Fishery-at-a-Glance: Pismo Clam

Scientific Name: *Tivela stultorum*

Range: Historically, populations of Pismo Clams were found from Half Moon Bay, California, to Socorro Island, Baja California Sur, Mexico. Their present known range in California is from Monterey Bay to Coronado Beach.

Habitat: Pismo Clams usually inhabit the intertidal zone of flat beaches along the open coast, but can be found in water depths of up to 80 ft (24 m). They are also found in the entrance channels to sloughs, bays, and estuaries. They bury themselves in the sand, usually between 2 to 6 in (50 to 150 mm) deep.

Size (length and weight): Pismo Clams generally reach lengths of XX in (XX cm) across and weights of XX lbs (XX g). The largest clam on record was found at Pismo Beach, California, and measured 7.37 in (18.72 cm) across.

Life span: The oldest Pismo Clam on record was collected from Zuma Beach, California, and was estimated to be 53 years old.

Reproduction: Pismo Clams in southern California mature after their first winter while clams in central California mature after their second winter. Clams may mature at sizes as small as 0.5 in (15 cm) 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.

Prey: IPismo Clams are filter feeders, and eat detritus from disintegrating plant and animal cells, phytoplankton, zooplankton, eggs and sperm, and bacteria.

Predators: Common predators of Pismo Clams include humans, sharks, rays, Bat Rays (*Myliobatis californica)*, gulls, moon snails (*Polinices* spp.), crabs, Sea Otters (*Enhydra lutris)*, and surf fishes such as California Corbina (*Menticirrhus undulatus*).

Fishery: Since 1947 the Pismo Clam fishery has been recreational only.

Area fished: Central California to Baja California, Mexico. The majority of the recreational catch in California has occurred in Southern California.

Fishing season: Pismo Clam take is legal in Santa Cruz and Monterey counties from September 1st through April 30th.1 September to 30 April. Take is legal year-round in all other counties.

Fishing gear: Spades, shovels, hoes, rakes, or six-tined potato fork for digging, a knife when diving, or other tools operated by hand except spears or gaff hooks.

Market(s): The sale of Pismo Clams taken in California has been illegal since 1947.

Current stock status: No current estimates of population abundance in California exist. 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. 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. In addition, Pismo Clam populations at the Channel Islands appear to be stable, as shown by surveys conducted by the National Park Service (NPS). Additional studies of abundance and density are underway by multiple researchers.

Management: State-managed as a recreational fishery only, with seasonal, size, and bag limit of 10 clams per day. In Monterey and Santa Cruz counties the open season is from September through April, while fishing is allowed year round south of Monterey There are minimum size limits in effect north of Monterey County of 5 in (13 cm) and south of San Luis Obispo County of 4.5 in (11 cm). Stocking beaches with juvenile clams from 1900 to 1989 was not effective in increasing local clam populations.

1 The Species

1.1 Natural History

1.1.1 Species Description

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 (Pattison 2006). Pismo Clams have two symmetrical shells that are connected 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. Typically, shells are pale buckskin in color, though they can range from white 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 (Pattison 2006).

1.1.2 Range, Distribution, and Movement

The Pismo Clam belongs to the Veneridae family, which is characteristic of tropical seas. Though the Pismo Clam is not tropical in distribution, it does prefer warmer temperate waters, with historical distributions from Half Moon Bay, California, to Socorro Island, Baja California Sur, Mexico (Pattison 2006). Fossil remains of Pismo Clams have been found in Pleistocene deposits at least 25,000 years old in Santa Barbara and San Diego Counties, indicating the presence of the species along the California coast since at least the last ice age (Masters 2006). However, its present range extends northward only to Monterey Bay, as Pismo Clams has not been found at Half Moon Bay for decades (Pattison 2006).

Pismo Clams have historically been found at three of the Channel Islands: Santa Cruz, Santa Rosa, and San Miguel (Pattison 2006). The distribution of Pismo Clams at island beaches is more limited than on the mainland, and the density of clams is much lower at island beaches.

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.

