Fishery-at-a-Glance: Kellet's Whelk

Scientific Name: *Kelletia kelletii*

Range: Current range of Kellet's Whelk spans from Monterey, California to Isla Asuncion, Baja California.

Habitat: Kellet's Whelk inhabits rocky reefs and adjoining sandy habitats.

Size (length and weight): The shell length of a Kellet's Whelk can grow up to 6.9 inches (17.5 centimeters). The maximum weight of Kellet's Whelk is unknown.

Life span: The life span of Kellet's Whelk is unknown.

Reproduction: The mating season of Kellet's Whelk generally occurs from March to May, but extends into June north of Point Conception.

Prey: Kellet's Whelk feed on detritus, and dead and dying organisms; they also prey on live benthic animals such as tube worms, annelids, and other gastropods.

Predators: Predators of Kellet's Whelk include adult moon snails, sea stars, octopus, and sea otters. Kellet's whelk larvae are preyed upon by zooplankton and fin fishes.

Fishery: A commercial fishery exists for Kellet's Whelk. A small recreational fishery also exists, though no data have been collected in recent years. The commercial fishery is primarily an incidental fishery to Spiny Lobster, rock crab, sea urchin, and sea cucumber fisheries in southern California.

Area fished: Most Kellet's Whelk are harvested from Point Conception, California to the California-Mexico border, while minor component also exists in Morro Bay.

Fishing season: The Kellet's Whelk fishery is open from July 1 through the first Wednesday after March 15.

Fishing gear: Kellet's Whelk may be taken by hand, and in commercial Spiny Lobster and rock crab traps.

Market(s): Kellet's Whelk are harvested primarily for domestic consumption.

Current stock status: The stock status of Kellet's Whelks is unclear, with some information suggesting the stock is stable; landings have remained stable for the past 7 years since the implementation of a total allowable catch.

Management: The commercial fishery for Kellet's Whelk was mostly unregulated prior to 2012. In 2012, in response to rising level of take, regulations went into effect including gear restrictions allowing commercial take by hand or incidentally in rock crab and Spiny Lobster traps, a seasonal closure from the first Thursday after March 15 to

June 30, and annual total allowable commercial catch of 100,000 pounds. Commercial landings of Kellet's Whelk under a marine aquaria collector's permit has also been explicitly prohibited since 1996. Recreational take of Kellet's Whelk is also prohibited from the first Thursday after March 15 to June 30. Up to 35 Kellet's Whelk can be taken per person with a valid recreational fishing license per day. Whelks can be taken recreationally by hand while skin diving or from shore, and hook and line. Recreational take by hand while SCUBA diving is also allowed south of Yankee Point in Monterey County.

1 The Species

1.1 Natural History

1.1.1 Species Description

Kellet's Whelk (*Kelletia kelletii*) is the largest whelk found in southern California. The shell of the animal can reach 6.9 inches (in) (17.5 centimeters (cm)) in length (Morris et al. 1980). Kellet's Whelk can be identified by their unique shell that is both spiraled and knobbed. The natural color of the shell is white with brown spirals, which is apparent in young whelks and new shell on adult whelks. Older shells often have purple or green algae that cover and impregnate the shell, masking the natural coloration. The foot and mantle are yellow, with additional black stripes and white spots on the foot, and the proteinaceous operculum is light brown (Figure 1-1) (Morris et al. 1980; Gotshall 2005).

Figure 1-1: Shell, foot, mantle, and operculum of a Kellet's Whelk (Photo Credit: Derek Stein, CDFW).

1.1.2 Range, Distribution, and Movement

Kellet's Whelk is found in nearshore areas at depths ranging from 6 to 230 feet (ft) (2 to 70 meters (m)) (Rosenthal 1970). The species was historically understood to have resided between Point Conception and Isla Asuncion, Baja California, based on Paleontological record (Lonhart and Tupen 2001). In 1980, the first live Kellet's Whelk were observed at the Hopkins Marine Life Refuge in Monterey, California (Herrlinger

1981). This finding expanded the previously known range by more than 250 miles (mi) (400 kilometers (km)) (Figure 1-2).

Figure 1-2. Range of Kellet's Whelk; Monterey, California to Asuncion, Baja California.

The species' historical northern boundary at Point Conception was likely caused by access limitation (larvae prevented from dispersing north of Point Conception due to strong current (Zacherl et al. 2003)). The species exhibits a relatively long larval phase of 40 to 60 days (Romero et al. 2012), and larvae could potentially be spread over long distances depending on the oceanographic currents (Zahn et al. 2016). The central

California population was likely first carried into the region by El Niño conditions in the 1970s, and the population now likely experiences consistent recruitment. This group was originally thought to be an isolated sink population due to a lack of recruits, few juveniles, and many large adults (Lonhart and Lupen 2001). However, subsequent surveys conducted in the 2000s and 2010s following later El Niño events suggest that if El Niño conditions become more prevalent and extreme (Power et al. 2013), more individuals may recruit into this northern population (Zacherl et al. 2003; Rodriguez 2017).

Kellet's Whelk are relatively slow moving. There is little available information on their movement rates or home ranges, though Cumberland (1995) noted a great deal of immigration/emigration of Kellet's Whelk in a >200 square meters (m^2) area during a monthly tag-recapture study, despite the area being surrounded by sandy channels. Cumberland observed that Kellet's Whelk could move equally well on rocky reef substrate or on sand.

1.1.3 Reproduction, Fecundity, and Spawning Season

Sexes are separate, and whelks can form mating aggregations in spring, consisting of several to dozens of whelks. Kellet's Whelk show no sexual dimorphism, however during mating females are consistently the larger individual in a mating pair, and fertilization is internal. Males cling to the shell of the larger female and transfer a sperm packet with a prehensile, flattened penis that extends into the female's mantle cavity. After fertilization, egg deposition occurs in April and May (Cumberland 1995) in southern California, but is later in central California, occurring from May to July (Lonhart unpublished data). Egg-depositing aggregations can consist of 200 to 300 individuals observed within 215 square feet (ft^2) (20 m^2) area (Rosenthal 1970).

Oval shaped egg capsules are deposited in clusters on hard substrate (Figure 1-3), including reef, discarded mollusk shells or other Kellet's Whelk. Eggs may be laid over several days at several locations. Females lay an average of 66 egg capsules (Cumberland 1995) with each capsule generally containing between 400 and 1,200 eggs, with occasionally as many as 2,200 eggs (Rosenthal 1970). The number of eggs depends on the height of the capsule, which directly correlates to the size of the spawning female. Egg capsule height generally ranges between 0.2 to 0.4 in (6.0 to 9.0 millimeters (mm)) (Rosenthal 1970).

Figure 1-3. Kellet's Whelk laying eggs capsules (Photo Credit: Steve Lonhart).

Embryos begin development within the capsule and emerge into the water column as free-swimming larvae after 30 days (Rosenthal 1970). Larval size is inversely correlated to egg capsule size, with smaller capsules containing larger larvae. This larval phase lasts roughly 5.5 to 9.0 weeks (Romero et al. 2012).

1.1.4 Natural Mortality

Determining the natural mortality (M) of marine species is important for understanding the health and productivity of their stocks. Natural mortality results from all causes of death not attributable to fishing such as old age, disease, predation or environmental stress. Natural mortality is generally expressed as a rate that indicates the percentage of the population dying in a year. Animals with high natural mortality rates must replace themselves more often and thus tend to be more productive. Natural mortality along with fishing mortality result in the total mortality operating on the stock.

To date, no method has been developed to age Kellet's Whelk, and the lifespan and mortality of the species is unknown at this time. However, from their slow growth rates it is likely that they live for many years, possibly decades. In a tag-recapture study in La Jolla, California, Cumberland (1995) estimated a 97% annual survival rate.

1.1.5 Individual Growth

Individual growth of marine species can be quite variable, not only among different groups of species but also within the same species. Growth is often very rapid in young fish and invertebrates, but slows as adults approach their maximum size. The

von Bertalanffy Growth Model is most often used in fisheries management, but other growth functions may also be appropriate.

The growth rate of Kellet's Whelk is not well known, but is thought to be slow. Wilson (2017) determined that a larva grows about 0.1 mm (0.004 in) over a span of 7 weeks while gestating in an egg capsule. Juvenile growth was estimated to be 0.3 to 0.4 in (7.0 to 10.0 mm) per year until sexual maturity (Cumberland 1995). Once reaching sexual maturity, growth slows considerably. Cumberland (1995) observed a maximum growth of 5.0 mm (0.2 in) per year, and some snails exhibited no growth during that period, possibly due to shell erosion. In that study the Brody-Bertalanffy growth rate constant *k* was estimated to be $0.0548_{/yr}$, while the maximum asymptotic shell length L_∞ was estimated to be 92.3 mm (3.6 in). It is important to note that the maximum size of Kellet's Whelk observed in that study was 99.0 mm (3.9 in), which is smaller than whelks that have been collected in areas north of San Diego. For example, White et al. (2010) collected whelks between 60.0 and 150.0 mm (2.4 and 5.9 in) in shell length at sites in Santa Barbara and the Channel Islands. Furthermore, Cumberland was only able to observe the growth of three individuals that were smaller than 60.0 mm (2.4 in) in length.

1.1.6 Size and Age at Maturity

Female Kellet's Whelk are generally sexually mature between 2.6 and 2.8 in (65.0 and 70.0 mm). Males mature at slightly smaller sizes (Rosenthal 1970). White et al. (2010) observed Kellet's Whelks as small as 60.0 mm (2.4 in) that were reproductively mature (White et al. 2010), however, the age of these individuals was not determined. Available size data from the Channel Island National Park Kelp Forest Monitoring Program shows that from 1985 to 2018 most of the individual whelks measured at their survey sites in the northern Channel Islands are above size at sexual maturity (Figure 1-4). The data also suggests that a pulse of recruitment may have occurred in 2013, when a large cohort of juveniles began appearing in the survey data.

