Baja California and is referred to as the "coastal stock." Two of these stocks are generally referred to as the "inside stocks;" they live and spawn in Puget Sound and the Strait of Georgia. A fourth major stock occurs off the west coast of southern Baja California.

The hake that spawn in Puget Sound and Strait of Georgia are considered a separate genetic stock from oceanic coastal hake. These hake spawn and live their lives entirely within Puget Sound, are small in size (14 to 18 inches total length), and lack the specific myxosporidian parasite that causes rapid postmortem flesh decomposition in coastal stocks. The differences in parasitization between inside and offshore stocks indicate the absence of interchange between populations.

The oceanic coastal stock of adult Pacific hake is migratory and inhabits the continental slope and shelf within the California Current system from Baja California to British Columbia. It is often classified as a demersal species (living on or near the sea bed), but its distribution and behavior suggests a pelagic existence. It exhibits extreme night and day movement during spring and summer feeding migrations as it feeds on a variety of pelagic fishes or zooplankton. It is commonly found at depths of 160 to 1,500 feet but has been found from the surface to 2,600 feet.

Coastal Pacific hake are pelagic spawners that appear to spawn from January to March. The location of spawning

appears to center on the Southern California Bight, but spawning may take place within an area from San Francisco to Baja California at depths of 660 to 1,600 feet and as far as 300 miles offshore. Active spawners aggregate in loose, stationary bands that can be up to 150 feet thick.

Coastal stock females mature at 16 inches total length or larger, and at weights greater than 0.9 pounds. These minimum sizes are achieved by some three-year-old fish and most four-year-old fish. Fecundity estimates range from 80,000 to 500,000 eggs per female, depending on body size. The pelagic eggs drift with the ocean currents and hatch in about three days. Larval hake are abundant from December through April within 25 miles of the coast from central California to northern Baja California. Peak occurrences of eggs and small larvae pinpoint January and February as the chief spawning months. The majority of eggs and larvae are found over the areas of the continental slope where bottom depths ranged from 430 to 1,640 feet.

Hake reach about 70 to 75 percent of their maximum length and about 50 percent of their maximum weight by age 4.3 years. As hake get older, differential growth is observed between the sexes with females attaining larger lengths and weight at age than males. Average maximum sizes are 22 inches fork length (FL) and 2.25 pounds for males, and 24 inches FL and three pounds for females. The largest female hake measured off California was 34 inches FL.

In late winter, following spawning, adult hake migrate north in deep water overlying the continental slope to the summer feeding grounds off northern California, Oregon, Washington, and Vancouver Island. The peak period of northward migration appears to be in March and April. The migration behavior of hake is strongly age dependent, and influenced by oceanographic conditions. In warm years, a significant portion (up to 50 percent) of the stock may move into Canadian waters off Vancouver Island. Large adults may travel up to 1,100 miles, while newly mature hake may travel a maximum of 900 miles from southern California spawning grounds during the summer feeding period. Hake caught from Oregon to Vancouver Island range from 16 to 18 inches FL and are four to 10 years old. Young-of-the-year are usually concentrated off central and northern California, and one year old hake are found in nearshore waters from central California to northern Oregon.

Range extensions to the north occur during El Niños, as evidenced by reports of whiting from southeast Alaska during warm water years. During the warm periods experienced in 1990s, there have been changes in typical patterns of distribution. Spawning activity has been recorded north of California, and frequent reports of unusual numbers of juveniles from Oregon to British Columbia suggest that juvenile settlement patterns have also shifted northward. Because of this, juveniles may be subjected to increased predation from cannibalism and to increased vulnerability to fishing mortality.