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1.1.3 Reproduction, Fecundity, and Spawning Season

Spawning usually begins in late July or early August and continues through November. Fertilization occurs externally when males release sperm and females release 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 in (30.5 mm) female contained 0.4 million eggs, and a 2.9 in (74 mm) female had 4.7 million eggs. In comparison, a 5 in (120 mm) female averaged 15 million eggs (Pattison 2006).

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 smaller clams maintain their position 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.

1.1.4 Natural Mortality

Natural mortality of juvenile Pismo clams is very high, and it is estimated that less than 1 percent of fertilized eggs become mature clams (Pattison 2006). Historic surveys have documented poor survival rates. For example, in one year only 33,000 clams resulted from an estimated 120 trillion eggs spawned (Pattison 2006). 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 (Pattison 2006).

1.1.5 Individual Growth

The oldest Pismo Clam on record was collected from Zuma Beach, California and was estimated to be 53 years old, measuring only 5.25 in (13.3 cm) across (Pattison 2006). 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 prolong periods of disturbance from storms, or during the spawning period.

The Pismo Clam grows continuously throughout its life, with the shell increasing in diameter and thickness. 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 in (0.229 mm) at metamorphosis, and grows at an average rate of 0.084 in (2.13 mm) for the first three years (Pattison 2006). Growth slows considerably as the clam ages, with the increase in shell length not more than 0.2 in (5 mm) per year

at age 10 (Pattison 2006). Growth rates are dependent on water temperature and vary among beaches (Pattison 2006). A 4.5 in (11 cm) clam could be from 5 to 9 yr in age. Along the central coast of California, clams are estimated to reach 4.5 in (11 cm) between ages 7 and 8 (Pattison 2006).

1.1.6 Size and Age at Maturity

The sexes are separate with an equal proportion of males and females represented in most 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 in (1.3 cm) in shell length (Pattison 2006).

1.2 Population Status and Dynamics

1.2.1 Abundance Estimates

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 first examined recruitment in 1919, and annual surveys were conducted from 1923 to 2000 to obtain information on age, recruitment, year-class 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.

In a study of 36 sandy beaches from Santa Barbara, Ventura, and Los Angeles County from 1986 to 1996, Dugan and others (2000) found that when present, Pismo Clams had densities of 32 to 770 clams per m (9 to 235 clams per ft) on mainland beaches, and 1 to 23 clams per m (1 to 7 clams per ft) on island beaches.

In addition, Pismo Clam populations at the Channel Islands appear to be stable, as shown by surveys conducted by the NPS.

Santa Cruz County

Since 2008, the Department has executed semi-annual field reports at Sunset Beach and Palm Beach in Santa Cruz County. Reilly's results displayed that although the 2011 Pismo Clam abundance was the lowest since the surveys at Sunset Beach started in 2008, the 54.2 mm (2.13 in) mean length was the longest within the time series (2011). More recently in 2015, Reilly highlighted that the previous 6.5 years of data in field reports have shown a decline in average density with rare evidence of recruitment, and as a result they decided to forego future studies until an exploratory study indicates potential for the species to return (2015).

Monterey County

None available at this time.

San Luis Obispo County

Most recently Pismo Clams had appeared and disappeared again at Pismo Beach reported by Lieutenant Tognazzini (personal communication in 2018 with Skinner-Horne and Willis) who had noted a recruitment of juveniles in 2015, and later no more clams were present. This was similar to his observations in the 1970s when the clams disappeared then returned, and this happened again in the 1990s (Skinner-Horne and Willis personal communication with Lieutenant Tognazzini unpublished 2018). While there were no citations written for illegal take of Pismo Clam until 2016, there were 83 citations written at Pismo Beach in 2017, with 2,581 Pismo Clams seized (Skinner-Horne and Willis Table 1 CDFW Wardens citation 1 January 2017 to 31 December 2017). Department wardens wrote 155 citations for the illegal take of 3,574 undersized clams from January to August 2018, which illustrates the public's continued interest in clamming despite the size restrictions (CDFW Warden Citations 1 Jan 2018 to 24 August 2018).

In February, 2015 at Pismo Beach, Department staff Stein and Michniuk assessed the condition of the local population to be poor, as they did not find any live Pismo Clams within their transect over a 2 hour period except for those discarded by seabirds.