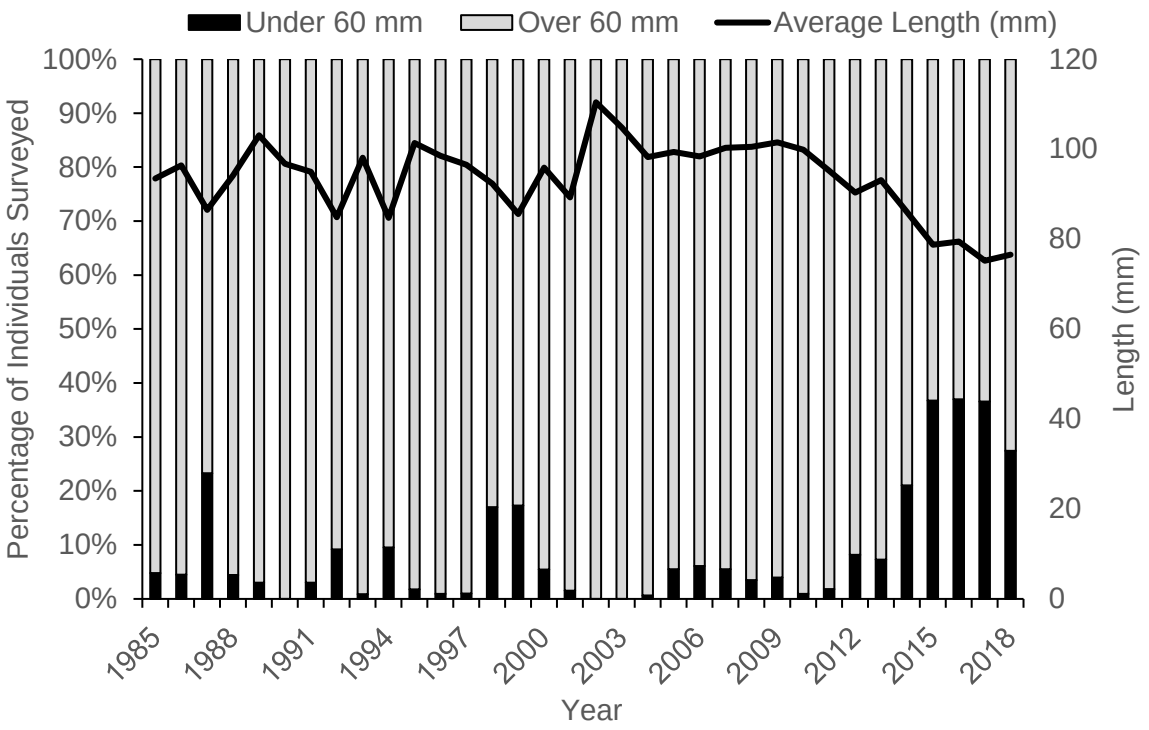

Figure 1-4. Proportion of Kellet's Whelk larger and smaller than known size at maturity, and the average length surveyed in the northern Channel Islands from 1985 to 2018 (National Park Service).

1.2 Population Status and Dynamics

The population status of the Kellet's Whelk population has been explored by targeted studies as well as long-term dive surveys conducted by various established research groups. No clear trend of the overall population increasing or decreasing can be established with current data. Size frequency data gathered from the northern Channel Islands suggest that recruitment into that area is likely sporadic.

1.2.1 Abundance Estimates

Little is known about the overall status of the Kellet's Whelk population. The Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO) coastal biodiversity survey, the National Park Service, and the Vantuna Research Group at Occidental College all conduct multi-year underwater surveys that include Kellet's Whelk within their survey designs.

Surveys done by Zacherl et al. in 1997, 1999, and 2000 north and south of Point Conception found the density of Kellet's Whelk to have ranged from 1 to 111 individuals per 100 m^2. However, the dataset does not extend beyond the 3 years (yr). Available PISCO data suggests that the species' density has fluctuated between 2.8 to 10.9 individuals per 100 m^2 north of Point Conception and 4.5 to 9.2 individuals per 100 m^2 south of Point Conception from 2004 to until 2012 (Figure 1-5a,b). Densities south of Point Conception began trending downward starting in 2011. Data from PISCO south of

Point Conception was sparse for 2016 and 2017 and cannot establish a clear trend of the population (Figure 1-5). Such a decline has not been observed in the data gathered between 2007 and 2015 by the Vantuna Research Group (Figure 1-5c). Data from those surveys are gathered from sites in the southern portion of the Southern California Bight (From Carpinteria in the north to Isla Coronado to the south) and do not overlap with the sites surveyed by PISCO.

PISCO data also show that the density north of Point Conception decreased sharply between 2014 and 2015. Density survey results have fluctuated significantly from year to year in the region (Figure 1-5), thus it is unclear whether there is a downward trend. Furthermore, the area is outside of where Kellet's Whelk are generally taken, and any decline is unlikely to be attributed to the take of adults in the area.

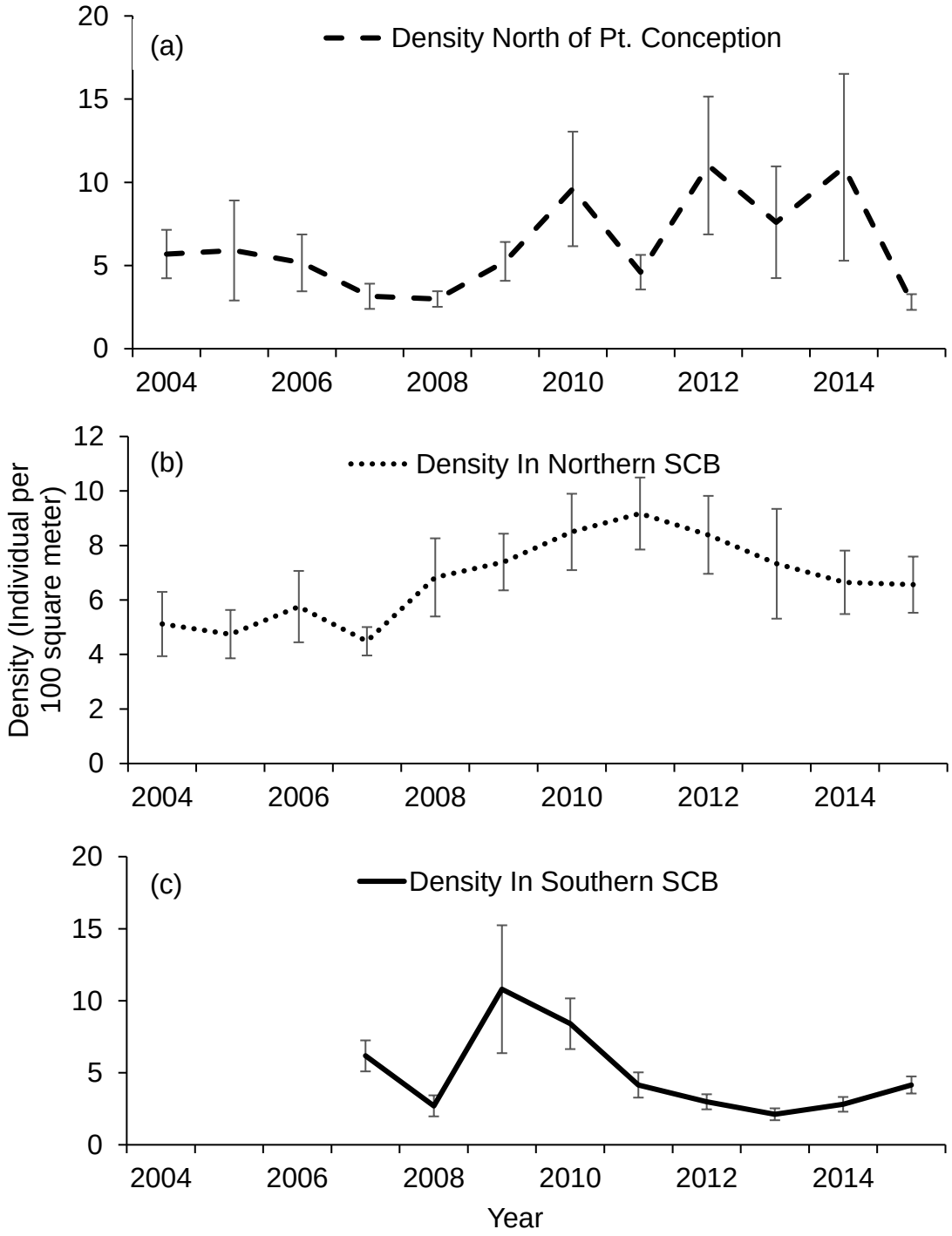

Figure 1-5. Kellet's Whelk average annual density observed (individuals per 100m^2) determined by SCUBA surveys across California from 2004 to 2015; bars represent standard error within each year between the averages of each site (Vantuna Research Group; PISCO).

The Channel Island National Park maintains one of the longest running datasets on Kellet's Whelk density. The Park Service's dataset focuses on the region around the

northern Channel Islands, and it shows that the density of Kellet's Whelk has fluctuated between 1.0 to 4.5 animals per 100 m^2 in the region until 2014. Starting in 2015, the density of the animal rose sharply, though the cause of this increase is unclear (Figure 1-6).

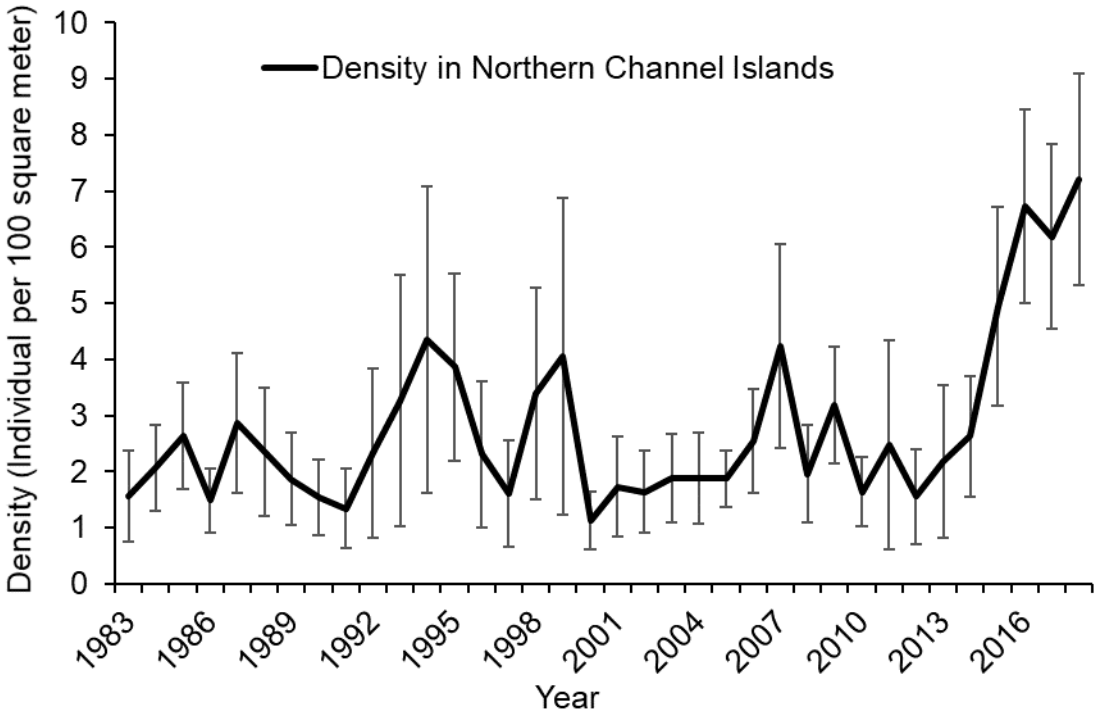

Figure 1-6. Kellet's Whelk average annual density (individuals per 100 m^2) determined by SCUBA surveys around northern Channel Islands from 1983 to 2018; bars represent standard error within each year between the averages of each site (National Park Service).

