

Dungeness Crab

History of the Fishery

Dungeness crabs (*Cancer magister*), also known as market crabs or edible crabs, were first taken commercially off San Francisco in about 1848. The fishery blossomed early, and now the California harvest of this important marine resource occurs from Avila to the Oregon border. Before the 1944-1945 season, the fishery was centered in the San Francisco area, and average annual statewide production was only 2.6 million pounds. The fishery expanded into the Eureka-Crescent City area as World War II ended. In the early 1940s, crab traps replaced the hoop net, leading to significantly increased landings with strong contributions from northern California. Annual statewide production since the 1945-1946 season has averaged about 10 million pounds and recent ex-vessel annual value has been about \$15 to 20 million. Approximately 75 percent of the catch is sold as whole crab (live, fresh-cooked or frozen) and the remainder is picked and vacuum packed.

The commercial fishery for Dungeness crabs occurs in two areas: northern and central California. Central California fishing areas include Avila-Morro Bay, Monterey, and San Francisco-Bodega Bay. The Morro Bay and Monterey fisheries have been of minor importance and San Francisco has always been the center of this fishery. Central California landings were relatively stable from 1945-1946 to 1955-1956, and peaked at 8.4 million pounds in the 1956-1957 season. The fishery then steeply declined at a rate of more than one million pounds per season until 1961-1962, when only 710,000 pounds were landed. The central California fishery remained seriously depressed from 1962-63 through 1984-85 when annual landings averaged less than one million pounds. More recent landings have averaged closer to two million pounds.

The central California fishery utilizes an area of over 400 square miles, including the Gulf of the Farallones north to the Russian River. The fleet consisted of 200 to 230 boats during the 1950s. When the fishery declined in the 1960s, a reduction in the number of boats followed and the fleet now consists of about 100 vessels. The central California crab fleet has evolved from, but still includes, some old "Monterey" style vessels. Larger multiple purpose vessels are now the norm.

The northern California fishery increased substantially after 1945. Landings reached an initial peak in the late 1950s but, unlike the central California fishery, which peaked and then experienced low production levels for many years thereafter, the north coast fishery then exhibited three 10-11 year "cycles" of production. In these repeating cycles, about six years of good or outstanding landings (a record 25.6 million pounds in 1976-1977) were followed by about four years of poor or extremely poor landings (as low as 350,000 pounds in 1973-1974). Since

1982-1983, landings have fluctuated much less dramatically and have not been as clearly cyclic. Recent landings have ranged from 2.2 to 13.1 million pounds and have averaged about 6.7 million pounds.

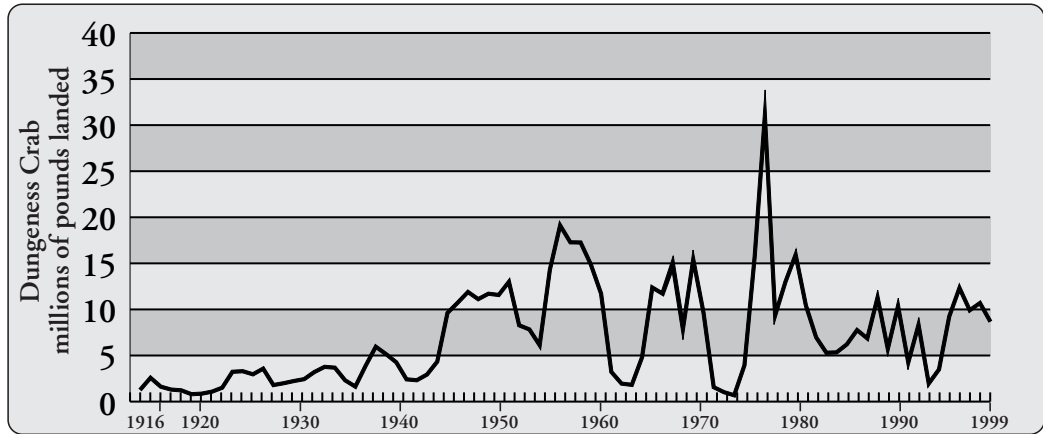
Dungeness fishing grounds off northern California are over twice the size of those in central California. They extend from Fort Bragg to the Oregon border with the prime area between Eureka and Crescent City. The northern California fleet fluctuated between 100 and 200 vessels in the 1950s and 1960s, dropped to a low of 61 in 1973-1974, then peaked at 410 during 1976-1977. Since then, effort has been high, averaging 330 vessels per season. Before the mid-1970s, most vessels were converted salmon trollers 30 to 60 feet in length; however, the complexion of the fleet changed during the record production years of the 1970s. Vessels ranging in size from 22-foot dories to trawlers in excess of 100 feet entered the fishery.

