Status of Rocky Reef Ecosystems in California

2006 - 2011

Reef Check California

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Jan Freiwald, Megan Wehrenberg, Colleen Wisniewski, Gregor Hodgson

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Reef Check Foundation
P.O. Box 1057
17575 Pacific Coast Highway
Pacific Palisades CA 90272-1057 USA

Tel: 1-310-230-2371
Email: rcinfo@reefcheck.org
http://reefcheck.org

Table of Abbreviations

AAUS – American Academy of Underwater Sciences

AOP – Aquarium of the Pacific

CDFG – California Department of Fish and Game (now called California Department of Fish and Wildlife)

CDFW – California Department of Fish and Wildlife

CeNCOOS – Central and Northern California Ocean Observing System

CIMI – Catalina Island Marine Institute

CRANE - Cooperative Research and Assessment of Nearshore Ecosystems

EBM – Ecosystem Based Management

EML – Ecological Metadata Language

HSU – Humboldt State University

MBA – Monterey Bay aquarium

MLMA – Marine Life Management Act

MLPA – Marine Life Protection Act

MPA – Marine Protected Area

NCCSR – North Central Coast Study Region

NED – Nearshore Ecosystem Database

NGO – Non-governmental Organization

PISCO – Partnership for Interdisciplinary Study of Coastal Oceans

QA/QC – Quality Assurance/Quality control

RCCA – Reef Check California

RLFF – Resource Legacy fund Foundation

SCCOOS – Southern California Coastal Ocean Observing System

SIMON – Sanctuary Integrated Monitoring Network

SMR – State Marine Reserve

UPC – Uniform Point Contact

UROC – Undergraduate Research Opportunities Center

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Executive Summary

Reef Check is an international organization with the mission of empowering people around the globe to sustainably manage coral and rocky reefs. The focus of the California program is to improve the health of California's rocky reef and kelp forest ecosystems. This is accomplished by training approximately 250 divers each year to carry out standardized scientific surveys of about 80 reef sites along the state's coast, from Oregon to Mexico, and then passing along the data and analyses to state resource managers, academic scientists and the general public. Reef Check's volunteer citizen scientists monitor inside and outside of California's newly established network of marine protected areas (MPAs) using scientific protocols that are robust, rigorous and repeatable. In many cases, we still don't know how marine ecosystems respond to the many threats they are facing such as pollution, overfishing and global warming. Therefore, it is important to track how these ecosystems change as the MPA network takes effect. Reef Check brings together community members, scientists, academic institutions, state agencies and business partners to collaborate to support improved management of California's nearshore rocky reef ecosystems. It provides an avenue for people to directly participate in ocean management. Analyses of Reef Check's monitoring data in comparison to historic datasets have shown that 19 of 25 fish species for which data are available have declined between the 1970s and now. At the same time, ongoing monitoring has detected signs that fish populations in some MPAs are starting to increase.

Deploying the same sampling protocol over a large geographic area allows for comparisons of population or community dynamics across biogeographic or management regions. For example, Reef Check's red abalone data demonstrate the effects of past exploitation of abalone populations under different regional management regimes. Red abalone are still abundant in the northern part of the state but are almost never seen in southern California (Figure 9). In central California, red abalone densities are about 10 times lower than in the north, but show stable or increasing population densities (Figure 9). This pattern is the result of overharvesting of abalone populations in central and southern California, and effective management measures in the north.

Reef Check documented a major and rapid decline in abalone abundance along the Sonoma County coast in 2011 (Figure 10). By fall, densities in several locations declined to less than half of the numbers counted in the spring of the same year. Divers reported dead and empty abalone shells everywhere. While the exact cause of the die-off is still in debate, it was related to a harmful algal bloom. Typically such "red tides" can kill organisms by reducing oxygen to fatal levels, introducing toxins into the system and increasing bacteria concentrations.

Using Reef Check's long-term datasets, this recent decline can be compared with past fluctuations in abalone abundance at this site. In 2007 there was a local die-off at Gerstle Cove, a marine reserve on the Sonoma coast, attributed to low oxygen that was even worse – a 70% reduction in red abalone densities. By 2009, the population began rebuilding through spring 2011 when the latest die-off occurred. Only through long-term monitoring is it possible to track population fluctuations and evaluate them in the context of previous years.

The first of California's marine protected areas (MPAs) under the Marine Life Protection Act (MLPA) legislation were implemented in central California in 2007 through a selection process that was completed in 2012. Reef Check has been monitoring many of the reefs in these new MPAs since 2006. Reef Check has thus served as an important participant in this process by providing data to stakeholders and policy makers to inform MPA design and implementation. As MPAs have been established in all subsequent regions, Reef Check's trained citizen scientists have played a key

role in the state's baseline monitoring programs. Reef Check's participation demonstrates a new level of cooperation between the state and community-based NGO's in California's marine management. This involvement has enabled Reef Check to expand its focus from data collection to providing analyses and MPA evaluation to state resource management agencies. By using trained citizen scientists, Reef Check is extremely cost-effective and provides a long-term solution to statewide monitoring of the new MPA network.

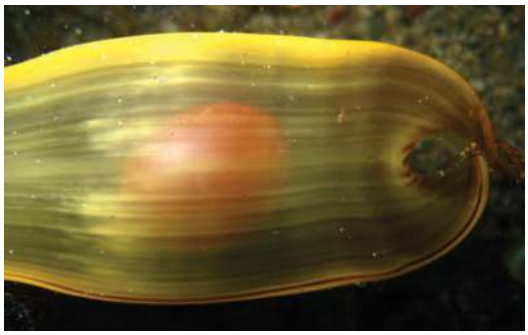
Analysis of Reef Check's data shows a positive response to protection in the population densities of several fish species in the Lover's Point State Marine Reserve (SMR) in Monterey Bay (Figure 20). This indicates that MPAs are an effective management approach in allowing this area to return to a more natural state. Other reserves do not yet show clear trends of recovery. All Reef Check data for 35 fish, 31 invertebrate and eight algae species are publically available through Reef Check's online Nearshore Ecosystem Database (NED) and are provided to state managers and included in MPA monitoring databases (ned.reefcheck.org).

Reef Check monitors over 50 sites in southern California annually, covering the mainland, the northern Channel Islands and Catalina Island. This large-scale monitoring network can be used to identify regional population trends. Over the first 6 years of monitoring we have identified region-wide declines in some species while other species' population densities seem stable or fluctuate from year to year. Two examples in southern California are kelp bass and spiny lobster. Kelp bass populations have declined over the monitoring period, especially larger individuals seem to have become less abundant over time whereas the number of smaller individuals is stable on a regional scale (Figure 15). This suggests that the decline is not driven by recruitment dynamics (successful reproduction and growth) but could be caused by exploitation of the adult population. In contrast, the population trend for the spiny lobster, another highly targeted species, appears stable when the entire southern California region is considered (Figure 16). Similarly, the dynamics of giant kelp (*Macrocystis pyrifera*), the foundational species of the kelp forest in this region, fluctuate widely between sites or geographic regions (Figure 8). Besides fishing or harvest, species interactions might play a role in these trends. For example, lobsters are likely to benefit when their predators have been removed through fishing.

An important goal of Reef Check is marine science education. Each year, we train and certify recreational divers who join our existing pool of volunteers to carry out our standardized scientific surveys of California's rocky reef ecosystem. These divers become keen observers of the natural environment and sometimes they spot species that are rarely seen or new to a geographic region. Reef Check divers have made several discoveries of rare or uncommon species. A subtropical sea cucumber (*Holothuria zacae*), usually found along the coast of Ecuador, the Galapagos and Mexico, was found at Catalina Island; a threaded abalone (*Haliotis assimilis*), now very rare in California, was observed off Palos Verdes; and Reef Check divers in San Diego have recorded several broadnose sevengill sharks (*Notorynchus cepedianu*), ranging from 5-10 feet in length. In Monterey, a Reef Check diver saw and filmed a white sturgeon (*Acipenser transmontanus*) in the kelp forest. So in addition to monitoring several known invasive and rare species, Reef Check's trained divers are of great value for tracking species range expansions or new invasives.

To accomplish our goals, Reef Check forms partnerships with California universities, state agencies, community groups, businesses and other non-profit organizations (for list of partners see page 35). In some cases, we link with existing monitoring programs to develop a comprehensive statewide rocky reef monitoring network. The synergy achieved through these close working relationships ensures that Reef Check's results are channeled into California's marine management process to help protect coastal rocky reefs and kelp forest communities. To further expand opportunities to collaborate with the business community, Reef Check has recently launched an Adopt-A-Reef program. Under this program, companies such as four founding partners the St. Regis Monarch Beach, The Ritz-Carlton-Laguna Niguel, the Doubletree Suites by Hilton Doheny Beach, Dana Point and the Laguna Cliffs Marriott Resort & Spa, agree to sponsor annual surveys of selected rocky reefs. To ensure successful integration of Reef Check's data with existing and historical datasets, the RCCA data are compared with data collected by other monitoring groups. Results of a 2008 study in southern California showed that the datasets integrate well for informing marine management and conservation. The full article can be found in the journal Environmental Monitoring and Assessment (Gillett *et al.* 2012) as well as on Reef Check's website (www.reefcheck.org).

1 Introduction



Since 2006, Reef Check California (RCCA) has used a standardized scientific monitoring protocol to survey rocky reef ecosystems along the California coast. Here we report on the status of California's rocky reef ecosystems based on six years of scientific monitoring data (2006 to 2011). The Reef Check California monitoring protocol (Shuman *et al.* 2011) was designed by marine scientists with the aim of using volunteers, trained and led by marine biologists, to collect data on the status of biological communities associated with rocky reef and kelp forest habitats. By using volunteers as citizen scientists, the program has the advantage of reduced costs and increased education of the ocean user community and the general public.