1.2.2 Age Structure of the Population

While there is currently no known method for directly aging Kellet's Whelk, size frequency data can be used to infer the age structure of the population. Size frequency data has been collected in the northern Channels Islands by the National Park Service since 1985. The survey data shows that most of the animals found in the area are larger than the size at sexual maturity, and the small percentage of individuals from the smallest class size for most years suggests that recruitment in this region may be sporadic (Figure 1-7).

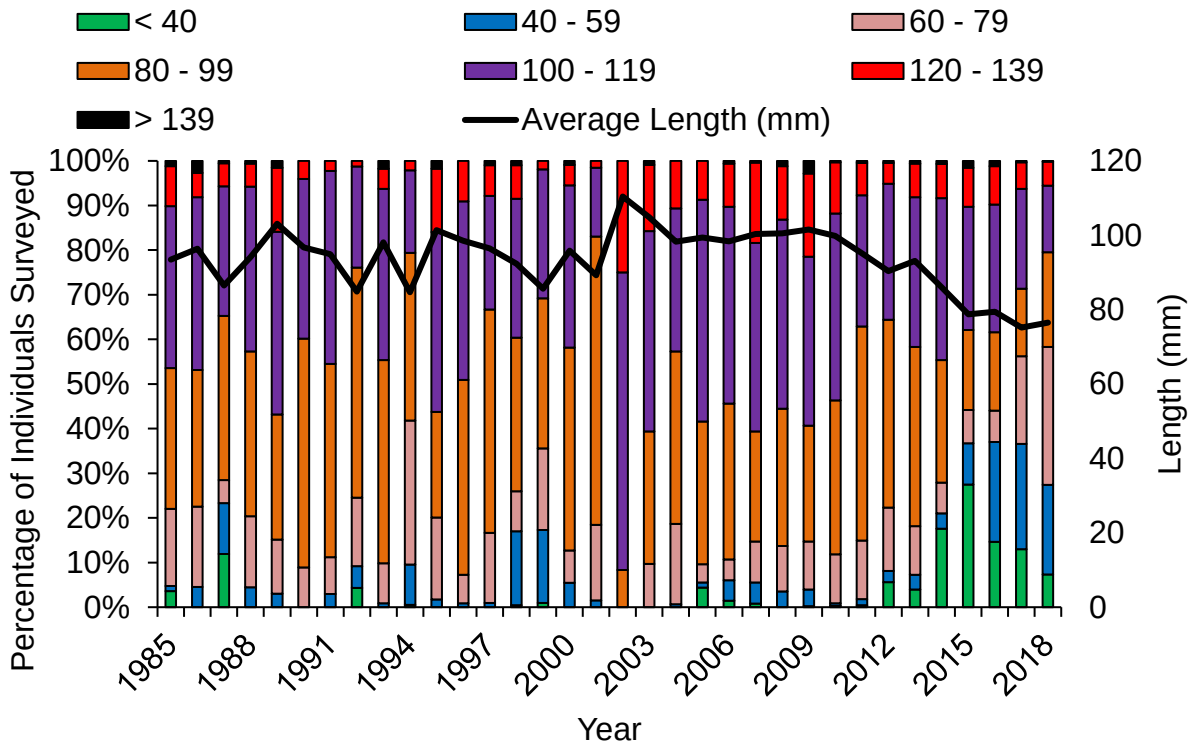

Figure 1-7. Kellet's Whelk size structure (in 20 mm bins) and average length as determined by SCUBA surveys around the northern Channel Islands from 1983 to 2018 (National Park Service).

1.3 Habitat

Kellet's Whelk is primarily found in kelp forests and temperate rocky reef habitat, but also occurs in rocky shores and protected sandy beach habitats from Monterey Bay southward to Isla Asuncion, Baja California, Mexico (Morris et al. 1980). Cumberland (1995) observed that Kellet's Whelks will occasionally bury themselves in sand to feed, and to protect themselves from predators. Such behavior has been observed and documented in sandy habitats off Santa Catalina Island (Lonhart unpublished data).

1.4 Ecosystem Role

The Kellet's Whelk is a generalist predator and scavenger, consuming living, dead, and dying organisms. As a scavenger that occurs at the transition zone between reef and sandy habitats, their presence likely impacts the surrounding substrate as they sift through the habitat for food. Directed research on the ecological role of Kellet's Whelk has been limited (Lonhart and Lupen 2001), but a study performed by Halpern et al. (2006) suggests that the species may play a crucial role in controlling the algae grazer population in the California kelp forest ecosystem.

1.4.1 Associated Species

Kellet's Whelk is known to host various species of parasitic worms (Hopper et al. 2014). The species is commonly caught with California Spiny Lobster (*Panulirus interruptus*) and rock crabs (*Cancer* spp.) in traps. The species is also taken by commercial divers targeting Red Sea Urchin (*Mesocentrotus franciscanus*) and Warty Sea Cucumber (*Parastichopus parvimensis*). The species presumably co-occur with other organisms inhabiting reef and near-reef habitats in the 6 to 230 ft (2 to 70 m) range, but is not known to be associated with other species other than as a predator, prey, or competitor.

1.4.2 Predator-prey Interactions

Kellet's Whelk is an opportunistic carnivore that feeds on dead or dying organisms and often feed in clusters. However, they will actively pursue prey including several species of turban snails, vermetid gastropods, and annelid worms.

Eating occurs through the scraping of the radula, a tongue-like structure bearing rows of teeth, and the muscular suction action of the prehensile proboscis, a tubular extension used for feeding, which can be extended up to three times the length of the shell (Figure 1-8). They are voracious eaters and often feed on bait and injured crustaceans in commercial crab and lobster traps.

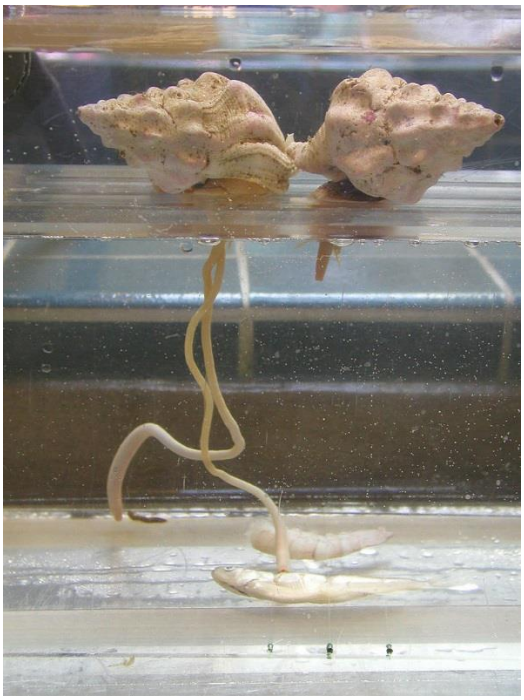

Figure 1-8. Extended prehensile proboscis of feeding Kellet's Whelk (Photo Credit: Steve Lonhart).

Predators of Kellet's Whelk include moon snails, sea stars, octopus, and Southern Sea Otters (*Enhydra lutris nereis*) in central California. Juvenile Kellet's Whelk

are eaten by a variety of fishes. Kellet's Whelk is often found feeding alongside its predator, the Giant-Spined Star (*Pisaster giganteus*).

1.5 Effects of Changing Oceanic Conditions

Point Conception has been a major northern biogeographic barrier for many marine species in the Southern California Bight (Doyle 1985). This collision point between two current systems likely serves as a physical barrier for Kellet's Whelk larvae but some evidence suggest that is not the case during El Niño Southern Oscillation (ENSO) events (Zacherl et al. 2003). Size-frequency surveys conducted in 1997, 1999, 2015, and 2016 suggests that the size structure of the species north of Point Conception may have shifted (Figure 1-9) (Zacherl et al. 2003; Rodriguez 2017). Based on data from 1997, it was observed that areas south of Point Conception tend to be occupied by individuals of different sizes. However, larger number of individuals at or smaller than the size of sexual maturity began to appear north of Point Conception after the 1997 El Niño event (Figure 1-9). As global climate conditions evolve, El Niño events could become more intense and frequent (Cai et al. 2015; Power et al. 2013). If that is the case, the species may have fully established itself north of Point Conception, and the age structure of Kellet's Whelk in this region may continue to mirror the age structure south of Point Conception.