The dividing line for management of the northern and central California areas is the Mendocino-Sonoma county line. Both fisheries are managed on the basis of simple "3-5" principles – sex, season, and size. Only male crabs may be retained in the commercial fishery (thus protecting the reproductive potential of the populations), the fishery has open and closed seasons, and a minimum size limit is imposed on commercial landings of male crabs. The central California season opens the second Tuesday of November and continues through June 30, whereas the northern California season opens December 1 and continues through July 15. The summer-fall closed periods are intended to prevent fishing on male crabs when they are soft-shelled. At this time, male crabs would be vulnerable to fishery-related handling mortality and would have market quality well below their potential. During open seasons, male crabs should be in prime condition (greatest meat content) for the market. The opening and closing are two to three weeks earlier in central California than in northern California, because crabs in central California molt earlier and achieve adequate market condition earlier than in the north. The director of the department



Dungeness Crab, *Cancer magister*
Credit: DFG

**Commercial Landings
1916-1999, Dungeness Crab**
Data Source: DFG Catch Bulletins
and commercial landing receipts.

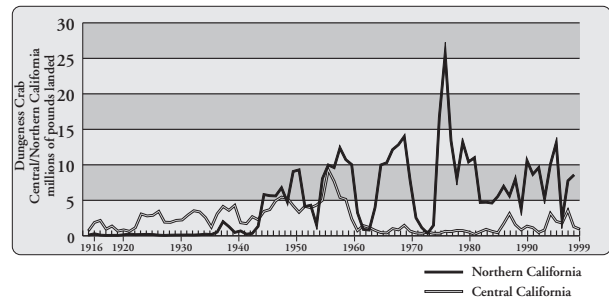


may delay the northern California season opening to as late as January 15, if market condition of crabs is not sufficiently high on December 1. Depending on crab condition, marketable crabs typically yield from 20 to 28 percent of their body weight as cooked meat.

Commercial gear for Dungeness crab is essentially the same throughout California. It consists of a circular steel trap three to 3.5-feet in diameter weighing 60 to 120 pounds. Each trap is required to have two 4.25-inch diameter circular openings to allow sublegal male and small female crabs to escape. These escape ports are remarkably effective in reducing handling of undersize crabs as most male crabs that are retained are close to or exceed the minimum size limit for males of 6.25-inches across the back. Traps must possess a destruction device that causes traps to open allowing crabs to escape should traps be lost. The heavily weighted traps rest on the bottom and each is buoyed independently to the surface. Traps are left overnight or longer depending on fishing conditions. Most traps are fished at depths ranging from about 60 to 240 feet, but some traps are fished in shallower and in deeper waters.

Almost all of the California Dungeness crab catch is landed in the commercial trap fishery. Trawl vessels are allowed an incidental take of 500 pounds per trip during the regular season, but only a few thousand pounds of trawl-caught crabs are landed annually in California. (Commercial trawling is prohibited within three miles of shore, where the vast majority of Dungeness are captured.) There is limited sport use of Dungeness crabs in central and northern California. The sport size limit is 5.75 inches across the back for either sex, and a limit of 10 crabs of either sex may be possessed. The annual sport harvest is believed to be less than one percent of the commercial take, but there have not been any recent estimates of total sport catch.

Because California Dungeness crabs are caught almost exclusively within three miles of shore and because California, Oregon and Washington often undertake coordi-

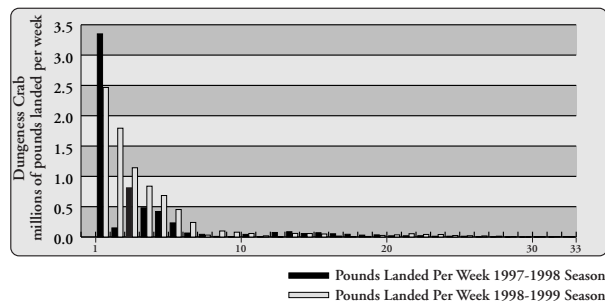


**Northern and Central California Landings Per Season
1916-1999, Dungeness Crab**

Seasonal landings for northern California, including Eureka, Crescent City, and Fort Bragg Landing, and central California including Bodega Bay, San Francisco Area, Monterey, and Morro Bay.