Santa Barbara County

According to Green's 2015 study of Pismo Clam size and abundance between intertidal and subtidal regions at Rincon Beach, Pismo Clams were significantly more abundant, but significantly smaller, in the intertidal zone than in the subtidal zone. There was no difference in distribution of sub-legal clams between the two zones, but there were significantly more legal sized clams in the intertidal zone. Green suggested that these patterns could be attributable to recreational fishing pressure, non-human predators, and disturbance from wave action (2015).

In April, 2013 the Department conducted a Field Report at Rincon Beach in Santa Barbara County, which yielded higher clam counts than at any other Department survey locations in California, yet only one clam was of legal size (Evans and Van Meeuwen 2013). The 2013 report stated that given the abundance at this site and average clam growth rates, it is likely that in two to three years there will be an increase in legal sized clams, if no abnormal weather events or poaching occurs. Evans and van Meeuwen determined that a majority of clams from Rincon Beach were in the offshore locations from depths of 101 to 195 ft (30.8 to 59.4 m) and that they were larger in size than the onshore samples (2013).

San Diego County

Annual surveys conducted by the Department from 2000 to 2005 at Coronado Beach indicated that the Pismo Clam population was relatively stable and that some recruitment was taking place. At the time of this study, reports from clam diggers, as well as divers, indicated that significant numbers of Pismo Clams continued to be harvested from some of the beaches in southern California.

1.2.2 Age Structure of the Population

The largest Pismo Clam recorded in California came from Pismo Beach and it was 7.37 in (18.7 cm) across and estimated to be 26 years old (Pattison 2006). 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 in (16.5 cm) across (Pattison 2006).

1.3 Habitat

Pismo Clams bury themselves in sandy areas, and they characteristically orient 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 ft (24 m), and are sometimes encountered in the entrance channels to sloughs, bays and estuaries. Their normal depth in the sand is 2 to 6 in (50 to 150 mm). They rely on sandy low tide terraces, or a moderately steep beach faces attached to a shallow terrace that is exposed at low tide made of fine to medium grained sand. 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.

1.4 Ecosystem Role

A 3 in (7.6 cm) Pismo Clam filters an average of 15.9 gal (60.2 l) of water during its feeding per day, or 482 gal (1,820 l) a month. This amounts to approximately 5,790 gal (21,920 l) of water per year being strained by one 3 in (7.6 cm) clam (Pattison 2006).

1.4.1 Associated Species

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 not 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 gill (Pattison 2006).

1.4.2 Predator-prey Interactions

The Pismo Clam is a detritus filter feeder, although living single-cell organisms comprise a considerable portion of the diet. The types of food utilized by Pismo Clams include detritus from disintegrating plant and animal cells, phytoplankton, zooplankton, eggs and sperm, and bacteria.

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.

Pismo Clams have many natural predators: humans, sharks, rays, gulls, moon snails (*Polinices* spp.), crabs, Sea Otters (*Enhydra lutris)*, and species of surf fishes such as the California Corbina, *Menticirrhus undulatus*. Humans have utilized Pismo Clams for food for over 2,000 yr, 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 plunger clears a drain. 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 in (7.6 cm) in diameter by carrying them up to 50 ft (15 m) into the air with their beaks and dropping them onto hard-packed sand. It can take 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 in (25.4 mm) 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 lb (29.5 kg) and the females average 45 lb (20.4 kg). 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 hr (Pattison 2006). 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 (Pattison 2006). In 1980, it was estimated that otters consumed over 700,000 Pismo Clams in the Pismo Beach area (Pattison 2006).

1.5 Effects of Changing Oceanic Conditions

Pismo Clams may be impacted by habitat changes stemming from increased storm activity. Pismo Clams depend on a sandy low tide terrace, or a moderately steep beach face attached to a shallow terrace that is exposed at low tide made of fine to medium grained sand. During periods of intense storms associated with the El Niño-Southern Oscillation (ENSO), sandy beaches experience changes in wave activity, resulting in sediment transport rate and direction changes which can cause a loss of sand to deep water (Masters 2006), and thus a loss of suitable habitat.