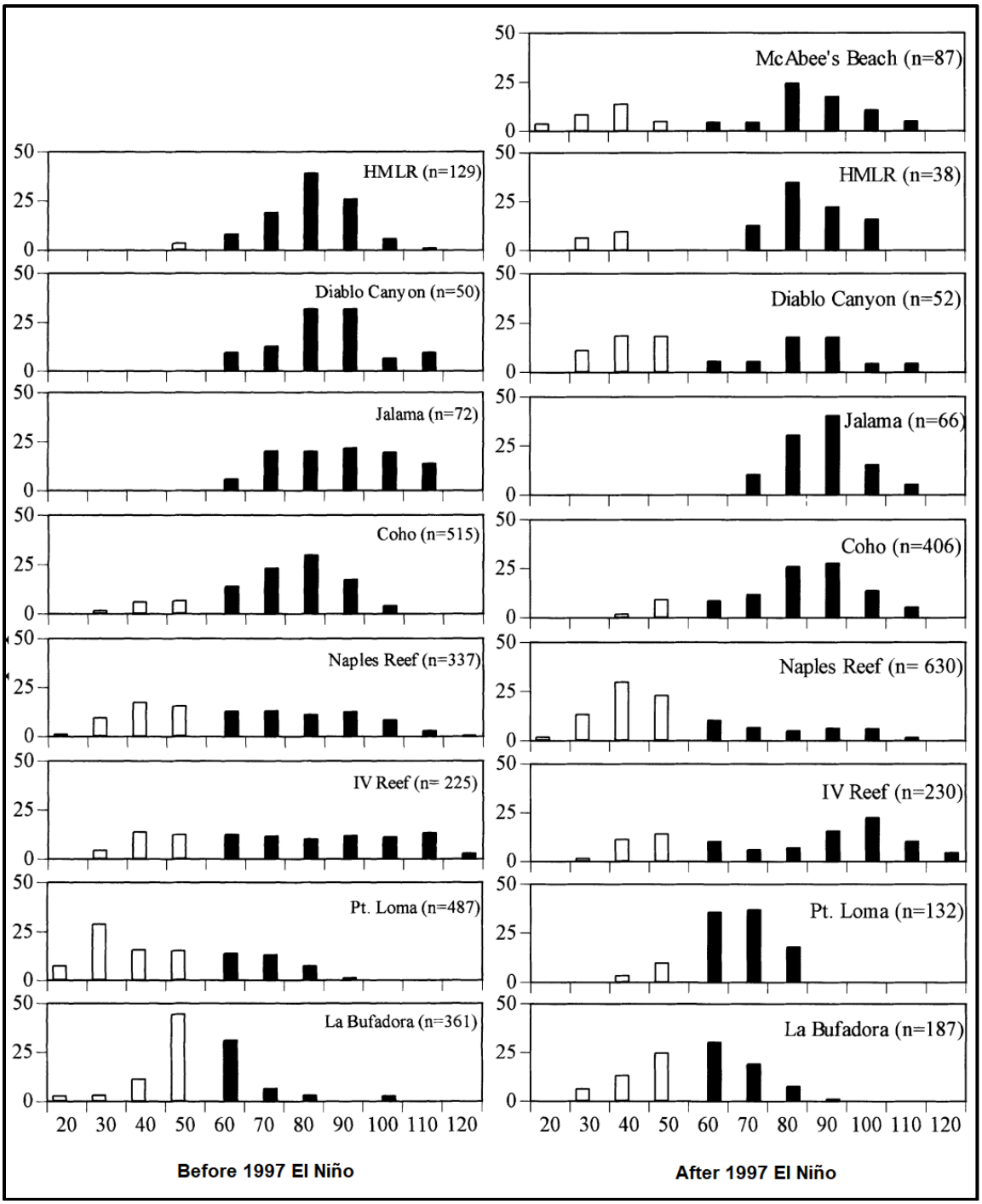

Figure 1-9. Size distribution (10 mm bins) of Kellet's Whelk in California before (1997) and after (1999) the 1997 El Niño. Jalama, Diablo Canyon, Hopkins Marine Life Refuge, and McAbee's Beach are north of Point Conception, while the rest are south of Point Conception (Note that La Bufadora is in Baja California; white bars represent juvenile classes; n = sample size (Zacherl et al. 2003).

As atmospheric carbon dioxide (CO_2) concentration increases, the temperature of the air increases, along with the temperature of the ocean (Solomon et al. 2007).

Marine animals may be particularly affected by the changing climate due to the ectothermic nature of most of their physiology (Sunday et al. 2012). Depending on whether the range for Kellet's Whelk shifts due to a warming ocean, and if so, by how much, the resilience of the population may increase or decrease accordingly.

Another effect of increased CO_2 concentration in the atmosphere is ocean acidification. As the concentration of CO_2 in the atmosphere increases, the molecules diffuse into the upper layer of the ocean and increase the acidity of ocean water, impacting various organisms that form hard shells (Gazeau et al. 2013). No study to date has looked specifically at the effects of climate-driven ocean acidification on Kellet's Whelk. However, past studies have shown detrimental effects towards other marine snails that form hard calcified shells (Nienhuis et al. 2010). Therefore, Kellet's Whelk larvae may be impacted from the effects of acidification as well.

2 The Fishery

2.1 Location of the Fishery

Kellet's Whelk is primarily an incidentally caught species in commercial lobster and crab trap fisheries. The commercial dive fishery in southern California, which primarily targets sea urchin and sea cucumber, marginally contributes to the overall landings of Kellet's Whelk as well. Between 2008 and 2018 approximately 1.18 million pounds (lb) of Kellet's Whelk were landed in California by the lobster and crab trap fisheries, and the dive fishery landed just over 20,000 lb. A commercial fishery also exists in Baja California, Mexico, but the level of take is unknown.

Due to the location of the species' historical range, coupled with the location of the lobster, crab, and dive fisheries, Kellet's Whelk landings occurred almost exclusively in the Southern California Bight. Based on landing receipt data from 2008 to 2018, a majority of the landings came from fishing blocks near ports in Santa Barbara and San Diego, followed by San Pedro (Figure 2-1).

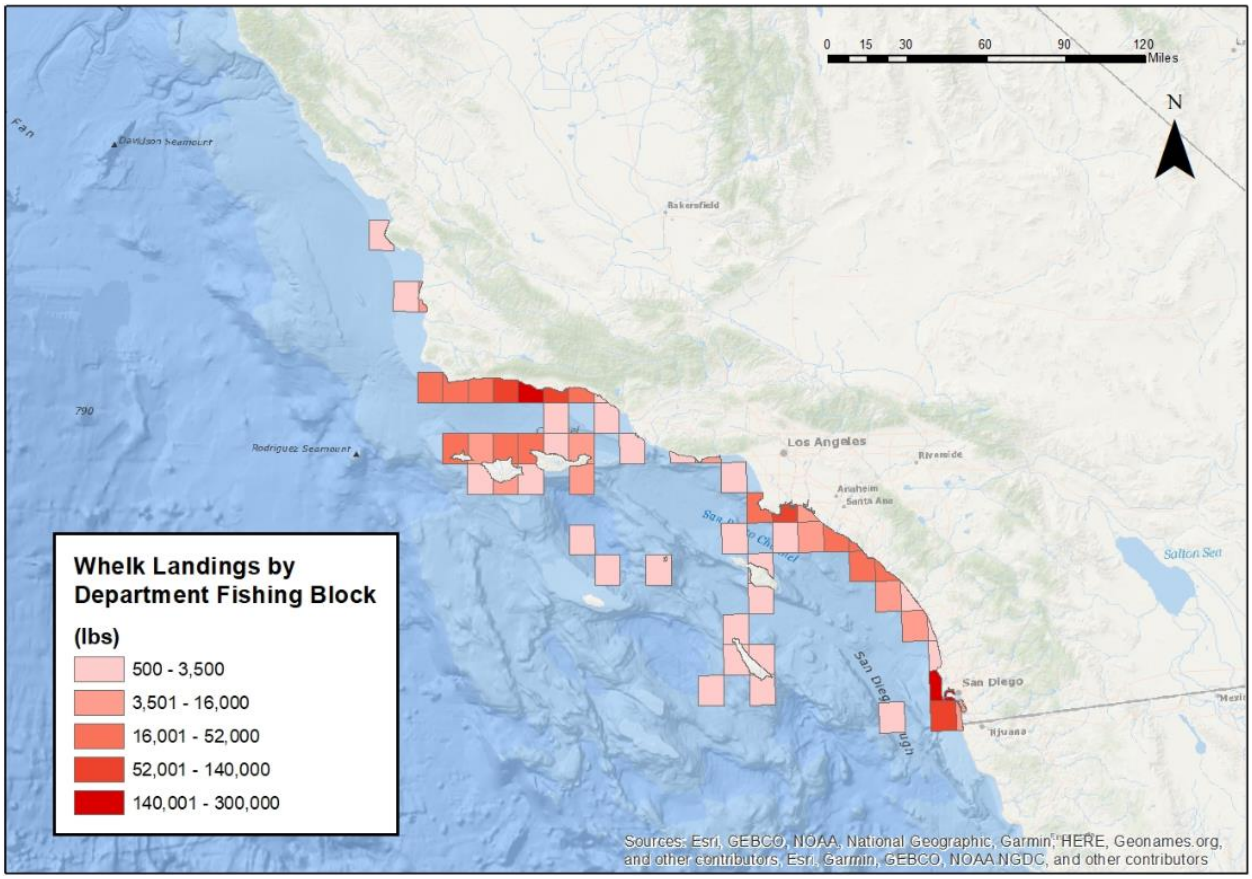

Figure 2-1. Reported origin of Kellet's Whelk landings by Department fishing block from 2008 to 2018 for blocks with more than 500 lb of cumulative landings (CDFW Marine Landings Database System (MLDS)).

2.2 Fishing Effort

2.2.1 Number of Vessels and Participants Over Time

There are 177 lobster operator permit holders, 117 southern rock crab trap permit holders, 274 sea urchin diver permit holders, and 80 sea cucumber dive permit holders in 2019. The fisheries overlap, with some individuals holding more than one of these permits. In total 482 individuals participate in fisheries that allow the take of Whelk in 2019.

While almost 500 individuals participate in fisheries that allow the take of Kellet's Whelk, the number of individuals landing Kellet's Whelk is much lower. The number of participants peaked at 77 in 2010, and then dropped to a low of 51 in 2014, 2 yr following the implementation of new management measures (i.e. a season and total allowable catch). The number has slowly risen to 75 in 2018 (Figure 2-2).

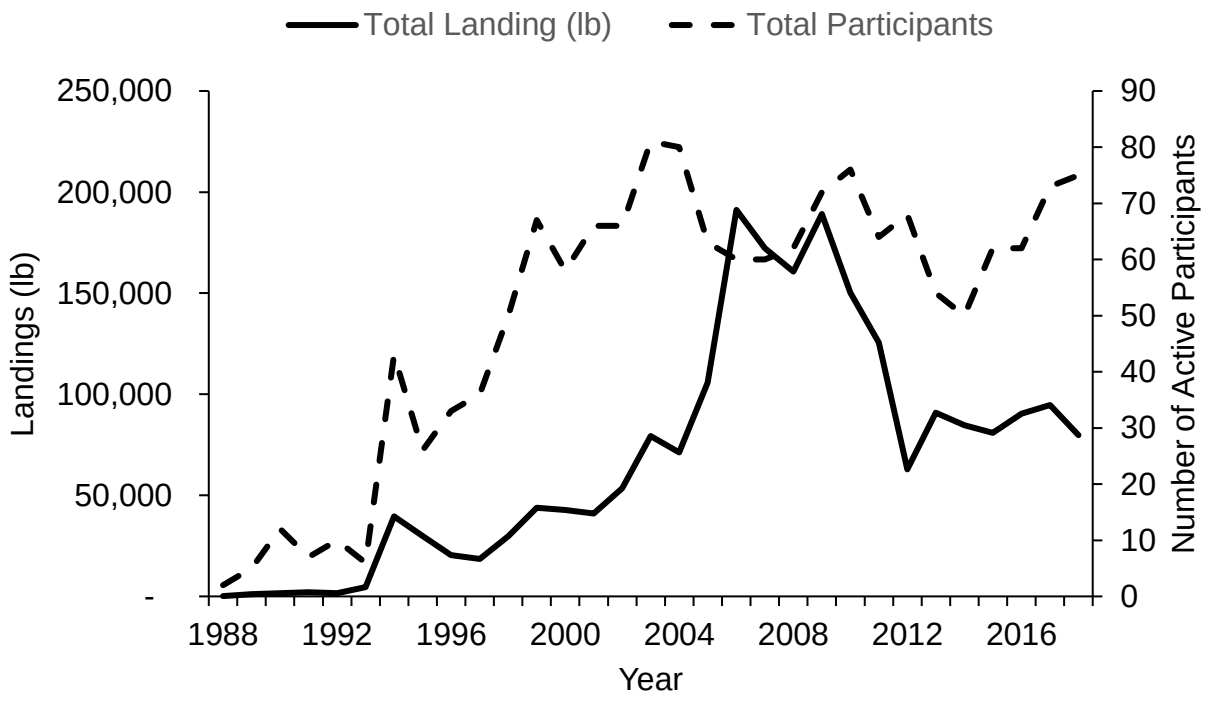

Figure 2-2. Kellet's Whelk landings and number of individuals making landings from 1988 to 2018 (CDFW Commercial Fisheries Information System (CFIS) 2019).