Note: data are recorded as seasonal landings, which differ from the DFG Catch Bulletin and commercial landing receipt data, which are reported on an annual basis.

Data Source: Seasonal Landings determined from reported commercial landings recorded by DFG Catch Bulletins and commercial landing receipts.



Commercial Landings by Week, Dungeness Crab

1997-1998 and 1998-1999, Dungeness Crab Catch data indicate consistent high early season landings of Dungeness crab.

Data Source: Seasonal landings determined from reported commercial landings recorded by DFG Catch Bulletins and commercial landing receipts.

nated management activities under the auspices of the Pacific States Marine Fisheries Commission, the fishery has remained under effective state jurisdiction despite repeated federal concerns regarding harvests beyond three mile state jurisdictional authority. Although total landings are not restricted by quota, beginning in 1995 California implemented a limited entry program that is designed to achieve an eventual reduction in the number of fishery participants. As of March 2000, limited entry permits have been granted to 604 California residents and 70 non-residents.

Status of Biological Knowledge

Dungeness crabs range from the eastern Aleutian Islands, Alaska, to perhaps Santa Barbara; however, the species is considered rare south of Point Conception. Temperature apparently determines the distribution, and the 38° to 65° F surface isotherms are considered the limits of the range. The geographic range of the species probably depends more on the restricted thermal tolerance range of larvae than of adults. Optimal temperatures for larval growth and development are 50° to 57° F.

This species has a preference for sandy to sandy-mud bottoms but may be found on almost any bottom type. Dungeness crabs may range from the intertidal zone to a depth of at least 750 feet, but are not abundant beyond 300 feet.

The resource off California has been demonstrated by tagging experiments to consist of five subpopulations: one each in the areas around Avila-Morro Bay, Monterey, San Francisco, Fort Bragg, and Eureka-Crescent City. As noted above, only the latter three are of commercial importance. DFG surveys indicate the combined San Francisco and Fort Bragg populations are not as large as the population extending from Eureka into Oregon. Little or no intermixing occurs. Tagging studies have also demonstrated random movement by both sexes. At times, an inshore or offshore migration is observed, but most movement is restricted to less than 10 miles. Travel up to 100 miles has been noted for individual males, but female movements seem much more limited.

Female molting and mating occur from February through June in California. Male crabs are able to sense when females are about to molt (presumably through detection of pheromones released by females) and carry such females in a protective pre-mating embrace for several days until they molt. Hard-shelled males then mate with the freshly molted, soft-shelled females. Sperm deposited by males are stored in a spermatheca inside the female. Fertilization of eggs takes place when internally-developing eggs are extruded between October and December.

Thereafter, they are carried beneath the abdominal flap of the female. The smallest females carry about 500,000 eggs and the largest from 1.5 to 2.0 million. Freshly molted females carry larger numbers of eggs than do gravid females that have missed a molt. "Skip-molt" females that have extruded eggs but have not molted recently must rely on stored sperm for fertilization of their eggs. Females may store viable sperm for at least 2.5 years. The eggs range in diameter from 0.016 to 0.024 inches and are bright orange after extrusion, becoming progressively darker as they develop. Hatching occurs between November and February.

The newly hatched larvae pass through five zoeal and one megalops stage before metamorphosing into the adult form. Larval development is inversely related to water temperature, and in central California 105 to 125 days are required to complete the larval stages. Zoeae are hypothesized to have an offshore movement regulated by factors such as depth, temperature, salinity and ocean currents. They are found near the surface at night and as deep as 80 feet in daytime. Megalopae are transported to nearshore waters beginning in April. Metamorphosis occurs from April to June. Estuarine areas such as Humboldt Bay and San Francisco Bay are important nursery areas for young Dungeness crabs, but most rearing must take place in nearshore coastal waters.

Growth is accomplished in steps through a series of discrete molts. In northern California, Dungeness crabs of both sexes molt an average of six times during their first year and attain an average width of one inch. Six more molts are required to reach sexual maturity at the end of their second year, when they are approximately four inches across. Once maturity is reached, growth of females then slows as compared to males. Females molt at most once per year after reaching maturity and rarely exceed the legal size of males. Maximum female size is about seven inches. Male crabs usually molt twice during their third year and once per year thereafter. The average size of males three, four and five years of age is about six, seven and eight inches, respectively. Males may undergo a total of 16 molts during a lifetime, reaching a maximum size of nine inches and age of six to eight years.