Alvarado-Alvarez et al. found a decrease in Pismo Clam fertilization rates at pH values of less than 8.5 in the lab studies (1996). As oceans become more acidic in response to elevated atmospheric concentrations of carbon dioxide, Pismo Clam populations could be negatively impacted.

2. The Fishery

2.1 Location of the Fishery

The historic epicenter of recreational clamming activity was Pismo Beach. Pismo Beach was named after “Pismu” the Chumash Indian village name that was next to a tar spring, and the name for tar which was important to the Chumash people to seal their baskets and canoes (Cuddy 2014). The recreational fishery has only been in California since 1947, with commercial fishery persisting in Baja until xxxx. Currently, the population is now centered near Rincon Beach in Santa Barbara County. The more recent surveys indicate the presence of Pismo Clams in California from Monterey Bay to San Diego County, with the healthiest populations from Santa Barbara County southward.

2.2 Fishing Effort

2.2.1 Number of Vessels and Participants Over Time

Given the difficulty in located legal size Pismo Clams, recreational digging 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 clammers probably number in the several thousands. There are no vessels associated with the collection of Pismo Clam; instead, clams are taken on beaches and mudflats at low tide, or by diving in shallow areas.

Over 2.5 months in 1949 at Pismo Beach, an estimated 5,000 diggers per day harvested more than 2 million clams on a stretch of beach that had just been reopened to digging after being closed for 20 years (Pattison 2006) . During those 2.5 months, an additional estimated 1 million undersized clams were left stranded on the surface, forcing a closure (Pattison 2006).

2.2.2 Type, Amount, and Selectivity of Gear

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. A six-tined potato fork is commonly used to collect Pismo Clam in the intertidal zone, along with a measuring device. Spades, shovels, hoes, rakes, or other appliances operated by hand may also be used to take clams, with the exception of spears and gaff hooks. No instrument capable of being used to dig clams may be possessed between one-half hour after sunset and one-half hour before sunrise on any beach in the state.

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. Divers use a knife to probe the sand. 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.

2.3 Landings in the Recreational and Commercial Sectors

2.3.1 Recreational

Pismo Clams remain an important sport fishery to recreational fishermen in California due to these clams being highly desired despite the declining availability of legal sized clams. They have a distinctive and excellent flavor; they are prepared as chowder, seafood cocktail, fried, or eaten raw.

Recreational digging has probably been the largest contributing factor to losses incurred in the Pismo Clam population.

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 (Pattison 2006). 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 (Pattison 2006). 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 (Pattison 2006). 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 (Pattison 2006).

2.3.2 Commercial

Commercial fishing for Pismo Clam occurred between the early 1900s and 1947. There is currently no commercial fishery for Pismo Clam. The commercial harvest of

Pismo Clams began 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 (Pattison 2006). Records of the commercial harvest of Pismo Clams began in 1916, and continued through 1947 when the fishery was prohibited (see Table 2-2). During these 29 years, it is estimated that commercial diggers harvested 6.25 million lb (2,834 t) 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 lb (302 t) 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.

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

Table 2-2 Pismo Clam commercial landings (round weight in lb) in California and imports of shucked meat (lb) from Mexico, from 1916 to 1947 (Pattison 2006).

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).

2.4 Social and Economic Factors Related to the Fishery

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 lb (6.5 t) of live Pismo Clams were imported from Mexico to Long Beach, California, at which point they were shucked and canned (Pattison 2006). 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 gal (18 l), 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 lb (4.9 t) to 6.76 million lb (3,069 t) annually (Table 3-2) (Pattison 2006). 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 (Pattison 2006). 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 (Pattison 2006).

Pismo Clams have been linked to several human fatalities involving Paralytic Shellfish Poisoning (PSP) (Pattison 2006). It is therefore advised that only the white meat be consumed and all dark meat and digestive organs be discarded. The California Department of Public Health (CDPH) coordinates a routine monitoring program along the California coast to sample clams and other for the presence of PSP and domoic acid toxins. If toxin levels are high enough, warnings and quarantines are issued to protect the recreational fishing public and shellfish consumers.

