

6. PISMO CLAM

Review of the Fishery

Commercial Pismo Clam Fishery

The Pismo clam, *Tivela stultorum*, gets its name from the Chumash Indian word “pismu,” meaning “tar,” because of the natural deposits of tar found in the Pismo Beach area. The Pismo clam is an important invertebrate species that once supported a significant commercial fishery, along with an extremely popular recreational fishery that still exists today. The commercial harvest of Pismo clams began in the early 1900s when horse-drawn plows were used to rake the beaches, and clams were hauled off in wagons for animal feed. The utilization of Pismo clam meat for human consumption grew to considerable importance by 1911, which led to the first regulations for managing the fishery (Table 6.1). Records of the commercial harvest of Pismo clams began in 1916, and continued through 1947 when the fishery was prohibited (Figure 6.1). During these 29 years, it is estimated that commercial diggers harvested 6.25 million pounds (2,834 metric tons) of Pismo clams (landings reported in round weight). Round weight is defined as the weight of the whole clam (including shell) before being processed. The average annual catch was nearly 100,000 pounds (45 metric tons) and the highest was 665,700 pounds (302 metric tons) in 1918. The sudden decrease in catch in 1942 was a result of beach closures by the U.S. Coast Guard that remained in effect during World War II. Overall, the commercial Pismo clam fishery was ranked third in economic importance to all mollusks, being exceeded only by oysters and abalone.

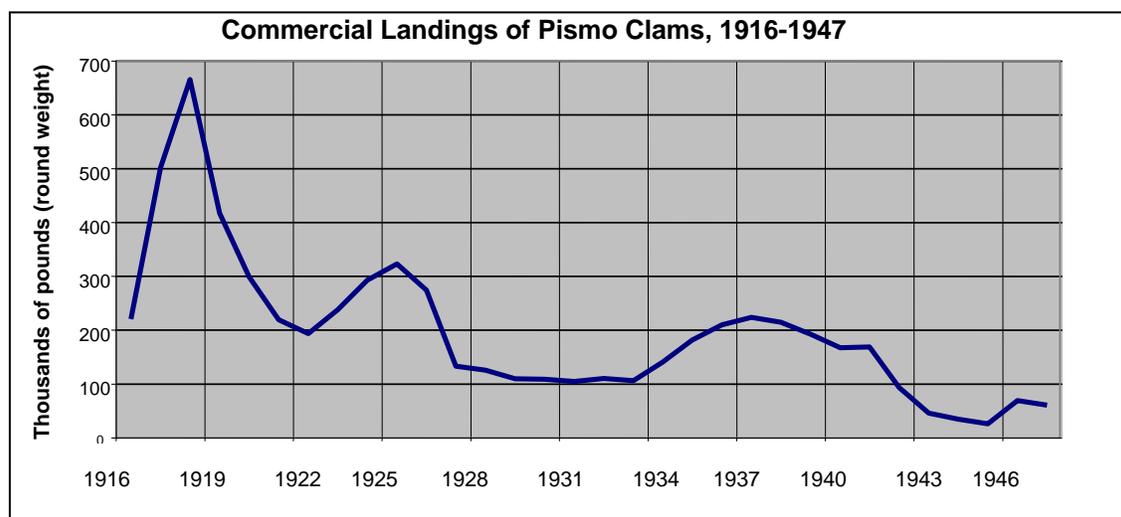


Figure 6.1. Annual commercial landings (pounds) of Pismo clam from 1916 to 1947. Data source: Bureau of Marine Fisheries (1949) Fish Bulletin with historical review (1916-1947).

The importation of Pismo clams from Baja California, Mexico occurred as early as 1919, and most likely continues to this day. In 1935, a total of 14,200 pounds (6.5 metric tons) of live Pismo clams were imported from Mexico to Long Beach, California, at which point they were shucked and canned. It is assumed that this venture was not economically successful, because no more clams were imported until 1941. Beginning that year, only the meat was imported to the U.S., the clams having been shucked at the beaches where they were dug. Shipments would arrive via boat, in 5-gallon (18-liter), refrigerated containers. At the U.S. canneries, the clams were cooked, minced, and packed into half-pound cans.