Dungeness crabs are opportunistic feeders not limited by abundance or scarcity of a particular prey. Clams, fish, isopods and amphipods are preferred, and cannibalism is prevalent among all age groups. Predators on the various life stages of Dungeness crabs, especially pelagic larvae and small juveniles, include octopuses, larger crabs and as many as 28 species of fish, including coho and chinook salmon, flatfishes, lingcod, cabezon and various rockfishes.

Status of the Population

Dungeness crab populations in California have been fully exploited for at least 40 years and intensity of fisheries is extreme. In most years, from 80 to 90 percent of all available legal-sized male crabs are captured in the fisheries. Although such high exploitation rates on adult males might give rise to concerns that female mating success might be reduced as a consequence, recent studies have shown that essentially all molting females receive attention from males in northern California. Usually one or no more than two year-classes of male crabs dominate annual landings. Thus, since about 1960, annual landings provide a reasonable notion of abundance of legal-sized males and also provide a strong signal of variation in year-class strength of recruited crabs. The dramatic decline in Dungeness crab catches in the central California fishery during the late 1950s focused considerable research attention on this resource during the 1970s. No definitive cause for the decline in the central California fishery has been established although researchers have assessed the possible effects of changes in ocean climate on survival and development of crabs eggs and larvae, the role of nemertean worm predation on egg survival, the effects of pollution on survival of juvenile crabs in San Francisco Bay, and possibly unstable internal population dynamics. Of these possible causes, a shift to warmer waters during and following the decline during the late 1950s seems the most plausible. If correct, the abundance of crabs in the central California fishery may improve over the next two decades if California coastal water temperatures remain cooler as a consequence of apparent ocean regime shifts.

The dramatic and periodic landings cycles that were exhibited in the northern California fishery from about 1945 to 1982 have caused this fishery to receive even greater attention from population dynamics modelers. Possible causes for the fluctuations in this fishery have included the nemertean egg predator, various internal density-dependent processes reflecting fluctuations in the abundance of unharvested females or cannibalism by adults on juveniles, and combinations of internal density-dependent controls and variable oceanographic factors. There seems little doubt that crab populations, with their extremely large fecundities and extremely vulnerable early larval stages, are prone to large natural fluctuations in abundance and that variable oceanographic factors (temperature, wind, currents) have important impacts on survival of year-classes.

Although many crustacean fisheries throughout the world have been overexploited and are now at low abundance levels compared to historic levels, Dungeness crab populations off northern California, Oregon and Washington have produced landings that have fluctuated around a fairly

stable long-term mean for more than 30 years. One might therefore consider this resource to have a healthy status. Compared to other fisheries of similar importance and economic value, however, the Dungeness crab has received less attention than other species. Among other things, no formal fishery management plans or stock assessments have been produced for any west coast populations. Fishery management has rested on the very simple, though biologically sound, 3-S principles and typically restrictive fishery regulations such as landings quotas have never been imposed on this fishery. A casual assessment of healthy status therefore rests on limited information.

Although imposition of limited entry in California should prevent any further increases in the total number of vessels that participate in the Dungeness crab fishery, it does not prevent increases in fishing effort - numbers of traps fished and the intensity with which they are fished. With declines in abundance and allowable landings of salmon and groundfish, many larger multipurpose vessels now devote greater attention to the Dungeness crab fishery and fish upwards of 1,000 traps. In the early season, these larger vessels fish continuously, day and night, even in heavy seas. Total annual landings are largely unaffected by such increases in trap-days of fishing effort, but increased fishing effort has produced substantial shifts in the distribution of catch over time. Prior to about 1980, crab landings were normally spread throughout the entire open season. In a typical recent season in northern California, more than 80 percent of total landings are made during the month of December.

Uncontrolled increases in the numbers of traps fished by individual vessels and the resulting front-loading of annual landings may have important consequences with respect to allocation of fishery income among limited entry permit holders. Also, the shortened period of substantial crab landings means that live Dungeness crab, the most valuable product, are available over a relatively short time period, thus possibly diminishing total economic value of the fishery.

These fishery economics issues are the subject of current research efforts.

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