3. Management

3.1 Past and Current Management Measures

California's Pismo Clam population was once large enough to support both commercial and recreational fisheries. However, heavy fishing pressure, first by commercial efforts and then by recreational efforts, have drastically reduced the range and abundance of Pismo Clams in the state. The commercial fishery was managed by the state from 1911 until its discontinuation in 1947.

Current regulations are in place to prevent further depletion. Recreational clamming is regulated by a size limit, bag limit, gear limitations, and a seasonal closure in some areas. (Table 3-1). The size limit is self-regulating to the point that there are not many locations in California where there are legal sized clams for recreational participants to take. However, there are many poaching cases as seen by Department wardens. Leslie (2018) reported in The Tribune that Department warden Tognazinni thinks that there could be a legal fishery in 2019 if people stop taking undersized clams in 2018..

Table 3-1 Pismo Clam regulations governing the take of Pismo Clam from 1911 to 1986 (Pattison 2006).

Year	Minimum Size Limit	Bag Limit	Remarks
1911	13 inches circumference (about 4⅛ inches diameter)	200	license required for sale of Pismo clams
1915	12 inches circumference (about 4⅛ inches diameter	50	
1917	4¾ 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	4¾ 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 form 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)

3.1.1 Overview and Rationale for the Current Management Framework

California continues to retain an open recreational fishery with guidelines including size limitations dependent on location, time and season, a bag limit, and specified gear. These measures are in place for the fishery to rebuild if possible.

3.1.1.1 Criteria to Identify When Fisheries Are Overfished or Subject to Overfishing, and Measures to Rebuild

There is not any existing criteria to identify when the species is overfished.

3.1.1.2 Past and Current Stakeholder Involvement

There has not been stakeholder involvement in the past, but an ongoing scientific study in San Luis Obispo County by Cal Poly researcherBen Ruttenberg is underway observing, gathering, and tagging clams to learn more about their growth rate, mortality, and limiting factors (Heinrichs 2018). State Parks Oceano Dunes District Rangers have a mentorship with Cal Poly students, and their State Rangers partner with the Department to help with enforcement (Heinrichs 2018) .

3.1.2 Target Species

3.1.2.1 Limitations on Fishing for Target Species

3.1.2.1.1 Catch

There is currently a bag limit of 10 clams.

3.1.2.1.2 Effort

No limitations based on effort.

3.1.2.1.3 Gear

Gear specification: Spades, shovels, hoes, rakes or other appliances operated by hand, except spears or gaff hooks, may be used to take clams. No instrument capable of being used to dig clams may be possessed between one-half hour after sunset and one-half hour before sunrise, on any beach of this state, except tools and implements used in the work of cleaning, repairing or maintaining such beach when possessed by a person authorized by appropriate authority to perform such work.

3.1.2.1.4 Time

No digging for clams is allowed between 30 minutes after sundown to 30 minutes before sunrise. No clam digging implements may be in possession during these hours. Clams may be taken in Santa Cruz and Monterey counties from September 1 - April 30, and from all other counties year-round.

3.1.2.1.5 Sex

No limitations based on sex.

3.1.2.1.6 Size

Minimum size of 5 in (12.7 cm) diameter north of boundary between San Luis Obispo and Monterey counties. Minimum size of 4.5 in (11.43 cm) diameter south of boundary. All undersized clams must be returned to the hole from which they were dug, or to deeper water. Unburied clams cannot rebury themselves and will die.

3.1.2.1.7 Area

There are no restrictions based on area.

3.1.2.1.8 Marine Protected Areas

May not be taken inside Marine Protected Areas that prohibit the take of Pismo Clams.

3.1.2.2 Description of and Rationale for Any Restricted Access Approach

There is currently no restricted access program for the Pismo Clam fishery.

3.1.3 Bycatch

3.1.3.1 Amount and Type of Bycatch (Including Discards)

Given the selective methods of taking of Pismo Clam, there is likely to be little bycatch in this fishery. In the event of an undersized clam being harvested, it must be returned to the hole and reburied, or returned to deep water.