The importation of Pismo clam meat to canneries in California developed into an industry of considerable importance. From 1941 to 1947 the shipment of Pismo clam meat (reported in shucked weight) ranged from 10,800 pounds (4.9 metric tons) to 6.76 million pounds (3,069 metric tons) annually (Table 6.2). Shucked weight is defined as the weight of the clam meat after it has been processed. This development reached its peak in 1945 as a direct result of the tremendous demand put on all fishery products during World War II. The importation of Pismo clam meat stopped in 1949 due to logistical problems associated with shipping, and competition with other clam species in the U.S. domestic market. It is documented that Pismo clams were imported sporadically in small quantities up until 1962. After 1962 seafood imports from Mexico into the United States were not identified by species.

Mexican landing records for Baja California Norte show that from 1990 through 1999 Pismo clam landings ranged from a low of 822,000 pounds (373 metric tons) in 1994 to a high of 2.05 million pounds (930.7 metric tons) in 1992, with a 10-year average of 868,000 pounds (394 metric tons). In Baja California Sur, from 1978 to 1995, landings ranged from a low of 2.42 million pounds (1,098.6 metric tons) in 1984, to a high of 13.01 million pounds (5,906.5 metric tons) in 1981, with an 18-year average of 6.46 million pounds (2,933 metric tons). The total percentage of these landings imported into the United States cannot be determined.

Recreational Pismo Clam Fishery

Pismo clams remain an important sport fishery in California. They have a distinctive and excellent flavor; they are prepared as chowder, seafood cocktail, fried or eaten raw. Pismo clams have been linked to several human fatalities involving Paralytic Shellfish Poisoning (PSP). It is therefore advised that only the white meat be consumed and all dark meat and digestive organs be discarded.

The most common method of harvesting Pismo clams is with a six-tined potato fork. The digger works backward in a line parallel to the edge of the water probing with the fork, increasing the success rate with the broad side of the clam presented to the fork. Working parallel to the water is also a good safety practice

since it allows the digger to watch for approaching breakers. Once a clam is struck it is lifted out and measured and placed in a sack, if legal. Regulations require that all undersize clams be reburied in the area from which they were dug. Another method is to shuffle one's bare feet along the bottom until a siphon or shell is felt. Pismo clams can be visually spotted during low tide by looking for the tufts of commensal hydroids exposed above the surface of the sand.

Diving for Pismo clams has become an increasingly popular sport among the recreational community. Divers search just beyond the breakers by probing the sand with a knife or looking for siphons, exposed shells, or tufts of hydroids. Diving for Pismo clams is particularly effective on beaches with a steeper sloping gradient. These types of beaches receive less exposure during low tide, and most of the clams are found in water too deep to target with a potato fork.

The historic epicenter of recreational clamming activity was once Pismo Beach itself. In 1949, an estimated 5,000 diggers per day harvested more than 2 million clams over a period of 2.5 months on a stretch of beach that had just been reopened to digging after being closed for 20 years. During that time, an additional estimated 1 million undersized clams were left stranded on the surface and wasted on that same stretch of beach.



Pismo Clam, *Tivela stultorum*
Credit: Kai Lampson

The recreational digger has probably been the largest contributing factor to losses incurred in the Pismo clam population. Current regulations are in place to prevent such a massive depletion. Recreational clamming is regulated by a 10 per day bag limit and a minimum size of 5-inches (127-millimeters) north of the San Luis Obispo/Monterey county line and 4.5-inches (114-millimeters) south of this county line. Sub-legal clams must be immediately reburied. In addition, clamming is closed during parts of the year and in specific geographic locations (Table 6.1). Healthy populations of Pismo clams can be found from Santa Barbara County to the U.S. Mexico Boarder. Digging for Pismo clams is not nearly as popular as it once was. There are no current estimates for the number of people who participate in the fishery, but Pismo clammers probably number in the several thousands.