The Department does not possess any information suggesting significant recreational interest in Kellet's Whelk. Anecdotal information suggests that the species is being pursued by some divers.

2.2.2 Type, Amount, and Selectivity of Gear

Since 2008, 98% of all harvested Kellet's Whelk have been taken incidentally in lobster and crab traps, which they enter to prey on bait and injured crustaceans. Smaller

individuals can enter traps through the mesh of the wire traps, while larger individuals can only enter though the entrance funnels and escape ports that allow undersized crab and lobster to escape. Kellet's Whelk that are smaller than the mesh size likely fall out of the trap upon retrieval. The other method of take is hand take by divers. Kellet's Whelk of all sizes are vulnerable to this method of take.

Kellet's Whelk can be taken in the recreational sector by hand while skin or SCUBA diving south of Yankee Point, Monterey County, by hand from shore, or hook and line.

2.3 Landings in the Recreational and Commercial Sectors

2.3.1 Recreational

There are currently no data on the recreational catch of Kellet's Whelk, but it is likely to be minor. Up to 35 Kellet's Whelk can be taken recreationally per person per day.

2.3.2 Commercial

Kellet's Whelk was subject to steadily increasing commercial landings. The earliest recorded commercial landing data specific to Kellet's Whelk are from 1979, but prior to this they may have been recorded as miscellaneous mollusks or sea snails. Landings data indicate an increase in take beginning in 1993 at 4,590 lb (2 metric tons (mt)), with highest landings in 2006 of 191,177 lb (87 mt) (Figure 2-3). An 81% increase in landings occurred between 2005 and 2006. Landings has remained relatively stable after a 100,000 lb Total Allowable Catch (TAC) was implemented in 2012, fluctuating between 67,000 lb and 96,000 lb from 2013 to 2018.

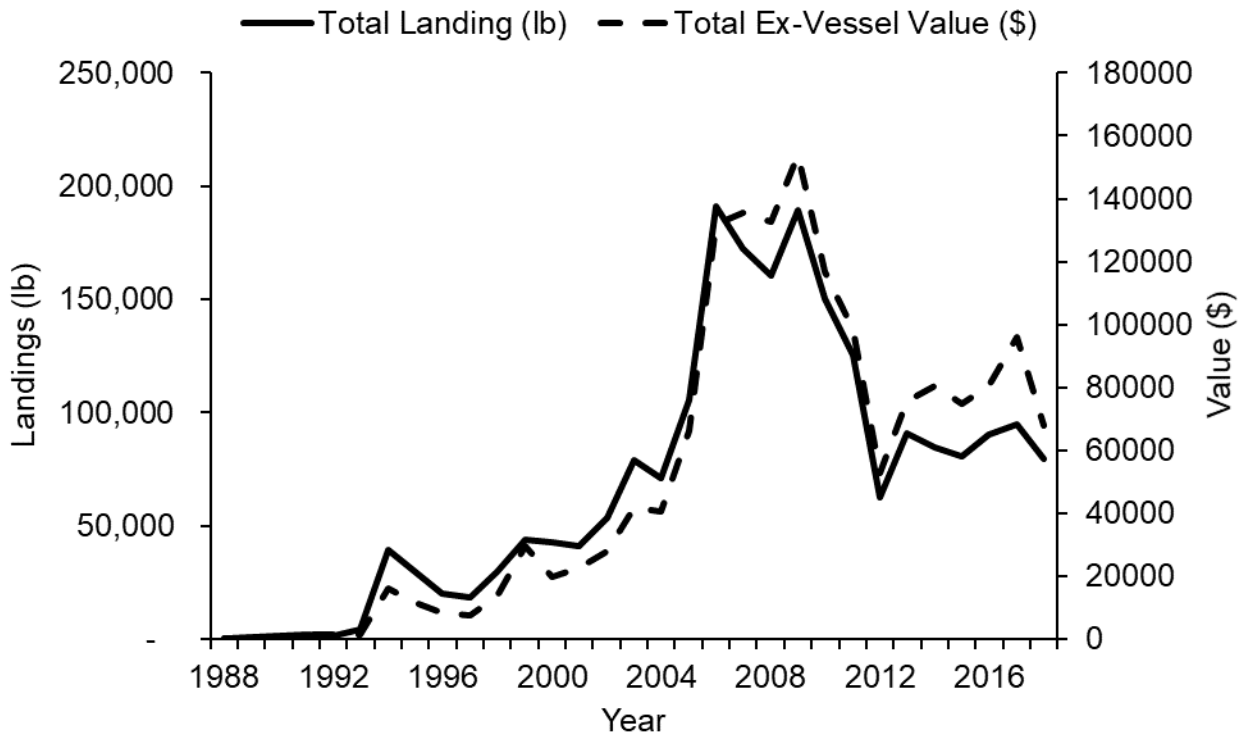

Figure 2-3. Kellet's Whelk landings (lb) and total ex-vessel value (dollar) from 1988 to 2018 (CDFW MLDS 2019).

2.4 Social and Economic Factors Related to the Fishery

Commercial ex-vessel value in 2018 was approximately $67,700 with an average price per pound of $0.85 ($1.87 per kilogram (kg)). Since 1979, the fishery's total ex-vessel value has ranged from $94 in 1988 to approximately $153,800 in 2009 (Figure 2-3), with the ex-vessel price per pound ranging from a low of $0.34 ($0.76 per kg) in 1993 to a high of $1.01 ($2.23 per kg) in 2017 (Figure 2-4). Overall the value of the species has steadily risen, but not to the extent observed in associated fisheries such as lobster or sea cucumber.

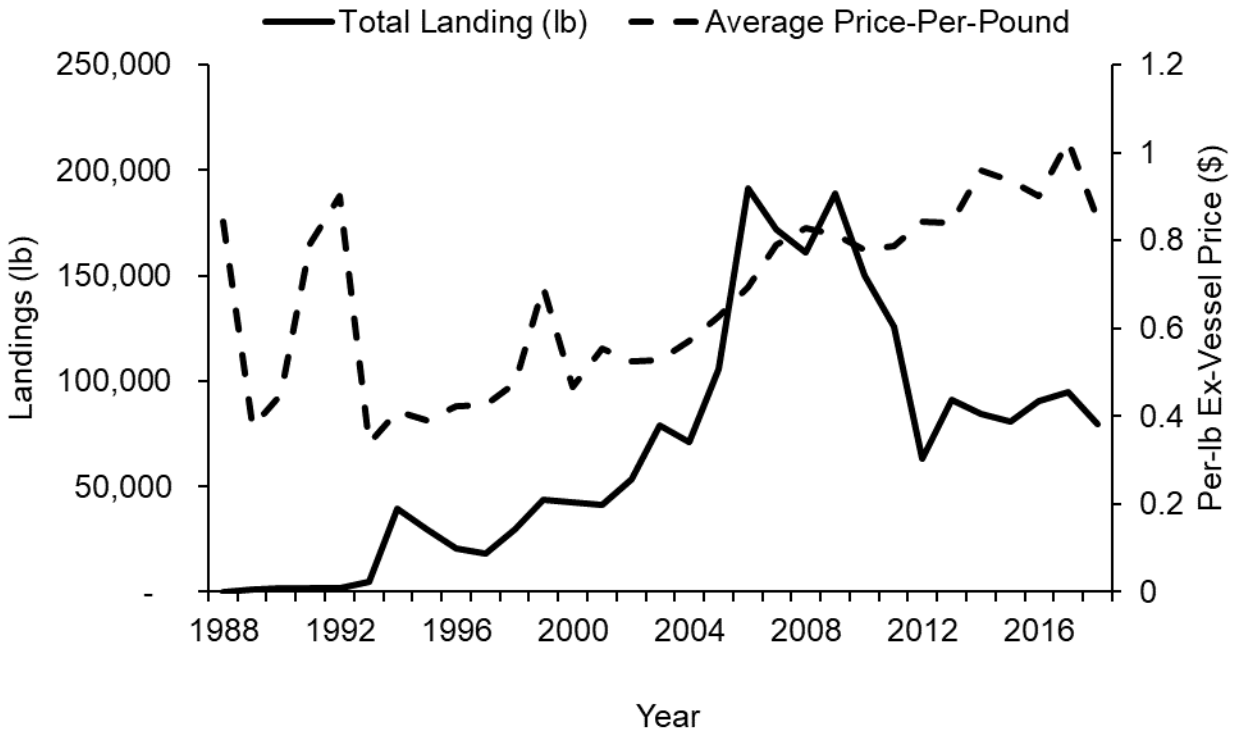

Figure 2-4: Kellet's Whelk landings (lb) and average per-lb ex-vessel value (dollar) from 1988 to 2018 (CDFW MLDS 2019).

Despite the rise in the species' per pound ex-vessel value, the value of Kellet's Whelk still trails the value of the targeted species it is associated with. As such, commercial trap fishermen and divers do not have a strong incentive to target Kellet's Whelk, except perhaps for when the price of rock crab is low. The species is known to be sold in local fishermen's market across southern California, such as the New Port Beach Dory Fleet market. However, it is unclear what proportions of the landings are packaged or sold to restaurants. It is unknown whether Kellet's Whelk has an international market. Export data from the National Oceanic and Atmospheric Administration shows that 26 mt of marine snails of all species were exported outside of the United States in 2017, but the data do not separate Kellet's Whelk out as a distinct species.

The distribution of landings over the last decade can potentially identify areas in California that are most likely to benefit from this fishery. Kellet's Whelk landings have been reported at 21 ports from 2008 to 2018, with 80% of landings occurring at four ports. Approximately 50% of the total reported landings over this period (586,447 lb (266 mt)), occurred at the Santa Barbara Harbor (Figure 2-5). The next three ports are San Diego, Terminal Island, and Dana Point, with cumulative landings of 175,269 lb (76 mt), 95,114 lb (43 mt) and 94,808 lb (43 mt), respectively.