3.1.3.2 Assessment of Sustainability and Measures to Reduce Unacceptable Levels of Bycatch

There are no existing measures to reduce bycatch at this time.

3.1.4 Habitat

3.1.4.1 Description of Threats

Management has not included descriptions of threats on the fishery at this time.

3.1.4.2 Measures to Minimize Any Adverse Effects on Habitat Caused by Fishing

Given the minimal long-term impacts of this fishery on sandy beach habitats, there are currently no measures to minimize adverse effects on the fishery.

3.2 Requirements for Person or Vessel Permits and Reasonable Fees

The taking Pismo Clams by the public requires a sport fishing license.

4. Monitoring and Essential Fishery Information

4.1 Description of Relevant Essential Fishery Information

There is no relevant essential fishery information available at this time.

4.2 Past and Ongoing Monitoring of the Fishery

4.2.1 Fishery-dependent Data Collection

None since the end of the commercial fishery in 1947.

4.2.2 Fishery-independent Data Collection

While no long-term, statewide data collection programs are currently in place, studies have been and continue to be conducted by Department and academic researchers. The Department has been conducting field reports annually or semiannually since 2008 in Santa Cruz County, San Luis Obispo County, Santa Barbara County, and San Diego County where locations, mean number of clams per square foot, number measured, length range have been recorded. Additionally, academic researchers at Cal Poly have an ongoing study in San Luis Obispo County, and NPS has ongoing studies in the Channel Islands which extends across Santa Barbara, Ventura and Los Angeles Counties. While this does not make a complete snapshot of the size and abundance of Pismo Clam throughout the state for the past ten years, it does provide a starting point to highlight areas that can be looked into in the future.

5. Future Management Needs and Directions

5.1 Identification of Information Gaps

Despite the few field studies at specific locations (Channel Islands National Park, Pismo Beach, and Rincon?) that are on-going, there are no complete current population, abundance, size, or location statistics that can characterize California's Pismo Clam fishery. When these questions are answered, the population sustainability thresholds could be analyzed appropriately by fishery managers.

Additionally, it is not currently known how many fishery participants target Pismo Clam at which locations. After this information is acquired, the actual participants versus potential participants could be estimated in turn to analyze a potential management plan for the future. These primary areas of study would complement the future management of this fishery.

5.2 Research and Monitoring

5.2.1 Potential Strategies to Fill Information Gaps

One way to pursue this primary information gathering on Pismo Clam could be through administering surveys to fishing license holders. Those who participate in the fishery could reply annually with: date, quantity, size, and location. Another avenue to obtain primary information on the fishery could be to administer a region-wide survey of distribution, abundance, and size, similar to how PISCO monitors organisms within the rocky intertidal zone. This would create an on-going time series, or a snapshot of the fishery's characteristics.

5.2.2 Opportunities for Collaborative Fisheries Research

Currently, studies of Pismo Clam are being conducted by researchers at Cal Poly at San Luis Obispo. Also, a study of sandy beach communities is being conducted by researchers at UCSB and Channel Island National Park Service. These current on-going studies allow for an opportunity to coordinate with CDFW to help meet this fishery's informational needs without duplicating research and continuing to be efficient with resources.

5.3 Recommendations for Any Management Changes

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. 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.

In southern California, the planting of large clams has paradoxically had a negative effect on local populations. News of a planting project eventually spread, and the public turned out in mass to search for these clams. Not only were the planted clams immediately removed, but most of the native stock was also taken and the beach was left more barren than before the project.

5.4 Climate Readiness

There are multiple areas that could directly affect the Pismo Clam fishery if there are changes in climate such as: ocean acidification, water temperature changes, circulation pattern changes, increasing storm intensities, and rising sea level. The change in ocean acidity to a lower pH would have negative impacts on the fishery. An increase in ocean water temperature could affect the locations of the fishery dependent on where the warmer water locations are located. If ocean circulation patterns change that could affect where the trends in recruitment take place. Storm intensity increases could result in the loss of san habitat. Rising sea level could contribute to the loss of sand habitat, less access for recreational clammers, and for beach based research opportunities.

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7. Appendices