Sea otters have been blamed for the loss of the recreational clam fishery at Pismo beach since the estimated sport catch declined from 343,000 clams in 1978 to zero by 1983. In actuality, the loss of the fishery at Pismo Beach cannot be entirely attributed to sea otter predation. The Pismo clam population was being fully utilized by the recreational fishery prior to the sea otter's arrival; the otters simply tipped the balance and caused the population to collapse. There is some evidence to suggest that a Pismo clam fishery might be able to coexist in an area utilized by otters. Relatively low adult Pismo clam densities have produced successful sets in the past and could do so if sea otter foraging pressure was low. Sea otter pressure does decline in an area when the large peripheral male group moves on to new areas. Such an occurrence most likely explains the resurgence of a recreational fishery at Pismo Beach between 1990 and 1993. During this period sea otters were foraging offshore and in other areas. In 1992, sea otters were observed again foraging in the Pismo Beach area, and in 1993 the last take of a legal clam was reported.

Status of Biological Knowledge

The Pismo clam has two symmetrical shells that are hinged together with interlocking teeth at one end by a dark raised ligament. The shell is thick, and the outside is smooth with fine concentric growth lines. It is covered with what appears to be a thin coat of varnish, the periostracum, which cracks and peels off when the shell is exposed to direct sunlight. The shells of individual clams are highly variable in both color and pattern. The characteristic color and pattern is solid pale buckskin, though they range from this to dark chocolate. Some individuals are marked with chocolate brown lines radiating from the margin. Surveys have shown that these "striped" Pismo clams comprise about 5 percent of the total population. A third color pattern consists of three light streaks radiating from the margin, though these streaks generally disappear completely with age. The tendency for stripes or streaks is a natural variation and the sex of the clam cannot be determined by pattern.

In the majority of Pismo clams, the sexes are separate with an equal proportion of males and females represented in populations. Pismo clams mature after their first winter in southern California and after their second winter in central and northern California. Sexually mature clams have been noted as small as 0.5-inches (12.7-millimeters) in shell length. Spawning usually begins in late July or early August and continues through November. Fertilization occurs externally when the male releases sperm and the female releases eggs into the surrounding water. The number of eggs per female is proportional to a clam's size. In laboratory-held clams, a 1.2-inch (30.5-millimeter) female contained 0.4 million eggs, and a 2.9-inch (73.7-millimeter) female had 4.7 million eggs. In comparison, a 5-inch (127-millimeter) female averages 15 million eggs. In nature, less than 1 percent of these eggs would become mature clams. Historic surveys have documented poor survival rates. For example, in one year only 33,000 clams resulted from an estimated 120 trillion eggs spawned. The mechanisms that cause these extremely high mortality rates and poor recruitment are not completely understood. Large surf, strong currents, shifting sand, red tide events, and sudden changes in temperature or salinity may all be contributing factors. Once a clam has settled out of the water column and onto the substrate, it is less susceptible to these forces, though mortality rates remain very high. Oil and other pollutants also play an important role in the mortality rate of the Pismo clam.

Little is known about the larval stages of the Pismo clam in nature. In laboratory culturing experiments, fertilized eggs hatched into larvae within approximately 48 hours. Laboratory larvae 60 to 70 hours old displayed the behavior of settling to the bottom and remaining benthic or near benthic throughout larval development. If larval Pismo clams in nature also exhibit a benthic phase, larval transport by near-shore currents may be limited, and recruitment would have to occur locally. At 22 to 55 days old clams have completely metamorphosed, developed a foot, and anchored themselves to sand grains with their thread-like byssus. The byssus helps the clam maintain itself in an environment of constantly moving sand and wave turbulence. As the clam increases with size the byssus disappears, and the clam's weight and burrowing power helps to maintain its relative position on the beach. Pismo clams characteristically orientate themselves vertically with the hinge and ex-current siphon towards the ocean, the mantle edge and in-current siphon towards the beach, and with the ligament at the center of the hinge oriented up. Pismo clams usually live in the intertidal zone on flat beaches of the open coast, but they have been found out to depths of 80 feet (24.4 meters), and are sometimes encountered in the entrance channels to sloughs, bays and estuaries. Their normal depth in the sand is 2 to 6 inches (51 to 153 millimeters). Burrowing is accomplished by moving the foot rapidly to loosen the surrounding sand. Jets of ejected water then help to further loosen the sand along the sides of the shell.