Reef Check is a non-profit (NGO) marine conservation organization that was established to provide local communities around the world with the tools needed to scientifically monitor and manage reef health. Initially launched in Hong Kong in 1996, and later as an affiliated research program of the University of California Los Angeles, Reef Check was incorporated in 2001 as a 501(3)(c) non-profit Foundation. With only 6 full-time staff and over 30,000 volunteers in more than 90 countries and territories, the Reef Check Foundation manages the world's largest coral reef monitoring network. Reef Check's mission is to effectively integrate science, community action and marine management to protect and improve the health and sustainability of the world's reefs. Many nations have adopted the Reef Check protocol to be part of or the primary monitoring tool for their national reef monitoring programs. The Reef Check Foundation is headquartered in Pacific Palisades, California and Reef Check chapters have been formally established in 10 countries. All other Reef Check groups are staffed by volunteer coordinators and scientists.

In 2005, Reef Check expanded its focus, from tropical reefs to include temperate rocky reefs for the first time, by starting a California monitoring program. California's nearshore waters host a unique and valuable marine ecosystem considered to be one of the most productive ocean areas in the world (Valiela 1995). In this ecosystem, the rocky substrate provides the foundation for animals and algae to attach, grow and thrive. On many rocky reefs, forests of giant kelp stretch over 20 meters, from the seafloor to the surface, providing habitat for invertebrate and fish life.

The State of California is often considered a national and even world leader in environmental initiatives. But prior to 1999, California's marine conservation efforts were minimal and many species had been overexploited (Jackson *et al.* 2001, Tegner and Dayton 2000). At that time, California only had a handful of tiny marine reserves that prohibited fishing and protected ecosystems. In addition, little attention was paid to the interactions of species or the effects of exploitation on the biological communities because most fished stocks were managed individually. The lack of holistic management was a failure and led to the collapse or decline of numerous fisheries, such as abalone and many rockfish species (Ruckelshaus *et al.* 2008). By 1999, many of California's iconic fish species such as the blue shark, basking shark and giant sea bass were rare and large individuals seldom seen. The failure of past management approaches led to an increased interest in ecosystem-based management (EBM), including the use of marine protected areas (MPAs) in the 1990's (McLeod *et al.* 2005). The sequential failure of shellfish and finfish fisheries led to the passage of two laws in 1999, the Marine Life Management Act (MLMA) and the Marine Life Protection Act (MLPA), which dramatically changed the way in which California's marine resources would be managed. These laws mandated ecosystem-based approaches to achieve sustainable fisheries management and the use of MPAs for preserving, restoring and conserving marine ecosystems, respectively. Both laws required adaptive management of resources and the monitoring and evaluation of management actions and results stimulating a push for more comprehensive statewide marine monitoring programs.

As the new laws were going into effect, the Partnership for Interdisciplinary Studies of the Coastal Oceans (PISCO), a consortium of academic researchers from four west coast universities was formed to study large-scale biological and oceanographic processes along the coast. It was the first time that California scientists came together to develop a program to track conditions of rocky reef ecosystems on a large geographic scale. While the program was designed to answer broad ecological questions, it also started to address important management issues. PISCO included a near shore subtidal reef monitoring protocol to study rocky-reef communities and began annual monitoring of rocky reefs in 1999. Lagging far behind tropical monitoring programs in the US, this was the first large-scale, long-term rocky-reef ecosystem monitoring program in the United States. In 2002, the Cooperative Research and Assessment of Nearshore Ecosystems (CRANE) program was developed by the California Department of Fish and Wildlife (CDFW, formerly California Department Fish and Game) in collaboration with academic and federal scientists to help meet the goals of the MLMA.

In 2005, the Reef Check Foundation established the California (RCCA) program. Modeled after the successful tropical Reef Check program, a protocol was designed for volunteer citizen scientists to monitor the rocky reefs and kelp forests. RCCA's protocol was modeled partly on the PISCO protocol in collaboration with a team of academic and state agency scientists. It is based on a suite of 35 fish species, 31 species of invertebrates and eight species of algae that are monitored on 36 transects which are randomly placed at a rocky reef survey site. This protocol is taught to new volunteers, who must be experienced California divers, in a rigorous four-day training. In subsequent years, every volunteer is required to participate in a recertification process before collecting data. RCCA's rigorous training, volunteer supervision during monitoring surveys, as well as RCCA's QA/QC procedures, and data reporting are conducted by Reef Check's professional marine biologists to insure high data quality. To implement the monitoring program, RCCA partners with many of California's academic research institutions and has worked especially closely with the California Department of Fish and Wildlife (CDFW) based on a 2007 Memorandum of Understanding (for a list of all partners see page 35).

Reef Check data have been essential for marine management considerations and decisions. Since its inception, Reef Check has been involved in the stakeholder driven MLPA initiative's process of designing and implementing California's MPA network. RCCA data were made available to, and used by, stakeholders in all study regions during decisions about design and siting of MPAs. In 2011, RCCA data were provided to the CDFW when an invertebrate die off was detected along the Sonoma County coast (see page 22). The documentation and reporting of this event that led to the death of thousands of abalone resulted in CDFW's decision to partially close the recreational red abalone fishery in the region. Currently, RCCA is involved in the baseline monitoring of the MPAs. The data our citizen scientists are collecting have been used to characterize the ecosystem conditions as MPAs were established as well as to detect early changes after MPAs were implemented. This participation in the MPA monitoring not only provides needed data but also the opportunity for stakeholders to become directly involved in the MLPA process after the initial implementation phase is completed. Citizen scientists' contribution to the evaluation and adaptive management of MPAs creates a participatory process and a sense of stewardship in the ocean user community.

2 Reef Check California's Approach

The Reef Check Foundation's California Program (RCCA) is a partnership of volunteer divers, community members, scientists, academic institutions, state agencies and business partners working together to conserve California's near-shore rocky reef ecosystems. Since its inception in 2005, Reef Check California has grown into a statewide monitoring network with sites stretching from Humboldt County to San Diego, and by 2012 included a total of 80 reef sites. By emphasizing public education and outreach, RCCA creates an informed constituency supportive of science-based management.

Pursuant to its mission of empowering Californians to become active stewards of local marine environments, RCCA has two primary program goals. The first goal is to facilitate ecologically sound and sustainable marine management in California. Reef Check California has positioned itself to become the leading organization in the state for long-term reef monitoring by developing scientific protocols that are robust, rigorous and repeatable at established sites ranging the length of California's coastline. The maturation of the program over the last five years has enabled RCCA to grow from a program that not only collects data, but also provides data analysis and evaluation of marine protected areas (MPAs) for state and resource management agencies. The survey methodology was developed in close coordination with academic, non-profit and state agency data collection efforts and was peer reviewed by our Science Advisory Team which includes government representatives and renowned kelp forest ecologists. As a result, our data collection system is scientifically sound and compatible with existing datasets and monitoring programs in the state (Gillett *et al.* 2011).

Michelle Hoalton, a long-term recreational diver, has been part of RCCA for two years:

"I had no idea how much I would be able to learn through the RCCA program. It has taught me to respect the ocean environment on a much higher level. From learning about the strong interdependence of marine life species and the alarming toll that overfishing and pollution have caused, which I have personally witnessed and documented during Reef Check surveys, ocean preservation activities have become a personal passion of mine….The fact that they put that data in the hands of policy and law makers so they have the ability to reference it and hopefully make informed decisions on marine preservation standards has kept me engaged in the program."

Reef Check organizes and advertises surveys throughout the state using an online forum system. For safety and to avoid the risk of expensive, weather-related cancellations, most surveys are carried out during the 8-month period beginning in April and ending in November each year.

The beauty of the ocean surface masks severe declines in both habitat quality and biodiversity throughout California's temperate rocky reefs. Divers, fishermen and other ocean users have observed these changes and many want to help address them. RCCA leverages donations, in-kind support and the commitment of volunteers, partners and the community at-large, to collect data that can help improve marine management in California. Through its approach of citizen science, RCCA has made scientific data collection accessible to community members by selecting a subset of key ecological and human impact indicator species to be counted, sized and recorded. By requiring rigorous training, testing and annual certification of all participants the program ensures that the data collected by volunteers are of

high-quality and scientifically robust. In addition, RCCA's education and outreach programs help build strong public support for marine stewardship and the use of scientific data in adaptive resource management and ecosystem protection. RCCA has trained and educated more than 1000 volunteer scuba divers and gives concerned citizens and communities an avenue for engagement in the management process. Through this approach, Reef Check advocates strongly for the use of scientific data to inform marine management decisions.

3 Volunteer Training and Survey Sites

Training, Volunteers and Internships

Since the first training course was offered in Pacific Palisades in 2006, RCCA has expanded to offer training and recertification courses throughout the state (Figure 1). In 2012, RCCA offered 24 new training courses or recertification classes for volunteers statewide, enabling divers from all over California to participate in the program. These classes were taught as public training courses by RCCA staff or in collaboration with partnering universities, community colleges, public aquaria (Monterey Bay Aquarium, Aquarium of the Pacific) or youth education facilities and science camps, such as the Catalina Island Marine Science Institute or the Emerald Bay Boy Scout Camp.

Figure 1. Map showing RCCA's partner, public, and university trainings in 2006-2011.