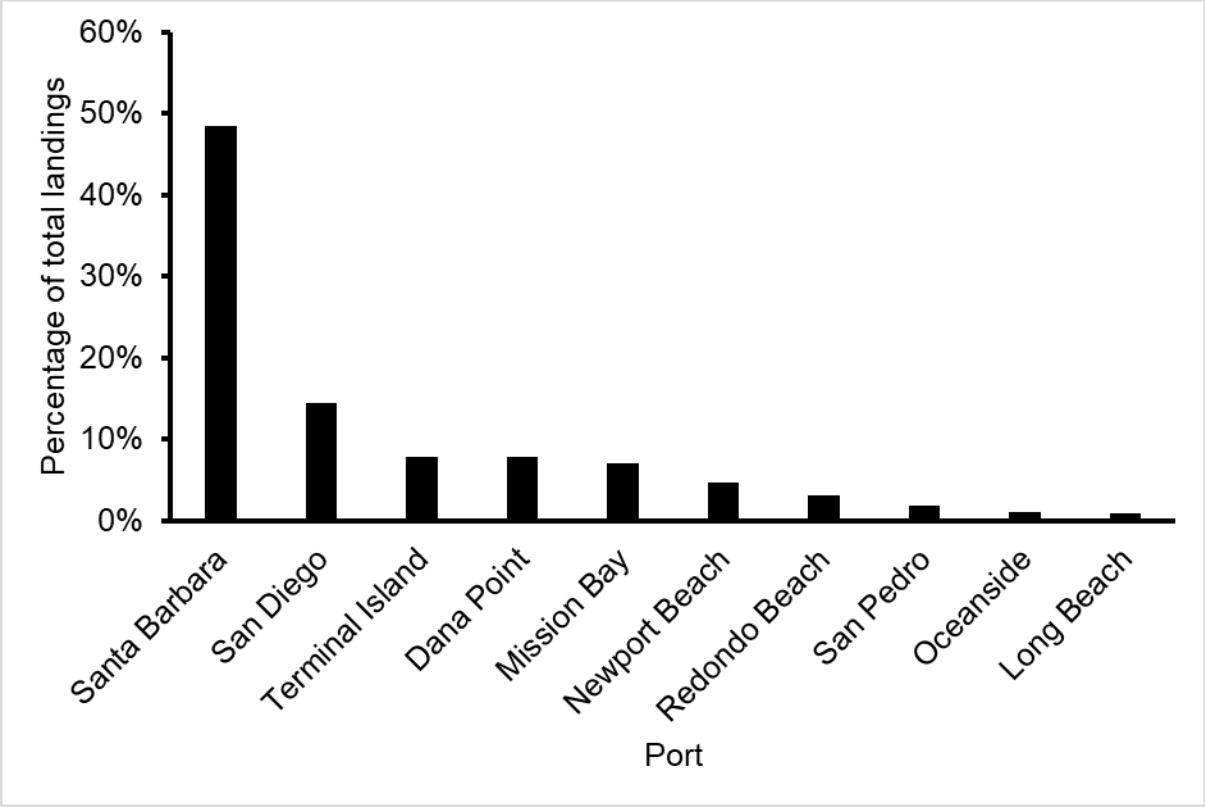

Figure 2-5. Kellet's Whelk percentage of total landings by port from 2008 to 2018 (CDFW MLDS 2019).

3 Management

3.1 Past and Current Management Measures

The current management measures for Kellet's Whelk went into effect in 2012, under California Code of Regulations Title 14 Section 127 (§127, Title 14, CCR). Kellet's Whelk can only be taken commercially by hand or incidentally in lobster or rock crab traps. Incidental take in rock crab traps is only allowed south of the Monterey-San Luis Obispo County line and incidental take in lobster traps is only allowed south of Yankee Point, Monterey County. Deployment of these traps are further prohibited in the front side of Santa Catalina Island, Santa Monica Bay, the Port of Los Angeles/ Long Beach, and San Diego Bay. The commercial fishery is closed from the first Thursday after March 15 to June 30 every year. The fishery is also subject to a TAC of 100,000 lb per season, a level yet to be reached since it was put in place.

Both the lobster and southern rock crab fisheries are limited entry fisheries with a limit on the number of permits specific to their fisheries. Rock crab fishermen must also hold a general trap permit, while a lobster operator permit holder is exempt from this requirement. Commercial divers are required to have a commercial fishing license and may only take Kellet's Whelk further than 1,000 ft (305 m) beyond the low tide mark, as the take of any snails is prohibited in the tidal invertebrate zone (§123, Title 14, CCR). Commercial take is further subject to prohibitions in State Marine Reserves and some State Marine Conservation Areas.

Recreational take of Kellet's Whelk by hand or hook and line is allowed (§29.10, Title 14, CCR) outside of the 1,000 ft (305 m) tidal invertebrate zone. Except where prohibited in state marine reserves and state marine conservation areas, the bag limit is 35 animals with take prohibited from the first Thursday after March 15 to June 30 each year.

3.1.1 Overview and Rationale for the Current Management Framework

The Kellet's Whelk fishery remained essentially unregulated until 2012. However, rising landings and participation in the 1990s and early 2000s drew the attention of fishery managers. Based on the advice and input from the Department, a recommendation from the Commission's Marine Resources Committee, as well as public testimony, the Kellet's Whelk fishery was designated as an emerging fishery in 2011 and the Commission directed staff to develop regulations to ensure the sustainability of the resource and fishery. In late 2011, new regulations were adopted by the Commission. The TAC was chosen based on a fixed fraction of historical landings. A closed season was put in place to avoid harvest during months when Kellet's Whelk aggregate to mate and that also coincides with the end of the commercial lobster season.

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

No objective overfished or overfishing benchmark has been designated due to the incidental nature of the Kellet's Whelk fishery and the relative stability of the

landings. However, landings, effort and value are monitored. Multiple years of the TAC being reached, a sudden drop in landings, or rise in effort or price may lead to an investigation by Department staff, and if warranted, the development of adaptive management recommendations.

3.1.1.2 Past and Current Stakeholder Involvement

The take of Kellet's Whelk came to the attention of fishery managers in the late 2000s due to rising landings. The question of whether to implement specific management measures for the species was first brought up in a public discussion at the June 2010 Commission meeting in Folsom, California. The issue was further discussed in front of the Marine Resources Committee of the Commission in October 2010 and again in February 2011. The full Commission further deliberated on the matter in its April 2011 meeting before the matter entered the rulemaking process. The rulemaking process involved three further Commission meetings (September 15, 2011; November 17, 2011; and December 15, 2011), during which the public was given further opportunities for input and comment.

Due to the incidental nature and the small scale of this fishery, there has been little periodic outreach to stakeholders outside those discussed above. However, any stakeholder may raise concerns or suggestions to the Commission at any of its regular scheduled meetings or by submitting a petition for regulatory change via email or mail.

3.1.2 Target Species

3.1.2.1 Limitations on Fishing for Target Species

3.1.2.1.1 Catch

The Kellet's Whelk fishery is currently managed under a TAC of 100,000 lb. The TAC resets after the end of each fishing season. Each year, Department scientists project the time at which the TAC would be reached based on the landing trends of that season. If the TAC is expected to be reached before the season ends, the Department will announce the fishery closure by providing a required 10-day notice to all individuals who have landed Kellet's Whelk commercially in the previous 5 years and all individuals who hold a lobster operator permit or Southern Rock Crab Permit. The Department will also publish a news release announcing the closure within the same timeframe (§127, Title 14, CCR).

3.1.2.1.2 Effort

Other than the seasonal closure, there is no direct restriction on fishing effort in the Kellet's Whelk dive fishery. The species is predominantly taken in the lobster and rock crab fisheries, both of which are limited-entry. As of 2019, there were 219 individuals that hold a lobster operator permit or a Southern Rock Crab Permit that may take Kellet's Whelk using traps. As of fall 2017, a limit of 300 traps per lobster operator permit was implemented for the lobster fishery.

3.1.2.1.3 Gear

Kellet's Whelk may only be commercially taken by hand or incidentally in lobster and rock crab traps. Both rock crab traps and lobster traps are subject to specific configuration requirements and pulling requirements, (§121-122.2, 125-125.1, Title 14, CCR; Fish and Game Code (FGC) §9000 *et seq.*) The species may be recreationally taken by hook and line or by hand while skin diving, and also while SCUBA diving south of Yankee Point in Monterey, California (§29.05 and 29.10, Title 14, CCR).

3.1.2.1.4 Time

Kellet's Whelk may be taken commercially and recreationally each year from July 1 to the first Wednesday after March 15 of the next year.

3.1.2.1.5 Sex

The sex of Kellet's Whelk cannot be differentiated visually, thus there is no sex restriction on the take of this species.

3.1.2.1.6 Size

There is no size restriction on the take of Kellet's Whelk.

3.1.2.1.7 Area

Kellet's Whelk may not be taken commercially or recreationally within 1,000 ft of the low tide mark.

3.1.2.1.8 Marine Protected Areas

Pursuant to the mandates of the Marine Life Protection Act (FGC §2850), the Department redesigned and expanded a network of regional Marine Protected Areas (MPAs) in state waters from 2004 to 2012. The resulting network increased total MPA coverage from 2.7% to 16.1% of state waters. Along with the MPAs created in 2002 for waters surrounding the Santa Barbara Channel Islands, California now has a statewide scientifically-based ecologically connected network of 124 MPAs. The MPAs contain a wide variety of habitats and depth ranges.

Although MPAs were not designed for fisheries management purposes, but they present related opportunities and considerations including the following:

1. They serve as long-term spatial closures to fishing if the species of interest is within their boundaries and is prohibited from harvest.
2. They can function as comparisons to fished areas for relative abundance and length or age/frequency of the targeted species.
3. They can serve as ecosystem indicators for species associated with the target species, as prey, predator, or competitor.
4. To varying degrees, they displace fishing effort when they were implemented.

Dive survey data from PISCO suggest that Kellet's Whelk may not derive notable conservation advantage from MPAs (Figure 3-1), but before any conclusions can be drawn more analyses are needed to investigate what may be driving the differences in density inside and outside MPAs.