The weight of the clam and the pull of the foot together drag the clam down through the sand.

The largest Pismo clam recorded in California came from Pismo Beach and was 7.37-inches (18.7-centimeters) across and estimated to be 26 years old. However, the size of a clam does not directly correlate with its age. A number of clams from Southern California have been aged as being over 35 years, though the majority of these clams were less than 6.5-inches (16.5-centimeters) across. The oldest Pismo clam on record was collected from Zuma Beach, California and was estimated to be 53 years old, measuring only 5.25-inches (13.3-centimeters) across. The age of Pismo clams can be determined by the concentric growth rings on the shell. The rings alternate from darker to lighter color, and are usually formed during the fall and winter months when the clam is exposed to prolonged periods of disturbances, or during the spawning period.

The Pismo clam grows continuously throughout its life. As it grows the shell not only becomes thicker but increases in diameter. Growth varies considerably from month to month, with the greatest increase taking place in the spring, summer, and early fall months. The Pismo clam is about 0.009-inches (0.23-millimeters) at metamorphosis, and grows at an average rate of 0.084-inches (2.1-millimeters) for the first three years. Growth slows considerably as the clam ages, with the increase in shell length not more than 0.2-inches (5-millimeters) per year at age 10. Growth rates are dependent on water temperature and vary among beaches. A 4.5-inch (11.4-centimeter) clam could be from 5 to 9 years old. Along the central coast of California, clams are estimated to reach 4.5-inches (11.4-centimeters) between ages 7 and 8.

Fossil remains of Pismo clams have been found in Pleistocene deposits at least 25,000 years old in Santa Barbara and San Diego Counties. Thus the species has been present along our coast since the time of the last ice age. The Pismo clam belongs to the Veneridae family, which is characteristic of tropical seas. Though the Pismo clam is not tropical in distribution, it prefers warmer waters, being historically recorded from Half Moon Bay, California, to Socorro Island, Baja California Sur, Mexico. However, it has not been found at Half Moon Bay for decades, and its present range extends northward only to Monterey Bay. Pismo clams have been historically found at three of the Channel Islands: Santa Cruz, Santa Rosa, and San Miguel islands. Healthy populations are known to currently exist at Santa Cruz and Santa Rosa islands, while San Miguel Island has not been surveyed for Pismo clams.

Unsuccessful attempts have been made to introduce Pismo clams as far north as Washington State. Pismo clams do not fare well in extremely cold water, and are very susceptible to freezing temperatures during low tide due to their shallow orientation in the sand. Surveys have shown that Pismo clams that have been translocated north of their historic range usually die within the first year of being planted.

The Pismo clam is a detritus filter feeder, although living single-cell organisms comprise a considerable portion of the diet. Water is taken in through the in-current siphon that has a very fine net of delicately branched papillae across the opening. The net forms a screen that excludes the entrance of large particles, but permits the intake of water and food, which then pass over the gills where food particles are trapped in strings of mucus. The mucus is brought directly into the stomach where food is carried towards the liver, and larger particles are expelled through the intestine. Despite this elaborate system, more than half of the contents of the stomach and intestine are sand.

The types of food utilized by Pismo clams include detritus from disintegrating plant and animal cells, phytoplankton, zooplankton, eggs and sperm, and bacteria. A 3-inch (7.6-centimeter) Pismo clam filters an average of 15.9 gallons (60 liters) of water during its feeding per day or 482 gallons (1,824 liters) a month. This amounts to approximately 5,790 gallons (21,915 liters) of water per year being strained by one 3-inch (7.6-centimeter) clam.