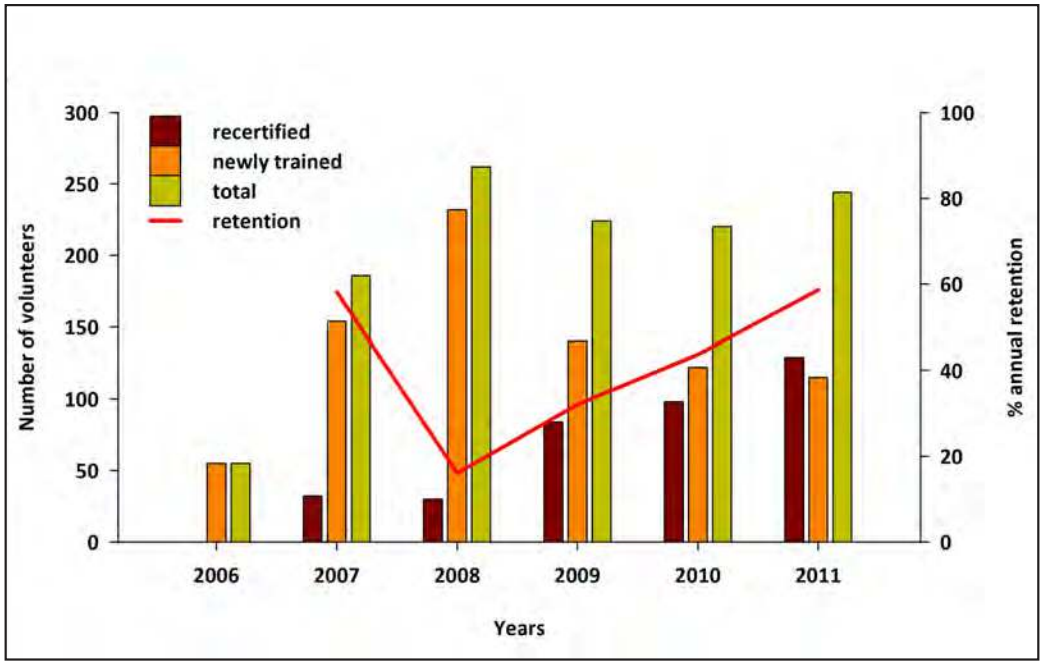


Figure 2. Annual number of RCCA trained and recertified volunteer citizen scientists. After fast growth in volunteer numbers in the initial years, the program has stabilized its number of volunteers and increased volunteer retention over the years.

Since its inception, RCCA has trained over 1000 divers. The program experienced dramatic growth from 2006 to 2008, increasing the number of volunteers rapidly. Participants were recruited from a diverse group of ocean users including commercial urchin fishermen, lifeguards, recreational divers, police divers, marine educators, university dive programs and high school students. Starting in 2009, the program focused on retaining more of its experienced volunteers rather than increasing the number of new trainees every year. In a program that requires intensive training and highly skilled volunteers, this trend of increasing volunteer retention is essential for maintaining a well-trained group of citizen scientists.

With substantial volunteer retention (Figure 2), the program has developed a base of well-trained volunteers throughout the state, thereby solidifying the program in regions where it is well established and allowing expansion into new areas. To further increase monitoring capacity, RCCA established internship positions and sought relationships with undergraduate programs. Currently, interns are recruited each survey season from the University of California, Santa Barbara and from the Undergraduate Research Opportunity Center (UROC) at California State University Monterey Bay. These internships are an important aspect of RCCA's educational goals of making the program part of the undergraduate education of students at universities in California.

David Horwich, a longtime RCCA volunteer who has taken a leadership position and is conducting survey dives in the Monterey area, single-handedly organizing large groups of volunteers to monitor these sites:

"Being involved with Reef Check has been an enriching and rewarding experience. The benefits have been many: for instance, I've learned a great deal about the local marine environment, both the species that inhabit it, as well as how the various parts of the ecosystem interconnect. … Last but not least, I've made many new friends through Reef Check and have learned much about both diving and marine ecology from my fellow volunteers."

Monitoring Sites

The number of sites monitored by RCCA has tripled since monitoring began in 2006. Sites have been added in response to newly established MPAs and within areas that are under-surveyed, such as the northern part of the state. The network of monitoring sites grew to a total of 82 sites by 2011 and an annual number of surveys of around 70 (Figure 3). Some of the sites are in remote or hard to reach locations, such as the northern Channel Islands. Therefore, not every site is sampled every year and opportunities are taken, as they arise, to add new sites even if it is uncertain if they will be surveyed every year. Overall, these sites will add to a more complete picture of the status of California's reef ecosystem than if the site selection were limited due to logistical constraints. The program is taking a two-pronged approach by dividing the reef sites in its network into two categories: 'core' sites and 'opportunity' sites. Core sites are the absolute priority and will be sampled at least once a year (unless weather or ocean conditions are prohibitive). Several of these core sites are sampled twice a year. 'Opportunity' sites are added to the network as the opportunities arise and sampled again whenever possible but may not to be sampled every year (Figures 4 to 7).

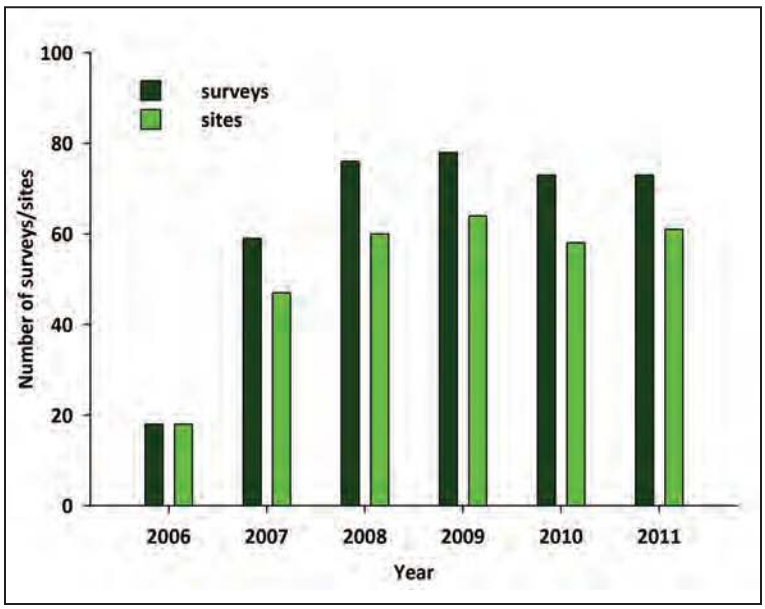


Figure 3. Number of sites and surveys conducted by RCCA volunteer citizen scientists annually. Some sites are surveyed more than once a year.

Ideally, the monitoring network would include sufficient sites to represent all California rocky reef ecosystems. While sites are spread throughout the state, there are still large sections of coastline that are very poorly represented. The density of sites is higher in southern waters than along the northern coast of California for example. There are no sites on several offshore islands and very few sites on most. With a 1000 mile long coastline, and about 80 sites, there is less than 1 site per 10 miles. Santa Cruz Island with a 100 mile long coastline has only six monitoring sites. While there are eight sites on Catalina Island, none are on the windward side. While a volunteer program is relatively inexpensive, the cost of boats and equipment to transport volunteers to these remote locations remains high and is a barrier to a more comprehensive network.