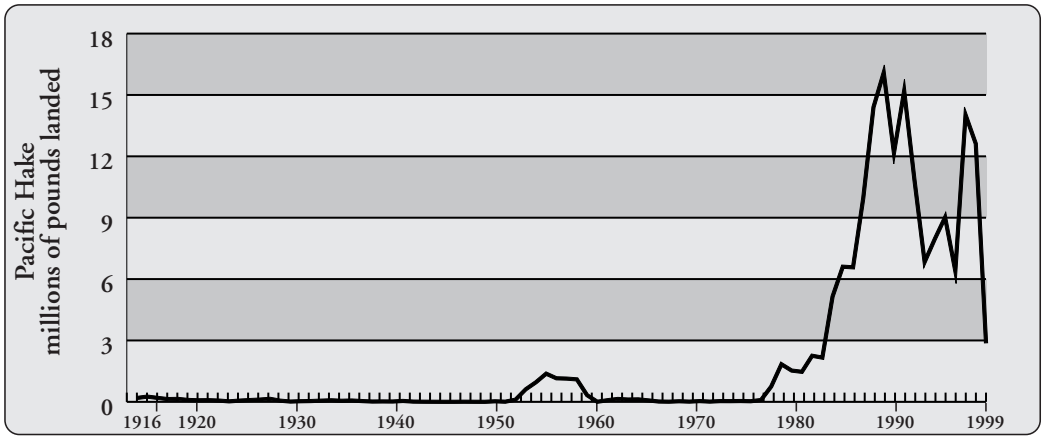
When northward-migrating hake inhabit waters overlying the continental shelf and slope, they form schools, which may be characterized as long, narrow bands whose axis is usually oriented parallel to the depth contours. Exceptions to this generality are those schools that align perpendicular to the edge of the continental shelf and extend offshore at a uniform depth, such that they are high-off the bottom over the continental slope. School sizes may vary in length from several hundred feet to 12 miles. The widths of schools have reached 7.5 miles at times. Most schools usually have a vertical height of 20 to 70 feet.

During the summer, when feeding adults are distributed over the continental shelf, schools exhibit pronounced movement into midwater associated with nighttime feeding activities. Hake feed during the evening on euphausiids, shrimp, and pelagic fishes. Vertical movement away from the sea bed occurs at nightfall and descent back towards the bottom occurs near dawn. At dawn, coastal hake descend and begin to regroup into schools near the sea bed (seven to 70 feet above the ocean floor), usually in the same area where they were the day before. The degree to which hake congregate during the day appears to be related to the type of food that was available during the feeding period. Schools are more dispersed when feeding on fish and other mobile nekton, but more compact when feeding on euphausiids.

The southward spawning migrations of the adults appears to occur in November and December, just prior to the spawning period. Availability of Pacific hake to bottom and midwater trawls off Oregon, Washington, and Vancouver Island drops sharply in November and is practically nil during winter.

Hake are a favorite prey for a great many creatures, especially marine mammals such as seals, sea lions, porpoises, and small whales. Hake have also been found

A catch of Pacific Hake is brought aboard
Credit: DFG



Commercial Landings 1916-1999, Pacific Hake
Data reflects commercial landings that occurred at California ports, but not foreign vessel catches landed outside of California. The reduction in commercial landings of Pacific Hake in 1960 is due to a change in the recording method for hake landed for animal feed. Data Source: DFG Catch Bulletins and commercial landing receipts.

in the stomachs of swordfish, lingcod, soupfin sharks, Pacific halibut, electric rays, and an assortment of other piscivorous fishes.

Status of the Population

The coastal Pacific hake stock is at moderate abundance. Stock biomass increased to a historical high of 5.7 million tons in 1987 due to exceptionally large 1980 and 1984 year classes, then declined as these year classes passed through the population and were replaced by more moderate year classes. The stock has fluctuated throughout its history from the irregular occurrences of strong year classes, which appear about every three or four years and remain in the fishery for about five to seven years. Recruitment is highly variable and appears to be strongly influenced by oceanic environmental conditions, especially water temperature at the time of spawning.

Over the past four years, stock size has been stable at 1.7 to 1.8 million tons. The mature female biomass in 1998 is estimated to be 37 percent of an unfished stock. Although 1998 stock size is near a historical low, it is close to average stock size under current harvest policies. The exploitation rate was below 10 percent prior to 1993, then increased to 17 percent during 1994-1998. Total U.S. and Canadian catches have exceeded the ABC by an average of 12 percent since 1993 due to disagreement on the allocation between U.S. and Canadian fisheries.

The prospects for the Pacific hake resource in the immediate future are for stable to slightly declining yields, depending on the timing of the next strong year class. An assessment survey conducted by the National Marine Fisheries Service in 1998 estimated the population biomass at 1.1 million tons, a decline of 15 percent from estimates made during a previous survey in 1995.

In the 1990s, hake recruitment averaged lower but was less variable than in the 1980s. If this pattern continues, the stock will continue to decline gradually. The most recent hake assessment projected a moderate decline in catches in 2001 as the 1994 year class, the most recent strong-year class, passes out of the population and is replaced by smaller sized year classes. However, the dependence of the hake population on occasional large year classes makes these projections highly uncertain. Widespread changes in California current ecosystem contribute to that uncertainty. A coastwide U.S.-Canada acoustic survey of the hake resource is planned for summer of 2001.

Management Considerations

See the Management Considerations Appendix A for further information.

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