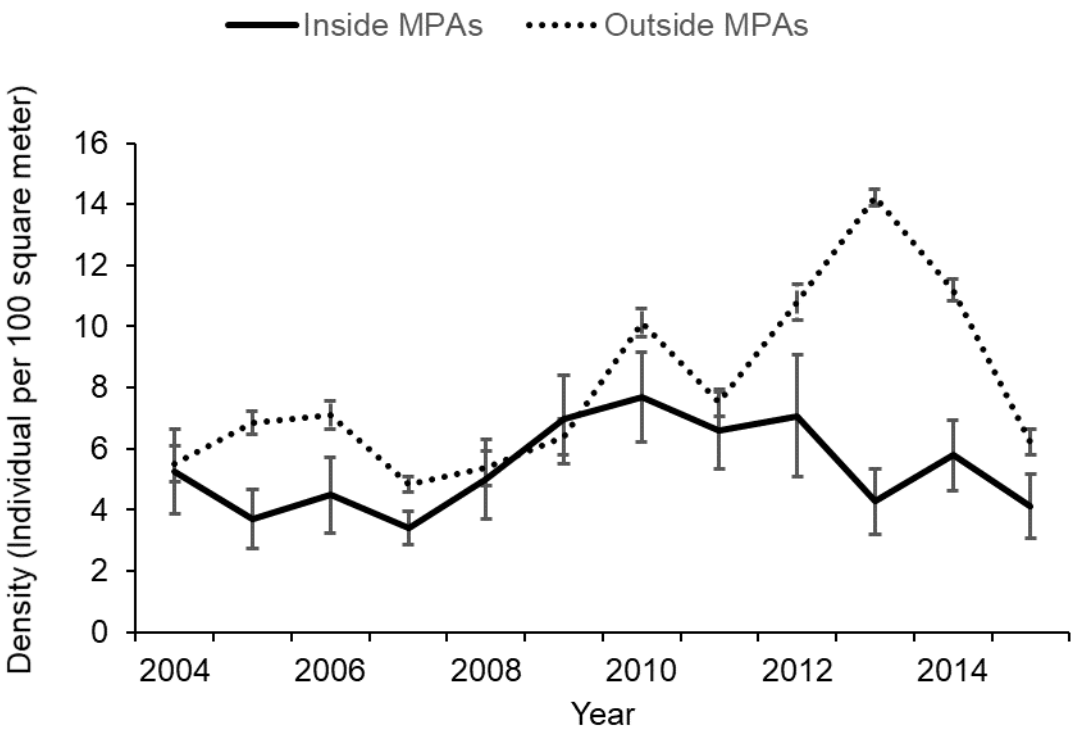

Figure 3-1. Kellet's Whelk average annual density (individuals per 100m^2) determined by SCUBA surveys across California from 2004 to 2015 inside and outside MPAs; bars represent standard error within each year between the average of all sites (PISCO).

3.1.2.2 Description of and Rationale for Any Restricted Access Approach

There is currently no restricted access program in place for Kellet's Whelk. However; both the lobster and southern rock crab fisheries that incidentally take Kellet's Whelk are limited access.

3.1.3 Bycatch

3.1.3.1 Amount and Type of Bycatch (Including Discards)

FGC §90.5 defines bycatch as "fish or other marine life that are taken in a fishery but which are not the target of the fishery." Bycatch includes "discards," defined as "fish that are taken in a fishery but are not retained because they are of an undesirable species, size, sex, or quality, or because they are required by law not to be retained" (FGC §91). The term "bycatch" may include fish that, while not the target species, and

are desirable and are thus retained as incidental catch, and does not always indicate a negative impact.

Kellet's Whelk is almost exclusively taken as an incidental species in other fisheries. As such, it is more accurate to characterize Kellet's Whelk as incidental marketable catch of other targeted species. In the lobster fishery where bycatch is well documented, Kellet's Whelk and lobster make up almost 90% of the individual animals caught by number, while sheep crab, rock crab, and sea star make up another 7.5% (CDFW 2016).

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

Discard Mortality

Bycatch is not an issue in dive fisheries generally since take is by hand and targeted. There is no data on discard mortality of Kellet's Whelk in the trap fisheries. Considering that Kellet's Whelks have some value and are relatively easy to store, discard level is probably low for marketable sized individuals. It is unknown whether discarded Kellet's Whelk tend to land in favorable habitats, but the animals are known to be resilient and likely sink to the bottom relatively quickly.

Bycatch of Overfished, Threatened, or Endangered Species

Because Kellet's Whelk are taken as incidental species in several fisheries, catch of other species associated with Kellet's Whelk are not characterized as bycatch of the Kellet's Whelk fishery. For bycatch of overfished, threatened, or endanger species in the rock crab and lobster fisheries, please consult the respective ESRs for those fisheries.

Measures to Reduce Bycatch

No measures to reduce bycatch are in place since there is no directed fishery for Kellet's Whelk. Both the lobster and the rock crab trap fisheries are subject to trap configuration restrictions that include minimum mesh size, escape ports to reduce bycatch, and destruction devises to minimize ghost fishing.

3.1.4 Habitat

3.1.4.1 Description of Threats

The targeted nature of a dive fishery means that no notable habitat disturbance occurs. Traps in general also do not create significant habitat disturbance, especially compared to other gear types such as trawls and gillnets (Eno et al. 2001). In 2017, a trap limit was implemented for the lobster fishery for the first time, reducing the number of lobster traps.

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

The dive fishery has no specific habitat disturbance to mitigate. Trap fisheries generally contribute little to habitat degradation. A trap limit was implemented for the Spiny Lobster fishery in 2017 to reduce the number of lobster traps. The Department is also tracking the number of lobster trap loss through a requirement for end of season trap loss reporting for all lobster operator permit holders as part of the trap limit program. As more information becomes available, improvements may be made to reduce trap loss.

3.2 Requirements for Person or Vessel Permits and Reasonable Fees

The particular license, permits, and fees associated with the commercial take of Kellet's Whelk depend on the specific method of take employed (See Table 3-1). All fees include a nonrefundable 3% application fee.

The requirements are as follows:

- All commercial fishermen must hold a valid commercial fishing license and they must operate from a registered commercial vessel:
    - Commercial Fishing License – All commercial fishermen must have a commercial fishing license. Commercial fishing licenses are $145.75 for residents and $431.00 for non-residents in 2019. Licenses are required for any resident 16 yr of age or older who uses or operates or assists in using or operating any boat, aircraft, net, trap, line, or other appliance to take fish for commercial purposes, or who contributes materially to the activities onboard a commercial fishing vessel.
    - Commercial Boat Registration – The commercial boat registration fee is required for any owner or operator for any vessel operated in public waters in connection with fishing operations for profit in the state and is $379.00 for residents and $1,122.00 for non-residents in 2019.
- Kellet's Whelk taken incidental to Southern Rock Crab fishery:
    - Southern Rock Crab Trap Permit – A commercial fisherman taking rock crabs using traps south of Lopez Point, Monterey County must hold a Southern Rock Crab Trap Permit. A Southern Rock Crab Trap Permit is limited-entry and must be transferred from an existing permit holder. A current Southern Rock Crab Trap Permit holder can renew the permit for $373.75 in 2019.
    - General Trap Permit – A commercial fisherman taking rock crabs using traps must also hold a general trap permit. A General Trap Permit could be purchased from the Department for $54.08 in 2019.
- Kellet's Whelk taken incidental to Spiny Lobster Fishery:
    - Lobster Operator Permit – A commercial fisherman taking lobsters using traps must hold a Lobster Operator Permit. A Lobster Operator Permit is limited-entry and must be obtained by having one transferred from an existing permit holder. A current Lobster Operator Permit holder can renew the permit for $820.50 in 2019.

The licensing requirement and associated fees for recreational take of Kellet's Whelk are as follow:

- Sport Fishing License – Individuals age 16 yr and older are required to have a California Sport Fishing License to fish recreationally in the state. A sport fishing license in 2019 costs $49.94 for California residents and $134.74 per year for non-residents.
- Ocean Enhancement Validation – Individuals fishing recreationally south of Point Arguello, Santa Barbara County, must obtain an Ocean Enhancement Validation at the cost of $5.56 in 2019.

Table 3-1. Permits and fees associated with Kellet's Whelk commercial and recreational fishery (Accessed June 6, 2019 https://www.wildlife.ca.gov/Licensing/Commercial/Descriptions; https://www.wildlife.ca.gov/Licensing/Fishing).

Permit	Fee (US dollars)
Commercial Fishery	
Commercial Fishing License residents	$145.75
Commercial Fishing License non-residents	$431.00
Commercial Boat Registration residents	$379.00
Commercial Boat Registration non-residents	$1,122.00
Incidental take in Rock Crab	
General Trap Permit	$54.08
Southern Rock Crab Trap Permit	$373.75
Incidental take in Lobster Fishery	
Lobster Operator Permit	$820.50
Recreational Fishery	
Sports Fishing License	$49.94
Ocean Enhancement Validation	$5.56

4 Monitoring and Essential Fishery Information

4.1 Description of Relevant Essential Fishery Information

Biological Information

Length-weight relationship, length-age relationship, and size at sexual maturity for the species are not well understood. Rosenthal (1970) estimated the age of sexual maturity to be between shell length of 2.6 and 2.8 in (65.0 and 70.0 mm). However, sexual maturity has been found in smaller individuals, and the relationship between age and size has never been established. In addition, more advanced information such as the species' trophic role, response to environmental factors, total biomass, and mortality rates have not been as well documented as some other species. Some information such as length-weight relationship and response to protected areas are being gathered by primary research institutions, and could become available by 2019 (White personal communication).

Environmental and Fishery-dependent Indicators

Currently, no biological or environmental indicators are tracked by the Department for use in management of this fishery. Instead, fishery-dependent indicators, such as landings, are used to evaluate the status of the fishery.

4.2 Past and Ongoing Monitoring of the Fishery

4.2.1 Fishery-dependent Data Collection

The Department's primary source of information on the fishery comes from landing receipt data. Data on the date, time, place, depth, effort and amount of take is captured on commercial dive logbooks, but the species is not recorded on lobster and rock crab trap logs where the majority of landings in California occur. Therefore, it is not possible to calculate Catch Per Unit Effort (CPUE) for the trap fisheries. Data collected on landing receipts include:

- fishermen and vessel information
- date the fish was landed
- port of landing
- commercial fishing block where the fish were harvested
- weight (in pound) landed by market category
- price paid to the fisherman by market category
- condition of the fish when sold
- type of gear used to harvest the fish

4.2.2 Fishery-independent Data Collection

The Department does not actively collect fishery-independent data on Kellet's Whelk. The density of Kellet's Whelk is monitored at a number of sites in southern

California by PISCO dive surveys and the Vantuna Research Group, which also collects size information. The National Park Service also similarly conducts dive surveys on a regular basis at the northern Channel Islands. Kellet's Whelk is also surveyed by Reef Check California in its dive surveys; the data from which has not been incorporated into this document, but could be in the future. The species is being actively studied by researchers at the California Polytechnic State University, California State University Fullerton, and Monterey Bay National Marine Sanctuary.

5 Future Management Needs and Directions

5.1 Identification of Information Gaps

Table 5-1. Informational needs for Kellet's Whelk and their priority for management.