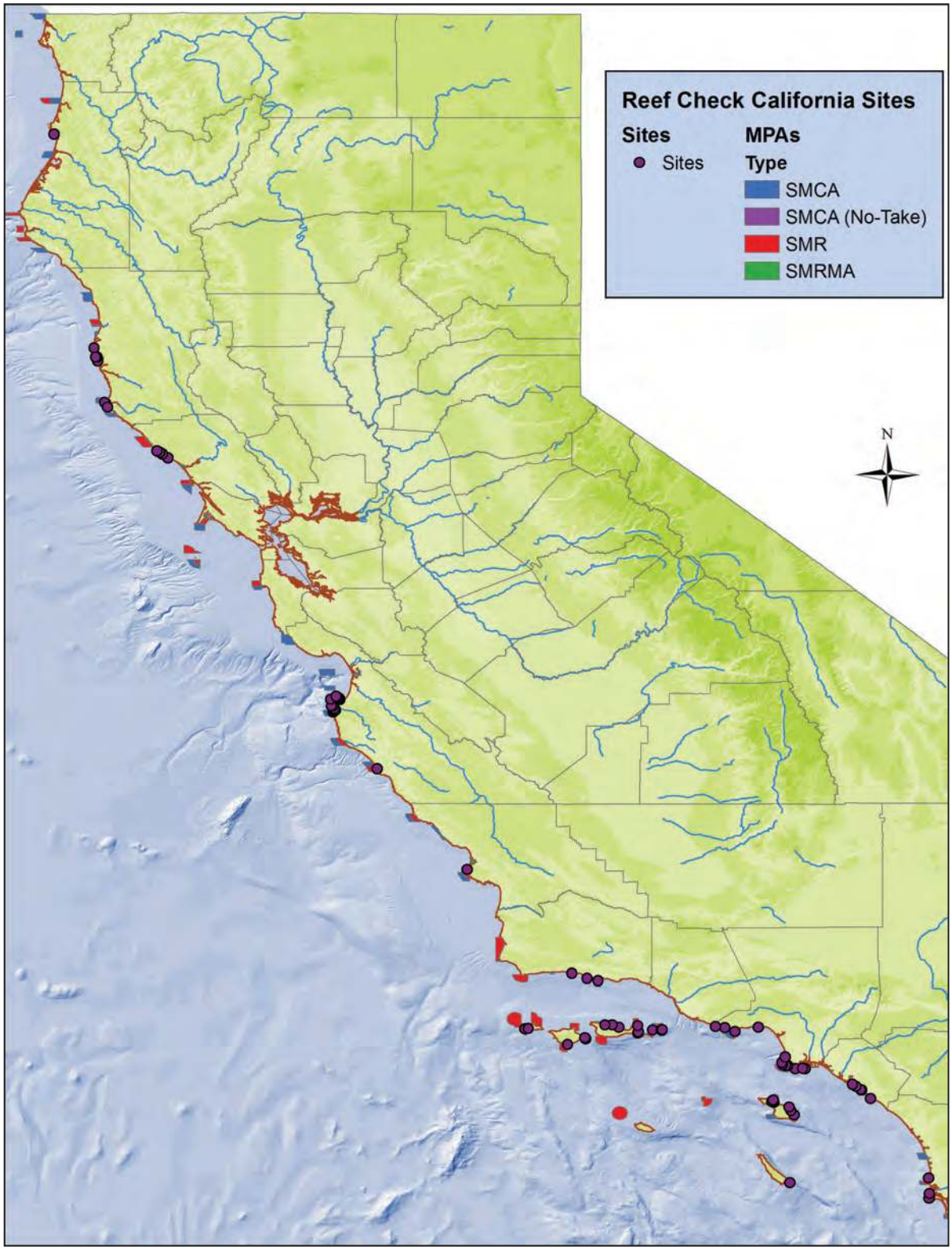
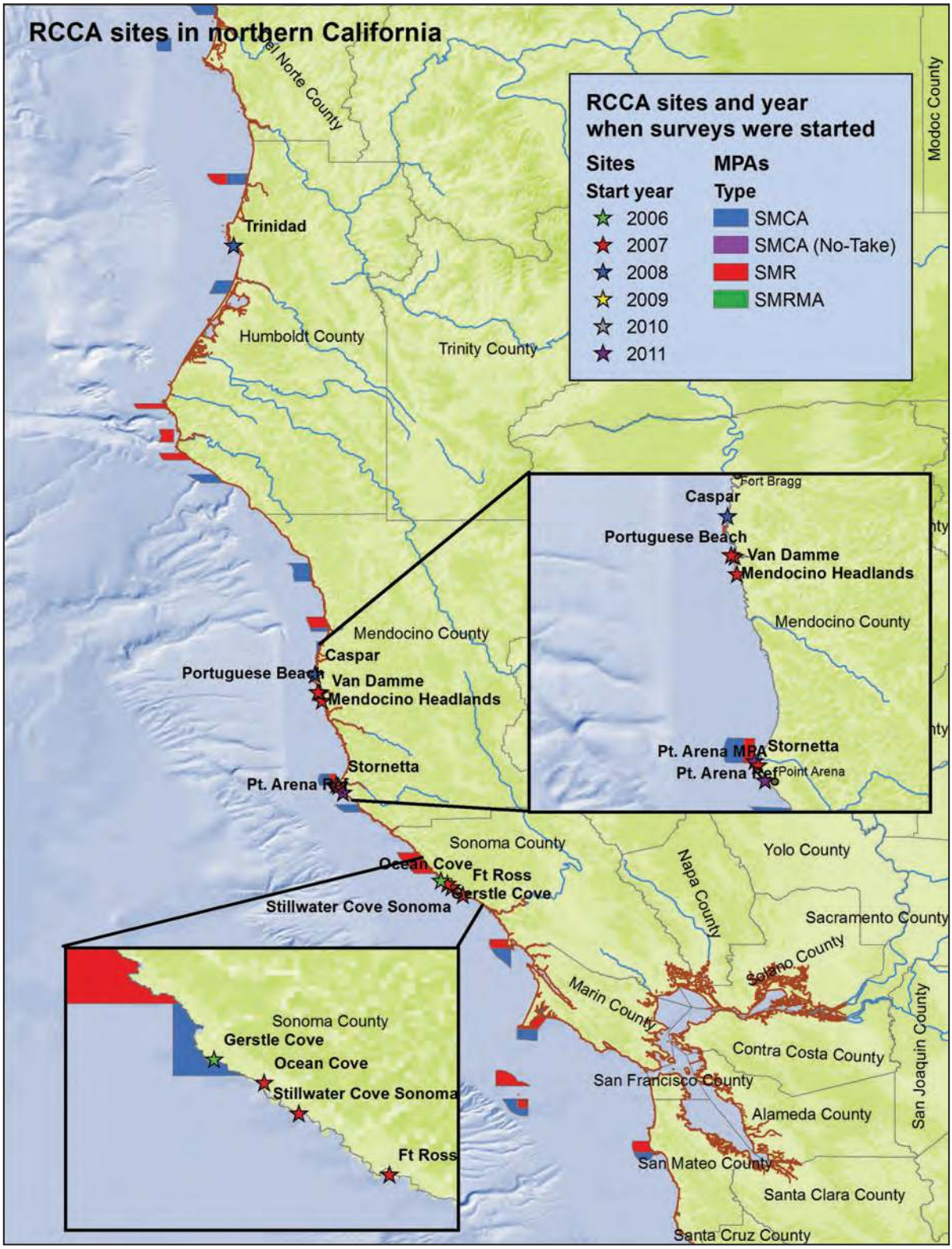


Figure 4. Statewide map of RCCA survey sites.



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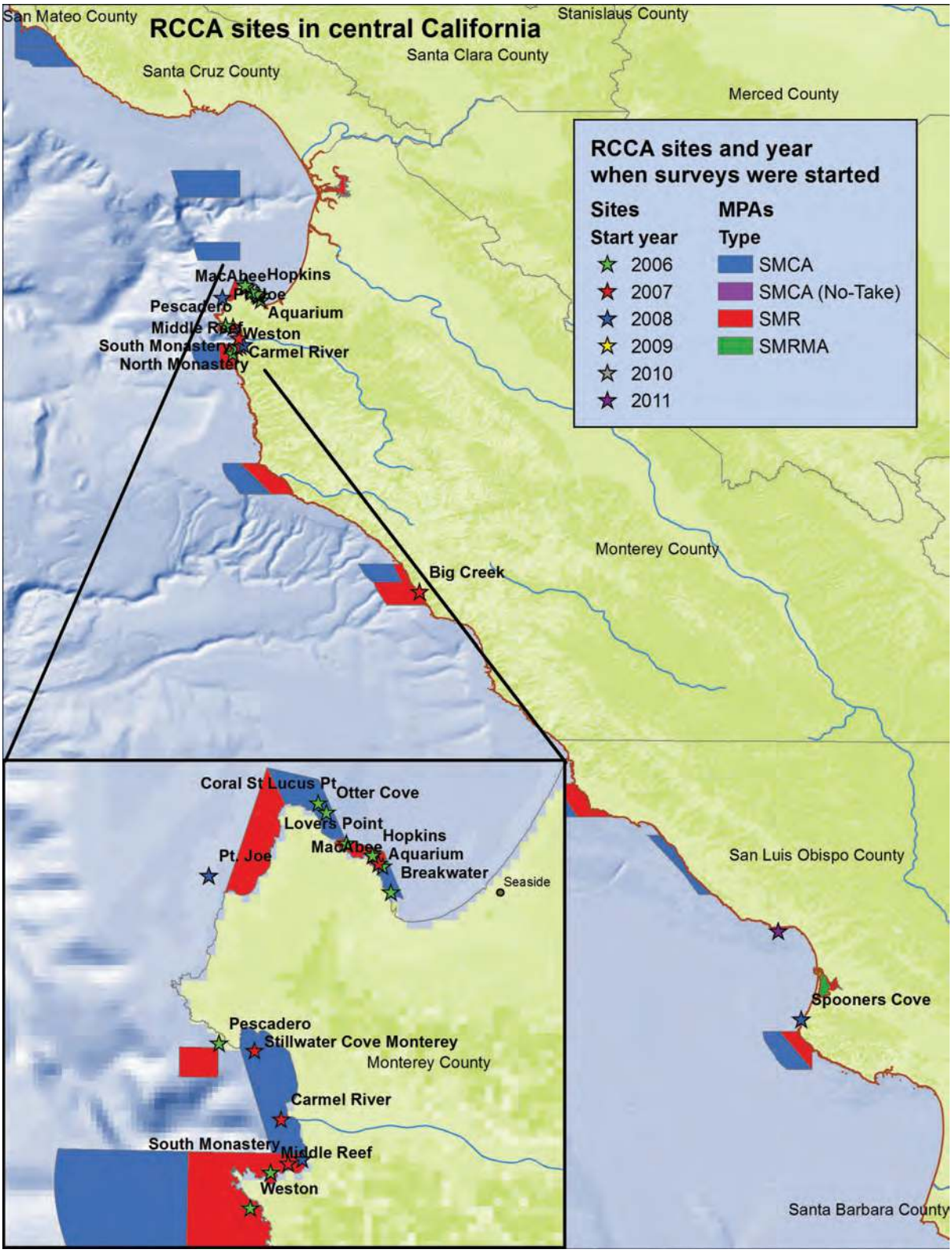


Figure 6. Map of RCCA survey sites in central California in 2006-2011. Colored stars indicate the year of the first survey. MPAs are shown.