Pismo clams have many natural predators: humans, sharks, rays, gulls; moon snails, *Polinices spp.*; crabs; sea otters, *Enhydra lutris*; and some species of surf fishes (such as the California corbina, *Menticirrhus undulatus*). Humans have utilized Pismo clams for food for over 2,000 years, as evident from shells and fragments found in the kitchen middens of Native Americans. Bat rays, *Myliobatis californica*, have developed an efficient technique to pull clams from their beds by using their “wings” to establish a suction force similar in manner to the way a plumber’s helper clears the drain of a kitchen sink. After the clams have been sucked from the sand, the ray can simply pick up, crush and swallow them. Gulls have learned to open live clams up to 3-inches (7.6-centimeters) in diameter by carrying them up to 50 feet (15 meters) into the air with their beaks and dropping them onto hard-packed sand. It only takes several attempts before the Pismo’s shell shatters, or the abductor muscle tears, and the soft flesh is exposed. The moon snail drills a tiny hole in the clam’s thick shell with a rasping tongue or radula. Once the hole is completed the snail inserts its radula to remove the soft flesh. Several crabs of the genus *Cancer* also feed upon Pismo clams. These crabs are able to crack clams up to 1-inch (25.4-millimeters) in diameter with their pincers.

Sea otters, efficient in harvesting Pismo clams, can quickly denude a local clam bed of everything except for small individuals. An adult sea otter needs to consume roughly 25 percent of its body weight each day in order to survive. An average male sea otter weighs 65-pounds (29.5-kilograms) and the females average 45-pounds (20.4-kilograms). This amounts to roughly 80 clams per otter per day if Pismo clams are their primary food source. A single otter has been observed to eat 24 clams in 2.5 hours. The extension of the sea otter’s range to Monterey Bay in 1972, Morro Bay in 1973 and Pismo Beach in 1979 has precluded the recreational fishery for Pismo clams in those areas. In 1980, it

was estimated that otters consumed over 700,000 Pismo clams in the Pismo Beach area.

Parasites of Pismo clams include a polychaete worm that bores into the shell, and the more common larval cestodes, which occur as small yellowish-white cysts. About one-third of all large Pismo clams are infected with cestodes. These cestodes have been identified as the larval stage of a tapeworm that infects stingrays and skates. Cestodes can impair the clam's sexual development but are in no way harmful to humans. Trematodes have also been reported in some clam populations. A commensal hydroid colony, *Clytia bakeri*, is often found attached to the edge of the shell nearest the surface, resembling a hairy tuft. Much less common are small, white, commensal pea crabs, *Fabia spp.*, (which are occasionally found in the mantle cavity of clams and feed on food particles collected in the gills).

Status of the Population

Over the past century, Pismo clam abundance has seriously declined in many parts of its historic range due to a number of fishery-dependent and fishery-independent factors. Historical observations have shown that Pismo clam populations are resilient and have the ability to rebound after just a few years of successful recruitment. The Department of Fish and Game first examined recruitment in 1919, and annual surveys have been conducted from 1923 to 2000 to obtain information on age, recruitment, year strength, and exploitation trends. Originally only Pismo Beach was surveyed, but after 1948, beaches in Morro Bay, Cayucos, Monterey County, and from Santa Barbara County to San Diego County were included. From 2000 to 2005 only Coronado Beach in San Diego County has undergone an annual survey by the Department of Fish and Game.

Surveys conducted from 2000 to 2005 at Coronado Beach indicated that the Pismo clam population was relatively stable and that some recruitment was taking place. Recent reports from clam diggers, as well as divers indicate that significant numbers of Pismo clams continue to be harvested from some of the beaches in southern California. In addition, Pismo clam populations at the Channel Islands appear to be stable, as shown by surveys conducted by the National Park Service.

Management Considerations

Past experience has shown that planting Pismo clams will most likely not expand the present range of the species, nor would it be expected to re-establish a population where the native stock is depleted. The spawn from planted clams would not help to repopulate a beach where the environmental conditions (shifting sand, erosion, pollution, etc.) are keeping the existing native population

at a low level. Pismo clams were sporadically planted on beaches from Washington to the Mexican border from 1900 to 1989 with extremely low survivorship. None of the clams planted north of Monterey Bay survived more than three years after being relocated, with an average survivorship of less than one year. Even under optimal conditions, considering natural mortality, not more than 200 out of 1,000 one- or two-year old clams would be expected to reach legal size.