Type of information	Priority for management	How essential fishery information would support future management
Fill data gaps and improve biological and life history information	High	Information obtained would include weight-length data, size at maturity, fecundity, adult sex ratio, natural mortality, and adult movement pattern. The information could be used to inform the development of management measures as well as help inform the future development of data poor fisheries models for assessing and projecting the status of the stock.
Capturing take of Kellet's Whelk on lobster and general trap logbooks and collecting size frequency of harvested individuals	Medium	Information would help the Department assess fishing effort, CPUE in the lobster fishery, and fishing mortality for the species
Assess species response to ocean acidification, temperature change, and climate-influenced ENSO events	Medium	Information would help the Department plan for long-term, multi-decadal management strategy. Ocean acidification may negatively impact the stock in the future, change in water temperature may shift the range of the species, while stronger and more frequent El Niño events may increase the recruitment rate of the population north of Point Conception
Assess larval movement and recruitment patterns	Medium	Parameter would help the Department assess recruitment dynamics
Fill data gaps in existing nearshore habitat maps.	Medium	Information could help refine population abundance estimates and would inform future management decisions that could impact the species' habitat.
Develop conversion factors to relate different dive survey methods and datasets used to estimate abundance	Low	Information is helpful to encompass as much data into abundance estimate as possible; data would also help detect population change by comparing densities inside and outside of MPAs, and measure the effectiveness of current management measures through additional fishery-independent datasets.
Assess stock in Baja California and inter-connectivity across national boundaries	Low	Information would help complete the assessment of the current population and projection of future trend for the portion of the population outside of U.S. jurisdiction

5.2 Research and Monitoring

5.2.1 Potential Strategies to Fill Information Gaps

Due to the relative stability of the Kellet's Whelk landings, future information gathering by the Department would likely be opportunistic. There are signs that the population's density has been decreasing across its range, but these data are not conclusive. The highest priority is to obtain all basic life history of the species to allow Department staff to more comprehensively assess the status of the stock. Information on weight-length relationship, reproduction, mortality, and adult movement are areas that are currently lacking. Information that can further complement management are better data on fishery take, larval movement, habitat, and effects of climate change. Lastly, information that help integrate all existing data sets on the species and information on the species' status in Baja California could help improve the overall integrity of the Department's understanding of the stock.

The bulk of future information gathering on Kellet's Whelk life history would likely be performed by academic institutions and in collaborative partnerships between the Department, researchers, and/or fishermen. Already, several researchers in California are conducting studies on Kellet's Whelk to collect information as a regular study subject. These institutions are not constrained by immediate management needs and policy consideration and they have the facilities to hold live animals and conduct these types of studies.

5.2.2 Opportunities for Collaborative Fisheries Research

The Department has collaborated in the past and will continue to work with outside entities such as academic organizations, non-governmental organizations, citizen scientists, and both commercial and recreational fishery participants to help fill information gaps related to the management of state fisheries. The Department will also reach out to outside persons and agencies when appropriate while conducting or seeking new fisheries research required for the management of each fishery

Currently, the Department does not have any active fishery-independent research planned for Kellet's Whelk. However, the Department provides vessel support for a number of Reef Check California and PISCO survey trips each year. Fishery-dependent information is collected regularly from fishery participants and buyers in the form of dive logs and landing receipts. Several laboratories, such as the Zacherl lab at California State University- Fullerton and the Center for Coastal Marine Science at California Polytechnic State University, conduct focused studies on Kellet's Whelk. The Department has and will continue to provide its fishery-dependent data and other support as appropriate to help aid these efforts.

In addition, research groups such as PISCO and the Vantuna Research Group conduct regular marine surveys in southern California that include Kellet's Whelk. However, different research groups have adopted different protocols and practices, and conversion factors may need to be developed before the datasets could be compared (Simmonds et al. 2014). The Department could help facilitate discussions between

these groups to develop and adopt data standardization practices to maximize the effectiveness of these survey datasets.

Should the need arise, the Department can further engage the members of the fishing industry. Information such as the end-use of Kellet's Whelks, market demand and dynamics, or individual participant's practice of capturing and retaining the species can be obtained through informal meetings, formal surveys, or other stakeholder engagement tools described in Appendix G of the 2018 MLMA Master Plan.

5.3 Opportunities for Future Management Changes

This section is intended to provide information on changes to the management of the fishery that may be appropriate but does not represent a formal commitment by the Department to address those recommendations. ESRs are one of several tools designed to assist the Department in prioritizing efforts and the need for management changes in each fishery will be assessed in light of the current management system, risk posed to the stock and ecosystem, needs of other fisheries, existing and emerging priorities, as well as the availability of capacity and resources.

No management changes for Kellet's Whelk have been identified or recommended since 2012. However, improvement to population estimates could allow the Department to adjust the TAC if necessary to improve sustainability. Further understanding population and recruitment trends relative to environmental factors and changes may lead to identifying and incorporating environmental indicators in monitoring efforts and management of the fishery and resource.

5.4 Climate Readiness

Some studies suggest that as the global climate changes, intense El Niño conditions would become more prevalent (Cai et al. 2015; Power et al. 2013), though such prediction is not dispositive (Collins et al. 2010). The species abundance north of Point Conception could thus continue to grow, potentially increasing its resilience.

Warmer ocean temperature may lead to a range shift of the species due to physiological limitations (Sunday et al. 2012). Depending on how the temperature change interacts with physical barriers and habitat suitability, the resilience of Kellet's Whelk may increase or decrease.

Ocean acidification may have a detrimental impact on Kellet's Whelk. As the ocean gradually acidifies (Feely et al. 2009), animals such as Kellet's Whelk that rely on calcified shells to protect themselves would generally become more fragile. Larvae may not develop properly into adults, and adults may need to expend more energy into maintaining their shells (Waldbusser et al. 2015).

None of the current management measures for Kellet's Whelk are directly designed to account for climate change, but the conservative TAC adopted by the Commission and the statewide network of MPAs may help buffer impacts of a changing climate. While the seasonal closure would continue to serve its purpose if the species' reproductive season remains the same, the dates and duration of the closure along with

the current TAC for the commercial fishery may require adjustment as ocean conditions change.

Literature Cited

Cai W., Santoso A., Wang G., Yeh SW., An SI., Cobb KM., Collins M., Guilyardi E., Jin FF., Kug JS., and Lengaigne M. 2015. ENSO and greenhouse warming. Nature Climate Change 5(9): 849.

California Department of fish and Wildlife 2016. California Spiny Lobster Fishery Management Plan.

Collins M., An SI., Cai W., Ganachaud A., Guilyardi E., Jin FF., Jochum M., Lengaigne M., Power S., Timmermann A., and Vecchi G. 2010. The impact of global warming on the tropical Pacific Ocean and El Niño. Nature Geoscience *3*(6): 391.

Cumberland HL. 1995. A life history analysis of the Kellet's Whelk, Kelletia kelletii [Master's thesis]. San Diego State University. 93 p.

Doyle RF. 1985. Biogeographical studies of rocky shores near Point Conception (524 pp), California. University of California, Santa Barbara.

Eno NC., MacDonald DS., Kinnear JA., Amos SC., Chapman CJ., Clark RA., et al. 2001. Effects of crustacean traps on benthic fauna. ICES Journal of Marine Science: Journal du Conseil, 58(1): 11-20.

Feely RA., Doney SC., and Cooley SR. 2009. Ocean acidification: Present conditions and future changes in a high-CO_2 world. Oceanography 22(4): 36-47.

Gazeau F., Parker LM., Comeau S., Gattuso JP., O'Connor WA., Martin S., and Ross PM. 2013. Impacts of ocean acidification on marine shelled molluscs. Marine biology 160(8): 2207-2245.

Gotshall D. 2005. Guide to marine invertebrates: Alaska to Baja California. Sea Challengers. 117 p.

Halpern BS., Cottenie K., and Broitman BR. 2006. Strong top-down control in southern California kelp forest ecosystems. Science, 312(5777): 1230-1232.

Herrlinger TJ. 1981. Range Extension of Kelletia-Kelletii. Veliger 24(1): 78-78.

Hopper JV., Kuris AM., Lorda J., Simmonds SE., White C., and Hechinger RF. 2014. Reduced parasite diversity and abundance in a marine whelk in its expanded geographical range. Journal of biogeography 41(9): 1674-1684.

Lonhart SI. and Tupen JW. 2001. New range records of 12 marine invertebrates: the role of El Nino and other mechanisms in southern and central California. Bulletin of the Southern California Academy of Sciences 100.3: 238-249.

Morris RH., Abbott DP., Haderlie EC. 1980. Intertidal invertebrates of California. California. Stanford University Press. 690 p.

Nienhuis S., Palmer AR., and Harley CD. 2010. Elevated CO2 affects shell dissolution rate but not calcification rate in a marine snail. Proceedings of the Royal Society of London B: Biological Sciences 277(1693): 2553-2558.

Power S., Delage F., Chung C., Kociuba G., and Keay K. 2013. Robust twenty-first-century projections of El Niño and related precipitation variability. Nature 502(7472): 541.

Reilly PN. 1987. Population Studies of Rock Crab, *Cancer antennarius*, Yellow Crab, *Cancer anthonyi*, and Kellet's Whelk, *Kelletia kelletii*, in the Vicinity of Little Cojo Bay, Santa Barbara County, California, California Fish and Game 73(2): 88-98.

Rodriguez KN. 2017. Linking large scale ocean-atmospheric patterns with recruitment in Kellet's Whelk (Kelletia kelletii) [Bachelors thesis]. California Polytechnic State University: San Luis Obispo. 19 p.

Romero MR., Walker KM., Cortez, C.J., Sanchez, Y., Nelson, K.J., Ortega, D.C., Smick, S.L., Hoese, W.J. and Zacherl, D.C. 2012. Larval diel vertical migration of the marine gastropod Kelletia kelletii (Forbes, 1850). *Journal of Marine Biology*, *2012*.

Rosenthal RJ. 1970. Observations on the reproductive biology of the Kellet's Whelk, Kelletia kelletii. Veliger 12(3): 319-324.

Simmonds SE., Kinlan BP., White C., Paradis GL., Warner RR., and Zacherl DC. 2014. Geospatial statistics strengthen the ability of natural geochemical tags to estimate range-wide population connectivity in marine species. Marine Ecology Progress Series 508: 33-51.

Solomon S., Qin D., Manning M., Chen Z., and Marquis. 2007. Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (996 pp).

Sunday JM., Bates AE., and Dulvy NK. 2012. Thermal tolerance and the global redistribution of animals. Nature Climate Change 2(9): 686.

Waldbusser GG., Hales B., Langdon CJ., Haley BA., Schrader P., Brunner EL., Gray MW., Miller CA. and Gimenez I. 2015. Saturation-state sensitivity of marine bivalve larvae to ocean acidification. Nature Climate Change *5*(3): 273.

White C., Selkoe KA., Watson J., Siegel DA., Zacherl DC., and Toonen RJ. 2010. Ocean currents help explain population genetic structure. Proceedings of the Royal Society of London B: Biological Sciences. rspb20092214.

Wilson MN. 2017. Understanding the transition from benthic egg to dispersive larvae: observations on the intra-capsular growth and development of a marine snail (Kelletia kelletii) [Bachelors thesis]. California Polytechnic State University, San Luis Obispo. 17 p.

Zacherl D., Gaines SD., and Lonhart SI. 2003. The limits to biogeographical distributions: insights from the northward range extension of the marine snail, Kelletia kelletii (Forbes 1852). Journal of Biogeography 30(6): 913-924.

Zahn LA., Claisse JT., Williams JP., Williams CM., and Pondella DJ. 2016. The biogeography and community structure of kelp forest macroinvertebrates. Marine ecology 37(4): 770-785.