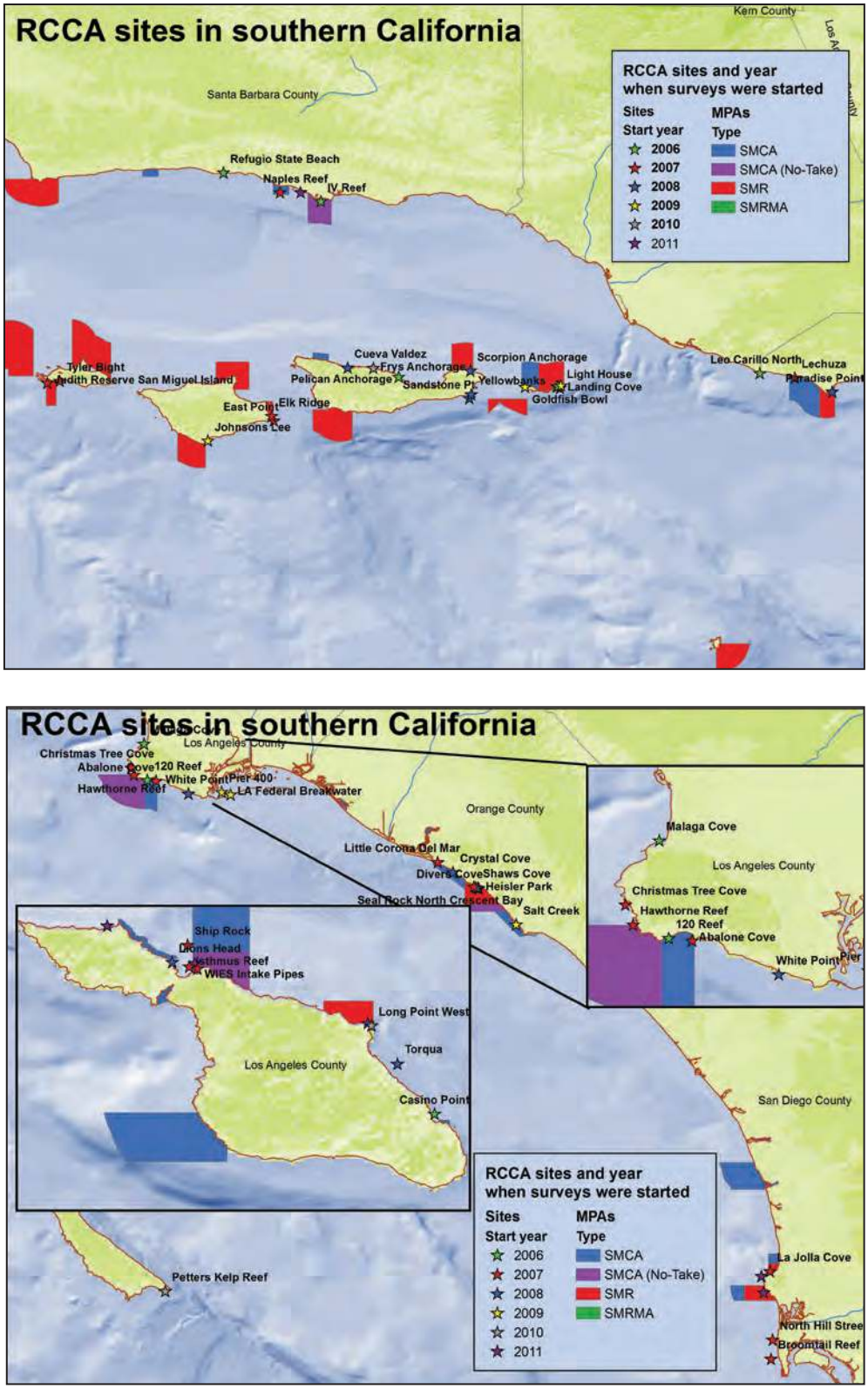
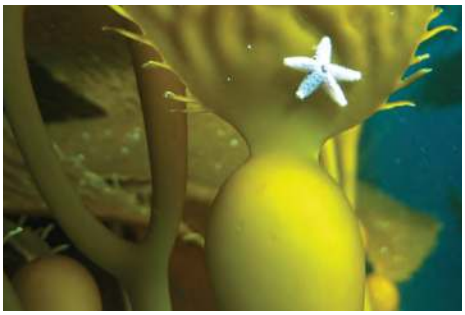


Figure 7. a) Map of RCCA survey sites in the northern half of southern California in 2006-2011. b) Map of RCCA survey sites in the southern half of southern California in 2006-2011. MPAs are shown.

4 Survey Results and Case Studies



California Kelp Forests

The rocky reefs of California are characterized by the presence of large kelp forests, made up of several species of brown algae in the order Laminariales. Two species dominate California's nearshore coast, giant kelp (*Macrocystis pyrifera*) in southern and central California and bull kelp (*Nereocystis luetkeana*) further north. These two species grow from the rocky reef at the sea floor to the surface creating structure in the water column and a biological canopy at the surface, thus providing substantial habitat, protection, and food for numerous species (Foster and Schiel 1985). California's rocky coast with its coastal upwelling regime provides ideal habitat for kelps, which favor cold, nutrient rich water. Kelps grow in depths ranging from two to more than 30 meters and giant kelp is one of fastest growing primary producers reaching up to 45 m long and growing at a rate of as much as 61 cm (2 ft) per day. Several other species of kelp (e.g., *Laminaria* spp., *Pterygophora californica*, *Eisenia arborea*) form understory forests extending up to 2 meters above the substrate providing another important layer of structure, habitat and food for rocky reef species.

The spatial extent and density of giant kelp forests on rocky reefs varies regionally, seasonally and from year to year. In Pt. Lobos, kelp counts have fluctuated annually while in Palos Verdes, kelp abundance has recovered from damage by storms and hot weather (Figure 8). Although giant kelp is a perennial species, local kelp forest sizes can increase or decrease due to seasonal fluctuations in sea-surface temperature, nutrient availability, and wave energy (Tegner *et al.* 1991). Increased swells during the winter months significantly reduce kelp bed sizes each year. Episodic warming associated with El Nino events can also dramatically affect kelp density. An important phenomenon that occurs within southern California kelp forests is the periodic population booms of sea urchins, particularly purple and red urchins (*Strongylocentrotus purpuratus* and *S. franciscanus* respectively), which graze upon live kelp resulting in a dramatic reduction of biomass referred to as an "urchin barren" (Steneck *et al.* 2003). These barrens lead to a substantial shift in the community composition on the rocky reef demonstrating the importance of kelps as foundational species for these ecosystems (Graham 2004). Research has shown several factors contributing to the establishment of urchin barrens including overfishing of urchin predators, sewage runoff, variable urchin recruitment due to oceanographic conditions, the red urchin fishery, and the state of the kelp (Tegner *et al.* 1991).

Giant kelp is not only of great ecological importance, it has historically been one of California's valuable economic resources. The remarkable growth rate and pharmaceutical and industrial benefits have led to a lucrative kelp harvesting industry in California. In 2001 the revenue from harvesting was valued at more than $30 million annually (CDFG 2004). Commercial harvesting began in the early 1900s and reached a peak during WWI for extracted potash and acetone used in explosives (CDFG 2004). After WWI giant kelp was harvested for livestock feed and algin, an emulsifier used in the food and pharmaceutical industries, as well as to feed farmed abalone. Regulations by the Department of Fish and Wildlife now restrict harvest to particular kelp beds, which can be leased, and to the top 4 feet of the kelp canopy (CDFG 2004). Since 2005 giant kelp harvesting has dramatically decreased with the closure of the largest harvesting company in California. Today kelp is harvested on a much smaller scale primarily for farmed abalone feed and "boutique" markets for human consumption.

Due to the importance of kelps in the structure and function of California's rocky reef ecosystem, Reef Check California monitors the yearly variations in the populations of the major habitat forming kelps. Algal surveys include density

estimates of five species of kelp, sizes of giant kelp individuals, and the presence/absence of four invasive algae that have the potential for competing for space with native algal species. The results of these surveys are reported in Appendix 2 for each RCCA site.