In southern California, the planting of large clams has paradoxically had a negative effect on local populations. News of a planting project eventually spreads, and the public turns out in mass to search for these clams. Not only are the planted clams immediately removed, but most of the native stock is also taken and the beach is left more barren than before the project. Past projects have shown that even if the clams are planted in Marine Protected Areas they are nevertheless not safe from poaching activities.

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Further Reading

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| Table 6.1. Regulations governing the take of Pismo clams, 1911 - present | | | |
|--|--|------------------|--|
| Year | Minimum Size Limit | Bag Limit | Remarks |
| 1911 | 13 inches circumference (about 4 ⁷ / ₈ inches diameter) | 200 | license required for sale of Pismo clams |
| 1915 | 12 inches circumference (about 4 ¹ / ₂ inches diameter) | 50 | |
| 1917 | 4 ³ / ₄ inch diameter | 50 | Monterey Bay between Pigeon Point and Yankee Point open only between September 1 and April 30. All other areas open year round. |
| 1921 | 4 ³ / ₄ inch diameter | 36 | |
| 1927 | 5 inch diameter | 15 | Shipping of clams by common carrier prohibited and no clam out of the shell may be possessed unless being prepared. |
| 1931 | 5 inch diameter | 15 | Sport fishing license required to take Pismo clams |
| 1933 | 5 inch diameter | 15 | No digging for clams between ½ hour after sundown and ½ hour before sunrise. No clam digging implements in possession on beach during these hours. |
| 1947 | 5 inch diameter | 15 | No Pismo clams taken in California can be sold |
| 1948 | 5 inch diameter | 10 | |
| 1949 | 5 inch diameter | 10 | All undersized clams must be returned from the hole which dug or to deep water. |
| 1986 | 5 inch diameter north of the boundary between San Luis Obispo and Monterey counties 4 ½ inch diameter south of the boundary between San Luis Obispo and Monterey counties | 10 | May be taken in Santa Cruz and Monterey counties September 1 through April 30. In all other counties, except in state marine reserves or other marine protected areas which prohibit the take of clams, Pismo clams may be taken all year. |
| Data source is the Bureau of Marine Fisheries, California Division of Fish and Game (1950) Fish Bulletin (1911-1949) and California Code of Regulation, Title 14. Natural Resources (2005) | | | |

Table 6.2. Commercial landings of Pismo clams (round weight in pounds) in California and imports of shucked meat (pounds) from Mexico, 1916-1947

| Year | Landings From California | Imports From Mexico | Year | Landings From California | Imports From Mexico |
|------|--------------------------|---------------------|------|--------------------------|---------------------|
| 1916 | 220,600 | ----- | 1932 | 110,300 | ----- |
| 1917 | 502,100 | ----- | 1933 | 106,200 | ----- |
| 1918 | 665,700 | ----- | 1934 | 140,700 | ----- |
| 1919 | 417,500 | ----- | 1935 | 181,900 | *14,224 |
| 1920 | 299,000 | ----- | 1936 | 209,800 | ----- |
| 1921 | 219,500 | ----- | 1937 | 224,000 | ----- |
| 1922 | 193,500 | ----- | 1938 | 214,600 | ----- |
| 1923 | 237,900 | ----- | 1939 | 192,700 | ----- |
| 1924 | 293,100 | ----- | 1940 | 167,500 | ----- |
| 1925 | 323,200 | ----- | 1941 | 168,800 | 10,837 |
| 1926 | 274,300 | ----- | 1942 | 93,600 | 90,979 |
| 1927 | 133,000 | ----- | 1943 | 45,900 | 565,764 |
| 1928 | 125,800 | ----- | 1944 | 34,500 | 1,464,974 |
| 1929 | 109,700 | ----- | 1945 | 26,100 | 6,676,775 |
| 1930 | 108,900 | ----- | 1946 | 69,200 | 1,426,062 |
| 1931 | 104,700 | ----- | 1947 | 60,600 | 159,968 |

----- No Pismo Clams were imported

* Live weight reported on fish receipts have been divided by 8 to supply the cleaned weight given here.
Data source is Bureau of Marine Fisheries (1949) Fish Bulletin with historical review (1916-1947).