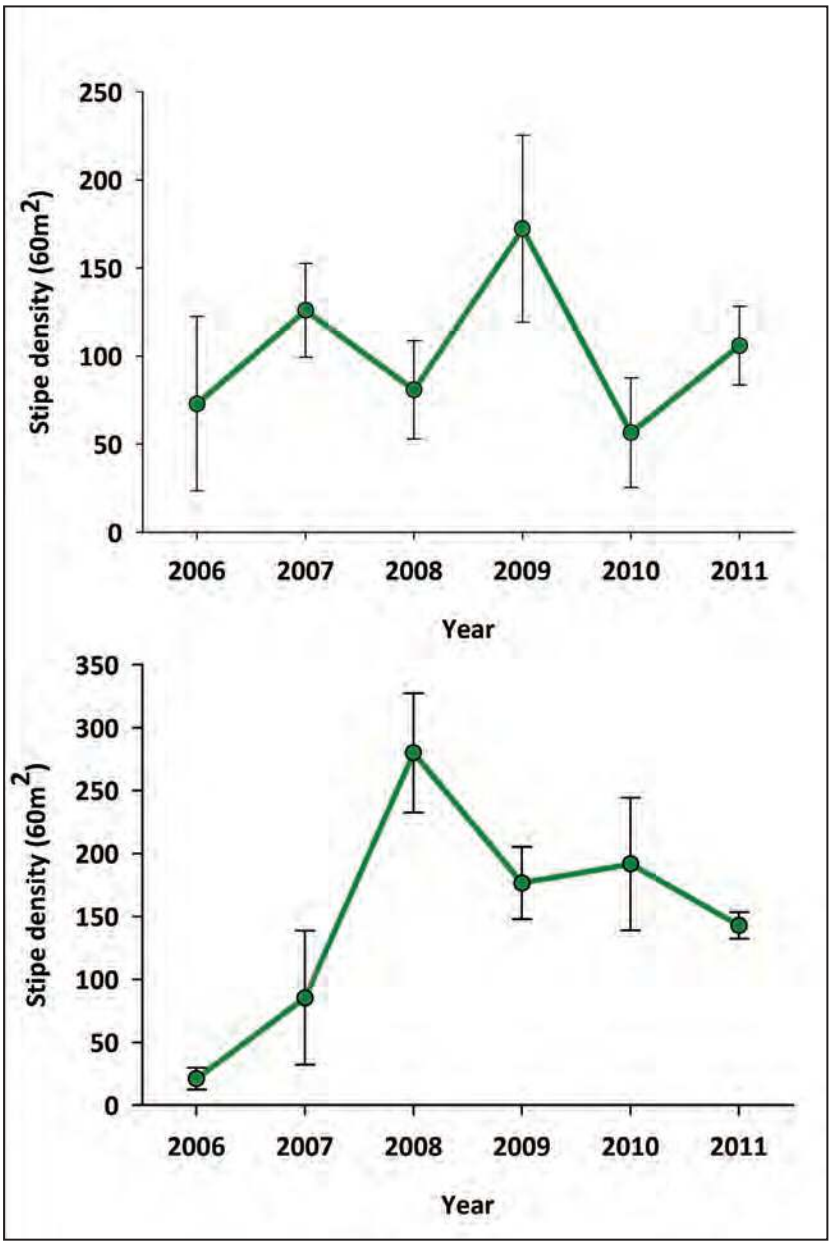


Figure 8. Stipe densities of giant kelp at two RCCA sites. top: Weston at the Pt. Lobos Marine State Marine Reserve in central California. Bottom: 120 Reef at Palos Verdes in southern California. These examples demonstrate how kelp densities fluctuate widely in both regions. Greater variability in oceanographic conditions (e.g., water temperature) in southern California lead to greater inter-annual changes in kelp density in this region and the oceanographic break at Pt. Conception contributes to the differences in dynamics between southern and central California. Grazing pressure from sea urchins and water quality may also play an important role.

Statewide Abalone Abundance

Historically, California had a large and economically important abalone fishery, but the commercial fishery was closed in 1997 due to massive declines in abalone abundances in southern and central California. Over the last century, California's eight abalone species have been serially depleted due to overfishing by commercial and recreational fisheries (Tegner *et al.*, 1992). In the first half of the 20th century the commercial abalone fishery focused on central California and in 1943 the commercial fishery reopened in southern California (after being closed in 1913). Historically commercial and recreational fishing were carried out in central and southern California by divers using either hookah or scuba equipment, whereas these gears were not allowed in the north. With the depletion of the stocks in the central region, the focus of the fishery moved south in the 1960s. By the 1980s, red abalone landings in central California had decreased to a level of about 10% of their historic average. In southern California, the fishery continued until 1997 when landings had declined to less than 10% of historic levels and the commercial fishery was closed statewide (Karpov *et al.* 2000). In northern California (north of San Francisco), commercial abalone harvest was only allowed for three years during World War II. In the north, a strictly regulated recreational fishery for red abalone exists today, but importantly – no scuba or hookah equipment are allowed – only free diving. Therefore populations were never depleted to the levels found in the other regions of the state.

In addition to exploitation, abalone populations were also affected by disease. The withering syndrome, a lethal bacterial infection, has decimated black abalone populations in southern California and caused large declines in the central region. The prevalence of this disease seems to be linked to water temperature and decreases with lower temperatures (Raimondi *et al.* 2002). Therefore, northern populations are less affected. In addition to disease, predation by rebounding populations of the once nearly extinct sea otter in central California might keep abalone populations well below the level seen prior to exploitation when sea otters were largely absent from this ecosystem. (Fanshawe *et al.* 2003).

Reef Check California's (RCCA) red abalone data demonstrate the effects of this management history (Figure 9). The current red abalone densities are very different in the three previously independently managed regions. There are almost no red abalone found in southern California and the density in the northern region is about ten times as high as in central California. The six-year time series of abalone data is beginning to show temporal trends on a regional scale. For example, in central California there seems to be an increase in abalone density over the six years of monitoring whereas in northern California, populations overall appear to be stable.

In a management context these data can be used to inform management actions as mandated, for example, by the state's Abalone Recovery Management Plan (CDFG 2005). The Recovery Plan states that abalone fisheries have to be managed with special measures when they fall below a specific threshold density (blue line in graph) and be closed when they fall below a second threshold (red line in graph). If densities grow larger than the upper threshold the

fishery could be opened. Reef Check's data show how red abalone densities in northern California fluctuate in relation to these management thresholds.

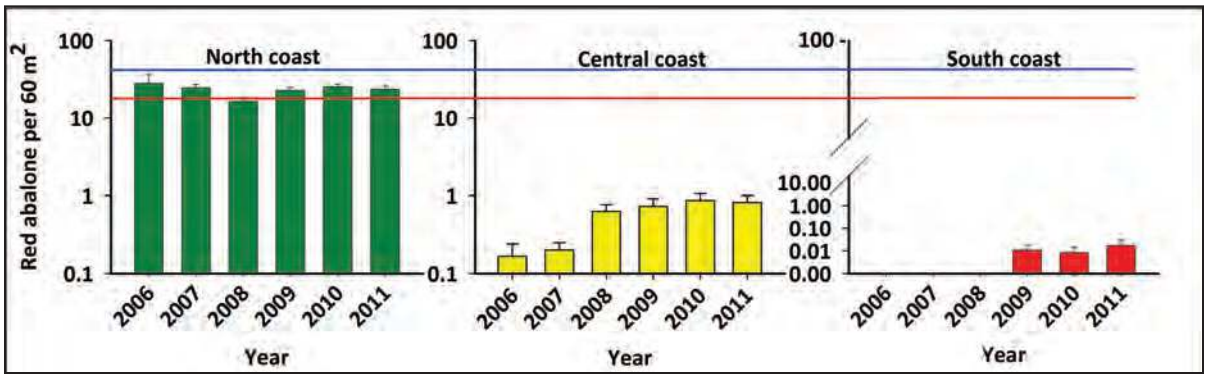


Figure 9. Average number of red abalone per 60 m^2 transect in three California regions (north coast = north of San Francisco; Central coast = Monterey to San Luis Obispo; south coast = south of Point Conception. The red and blue lines indicate density thresholds for management actions.

Mystery Abalone and Invertebrate Die-off Along the Sonoma Coast

In late August 2011, dead red abalone and other invertebrates started washing up on beaches along the Sonoma County coast. At the same time, Reef Check divers started reporting many dead or dying abalone on the shallow rocky reefs at many of their favorite dive sites in Sonoma County. This sudden and unprecedented die-off was not limited to abalone – gumboot chitons, sea urchins and sea stars were also affected. This event coincided with one of the most intense algal blooms (red tides) seen in this region. Plankton blooms occur when large numbers of microscopic, planktonic algae (protists) reproduce rapidly reaching such high densities (15,000 per ml) that the water appears red or other colors.

As these events unfolded, Reef Check California teams, in collaboration with PISCO (Partnership for Interdisciplinary Studies of the Coastal Ocean), were in Sonoma County to survey 32 reef sites as part of the baseline marine protected areas (MPA) monitoring for the MPAs that were established in 2010. In addition, a team of RCCA staff and volunteers went to the Sonoma coast for a long weekend of surveying to document the effects of the die-off on invertebrate populations in the shallow coves that have been monitored for the past six years. Despite rough conditions, teams were able to survey several sites where they recorded many fresh, empty abalone shells and our data from one of the hardest hit sites, Gerstle Cove, showed a large decline in abalone density since our previous survey on September 24th 2011. Previously, in the fall of 2007, Reef Check teams had observed a severe reduction in the density of red abalone at this site, as well (Figure 10). This reduction was accompanied by observations of empty abalone shells, not unlike what had been reported during this recent event along the Sonoma coast.

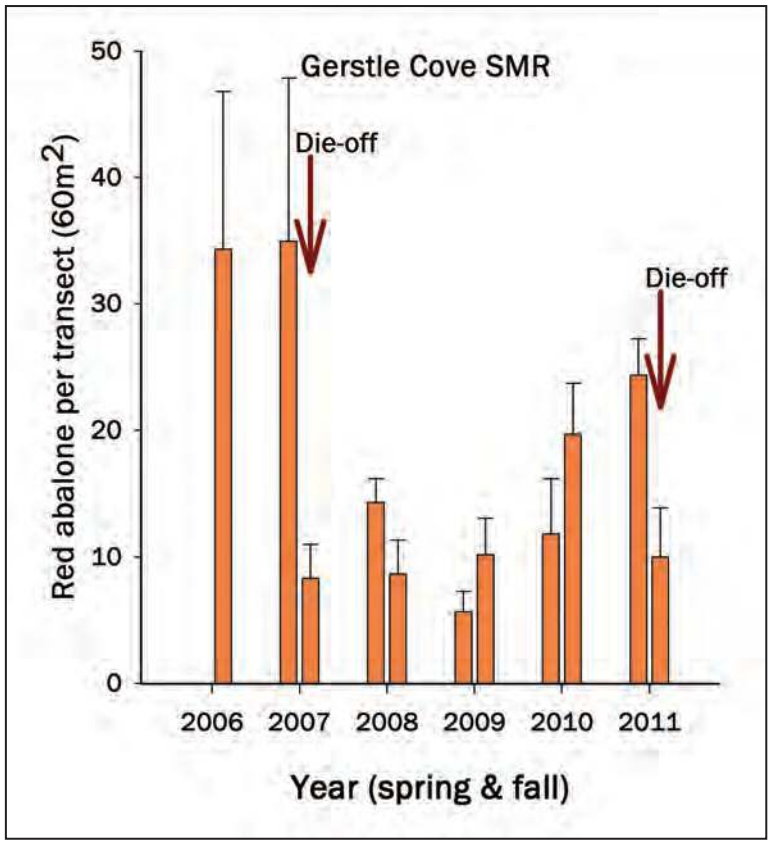


Figure 10. Average density of red abalone found during surveys of Gerstle Cove (Sonoma County) from 2006-2011.

Low oxygen levels (hypoxia) due to plankton blooms and die-offs are suspected as the cause of invertebrate mortalities in Sonoma. Past localized events RCCA recorded have been attributed to local oxygen depletion in the shallow and protected coves along this stretch of coast. When high densities of phytoplankton and macro-algae die, bacteria feeding on them can reproduce rapidly, severely reducing oxygen levels enough to kill invertebrates, including abalone. The 2011 event was more extensive, affecting reefs along a stretch of over 50 miles of coastline, both inside and outside of coves, and at all depths that have been surveyed.

Researchers tested abalone for the toxic compounds produced by some of the species found in the bloom. One of the species identified was the dinoflagellate *Gonyaulax spinifera*. Rita Horner at the University of Washington and David Crane at the California Department of Fish and Wildlife's Office of Spill Prevention and Response determined that this was the most abundant phytoplankton species and it releases a toxin called a yessotoxin. But only minute amounts were detected in dead abalone. According to Dr. Raphael Kudela at the University of California Santa Cruz, it is unlikely that the die-off was caused by this toxin alone. The concentrations found in the water and abalone tissue were too low. They were also well below any levels that are considered detrimental to human health. Kudela's laboratory continued researching other potential causes for the invertebrate death. These included unknown or little understood toxins and the possibility of a bacterial or viral infection stimulated by the red tide that caused the fatalities. If toxins were responsible for the death, it was also not clear how they were ingested by various species such as abalone and urchins that do not directly feed on plankton by filtering them from the water. Abalone feed on larger seaweeds and kelps. Studies in other regions of the world have suggested that invertebrates can take in toxins from algal blooms because the phytoplankton coat the seaweeds that they feed on. As the research into the mystery die-off continued, the Department of Fish and Wildlife closed the recreational abalone fishery earlier than normal in Sonoma County. Reef Check teams continue to survey the regional sites to further investigate the effects of the die-off and provide data to California Department of Fish and Wildlife and other researchers to inform decision making on abalone fishery management.

Rocky Reefs Ecosystems Since the 1970s

Over the last forty years the ecological communities in California's nearshore environment have changed and declines of once-common species including several that served as important fisheries have been documented. Yet few, if any datasets exist that continuously track the abundance of nearshore rocky reef fish species along the coast over this time period. To investigate if rocky reef fish populations have declined along the California coast over the last forty years, we compared data from underwater fish surveys conducted in the 1970s with fish densities recorded in Reef Check California surveys conducted at the same sites between 2006 and 2011.

We used data from four studies spanning a geographic range from the Monterey Bay in central California to Palos Verdes in the southern California (Ebeling *et al.* 1980, Hallacher and Roberts 1985, Miller and Geible 1973, Stephens *et al.* 1984). All of these studies either used repeated annual diver counts or video transects to estimate fish densities in rocky reef habitat over periods of two to seven years. To compare fish densities to RCCA's surveys conducted at the same sites, historic density estimates were converted to the same area as covered by an RCCA transect (60 m^2). Average densities for each species at each site were estimated by weighting annual surveys by the number of transects to normalize differences in annual sample size. These estimates were compared to the mean densities recorded by RCCA between 2006 and 2011 at those sites. In four of the five study locations, Reef Check's reef monitoring site is located on the same reef as the historic surveys and in one case the nearest RCCA site is about one mile south of the historic site (Palos Verdes).

Table 1. Fishing intensity for species surveyed in the 1970's and by RCCA.

Species	**Fishing intensity**
rockfish species	high
lingcod	high
CA sheephead	high
kelp bass	high
cabazon	high
opaleye	high
surf perch	medium
kelp greenling	medium
blacksmith	low
garibaldi	low
rock wrasse	low
senorita	low

The historic studies can be grouped geographically into studies conducted in the central California region by Miller and Geible (1973) and Hallacher and Roberts (1985), two surveys in southern California's cold water region of the Santa Barbara coast and northern Channel Islands conducted by Ebeling *et al.* (1980) and one study site in southern California's warm water region along the Palos Verdes Peninsula conducted by Stephens *et al.* (1984) (Airamé *et al.* 2003, Hamilton *et al.* 2010). The species studied can be characterized as low, medium or highly sought after by fishermen (Table 1).

Of the two sites in central California, Hopkins has been an MPA since the 1930s, while Carmel Bay has been fished. At Hopkins, most of the 15 species studied show no significant change between the 1970 and now but six decreased in abundance (Figure 11). Of these latter, however, two of the species found in high densities by Miller and Geible (1973) at Hopkins Marine Station, kelp bass and opaleye, were noted as very unusual and atypical species for this region by the authors, and most likely represent an unusual density of these species in central California at that time. They are still present at this site but in low abundance and are almost never seen at other survey sites in this region. Therefore, their reduction in density is probably not representative of a regional decline. In Carmel Bay, on the other hand, which has not been protected, all ten species show statistically significant population declines since the 1970s and three sought after species that Hallacher and Roberts (1985) recorded have not been seen at all at this site in recent years: rosy, vermillon and china rockfish (Figure 11).

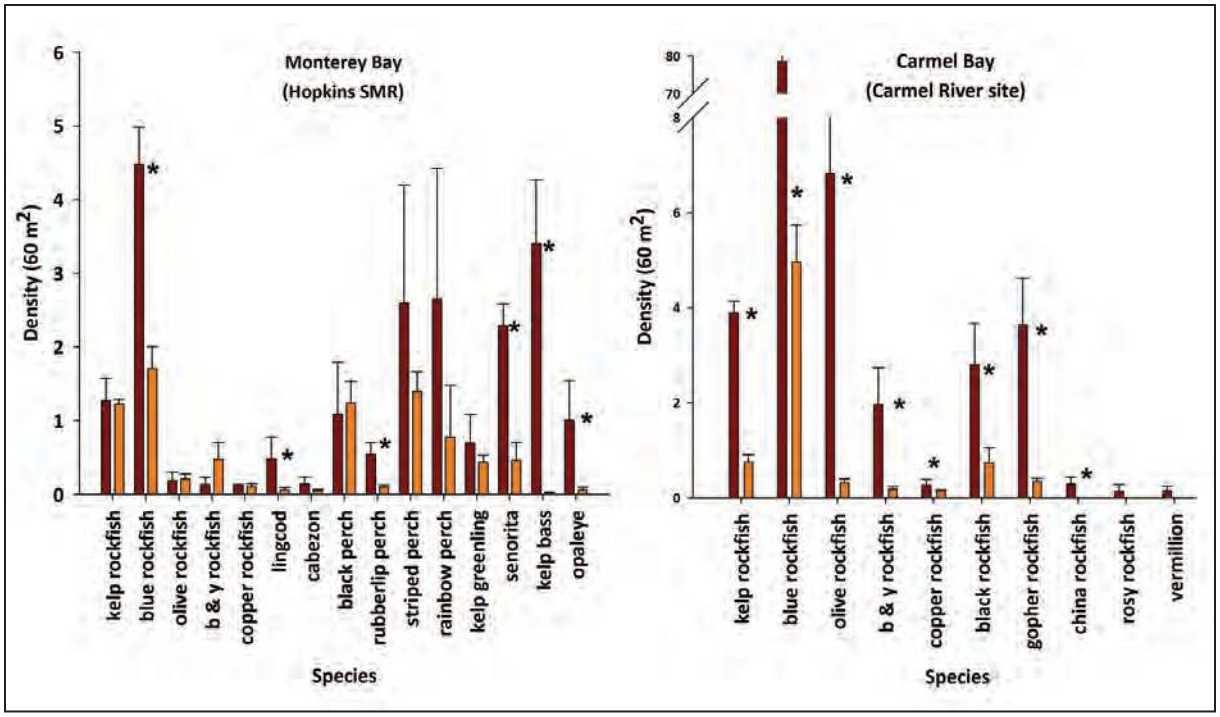


Figure 11. Fish densities in the early 1970s (red bars, data from Miller& Geible (1973) in Monterey Bay and from Hallacher & Roberts (1985) in Carmel Bay) and between 2006-11 (orange, RCCA data) in Monterey and Carmel Bay, central California. *indicate species with significant differences in densities between studies (t-test, p< 0.05).

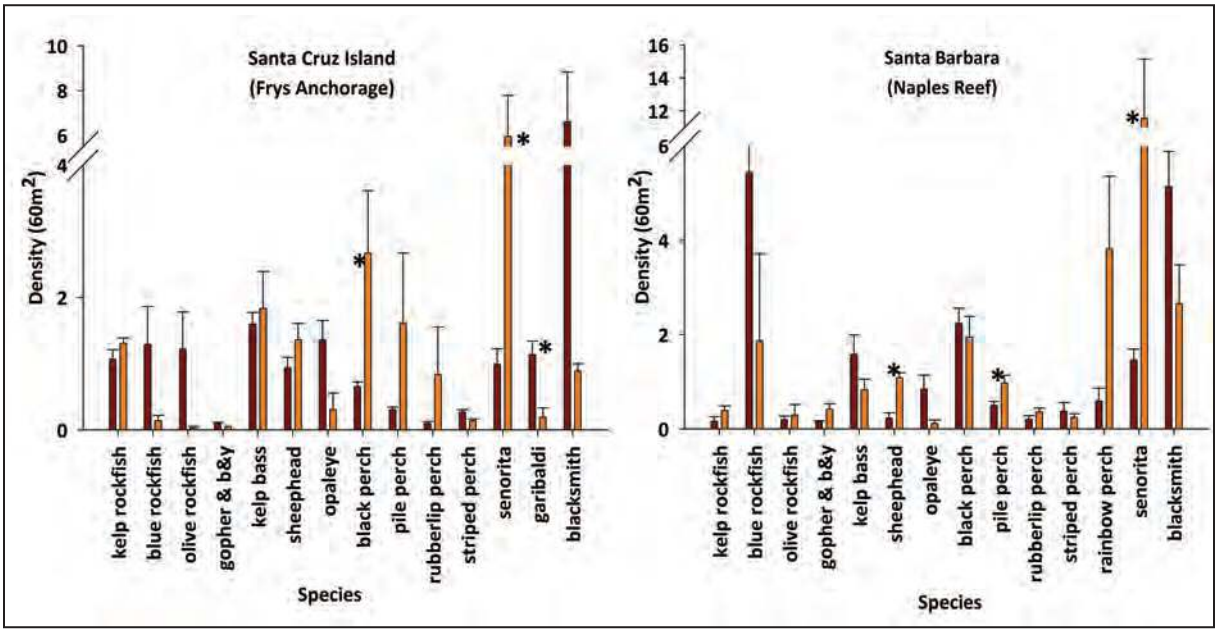


Figure 12. Fish densities in the early 1970s (red bars, data from Ebeling *et al.* (1980)) and between 2006-11 (orange, RCCA data) at a Channel Island site and near Santa Barbara, southern California. *indicate species with significant differences in densities between studies (t-test, p< 0.05).

In the Santa Barbara and Channel Island region the changes between the sites in the 1970s and today are not as clear or dramatic. Some species declined and others increased in abundance over the last forty years and few of the changes were statistically significant (Figure 12). At Palos Verdes in southern California, all but two of 14 species (California sheephead, rainbow perch) are found at lower densities now than between 1974 and 1981 by Stephens *et al.* (1984) (Figure 13). And again some of the species found in the earlier study were absent during the recent surveys: blue rockfish, olive rockfish and brown rockfish. When the data from all five historic studies are combined, declines of 19 of 25 species become apparent. On average species densities have declined by about 25% and fished species show the strongest declines (Figure 14).

Some of the differences in population densities can be attributed to the natural variably of local fish populations, while others are probably due to differences in the methodology. The study by Ebeling *et al.* (1980) was conducted using video transects and if those methods recorded lower densities than *in situ* counts, comparisons might not reflect the actual changes at those sites. Other changes in population densities can be attributed to climatic changes such as the shift from a cold to a warm water period in the late 1970s (Barry *et al.* 1995, Holbrook *et al.* 1997, McGowan et al. 2003, Sagarin et al. 1999). For example, blue rockfish, a cold water species feeding on planktonic organisms, might have responded to the reduced availability of prey during the warmer period (Love *et al.* 1998). But the fact that most heavily fished species, indicated in red in Figure 14, show the strongest declines statewide suggests that changes are also caused by overfishing. This has been clearly demonstrated for some species in southern California, for example for kelp bass by Erisman *et al.* (2011).

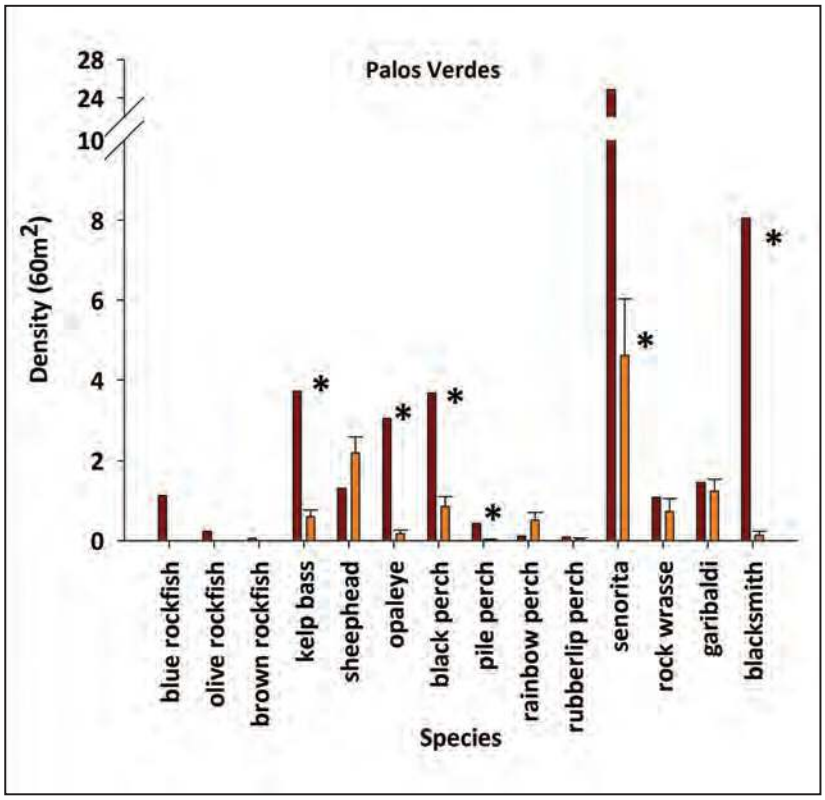


Figure 13. Fish densities in the 1970s (red bars, data form Stephens *et al.* (1984)) and between 2006-11 (orange, RCCA data) at Palos Verdes, southern California. *indicate species with significant differences in densities between studies (t-test, $p < 0.05$).

These historic analyses are based on correlations in population declines – for which there could be multiple causes – fishing, natural environment change, such as the observed regime shift in 1977, or anthropogenic environmental impacts such climate change. In order to confirm a particular cause like overfishing, we need control sites that are exposed to the same environmental conditions but without fishing. Now that the statewide network of marine protected areas is complete, we will have the opportunity to distinguish environmental from fishing effects. This is an unprecedented opportunity to study these effects on a large spatial scale for a set of species that is ecologically and economically important but has fallen outside management efforts in the past. Results from these types of analysis will greatly increase our understanding and inform management, mitigation and conservation approaches in the future.

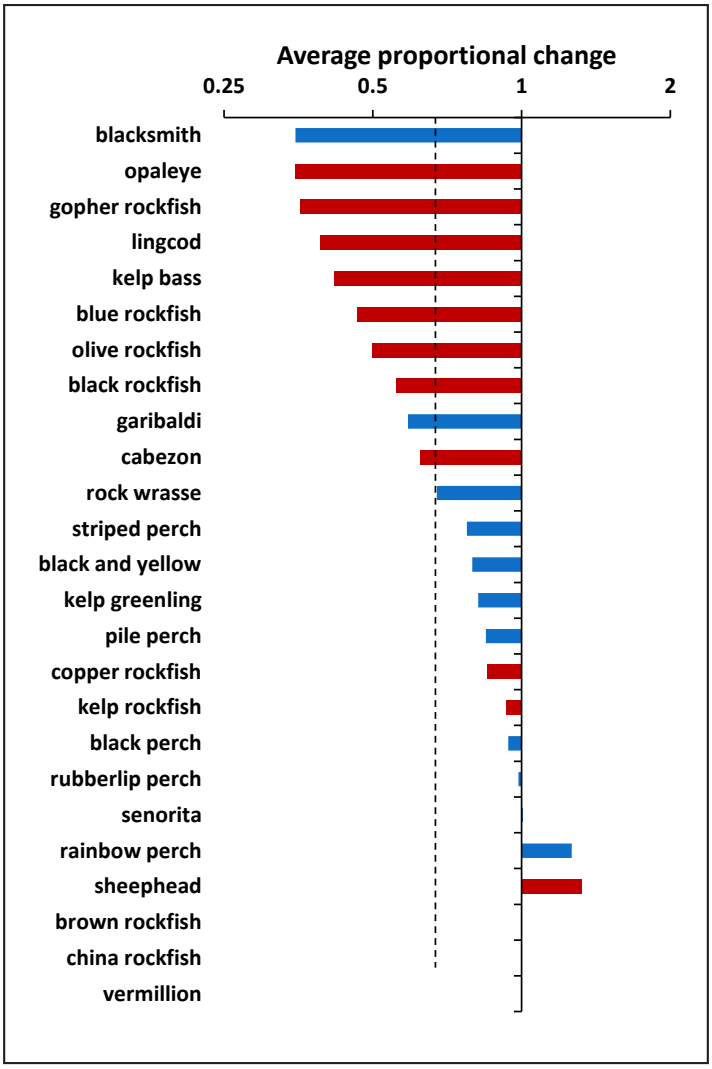


Figure 14. Changes in population densities from all five studies combined. Density changes are represented as log response ratios between average historic and recent densities. Heavily fished species are shown in red, less fished species are blue. Dotted line indicates average change.

Regional Population Trends

Reef Check's California monitoring network can be used to identify regional population trends for many of the key species considered important indicators of ecosystem health in the rocky reef communities. RCCA's largest regional network of monitoring sites is located in southern California, where its citizen scientists survey 50 sites covering the mainland, the northern Channel Islands and Catalina. With a time series of six years of monitoring data the program is beginning to identify population trends at the regional level. Some species show region-wide declines while other species' population densities seem stable or fluctuate from year to year. Data on this scale are important to establish the baseline status of the ecosystems at the time of MPA implementation in southern California and for future analyses measuring their efficacy.

Two examples of exploited species showing different population trajectories in southern California are kelp bass (*Paralabrax clathratus*) and the California spiny lobster (*Panulirus interruptus*). Kelp bass populations have declined over the six year monitoring period. In particular larger individuals have become less abundant over time whereas the number of smaller individuals is stable on a regional scale (Figure 15). This suggests that the decline is not driven by recruitment dynamics (successful reproduction and growth) but could be caused by exploitation of the adult population.

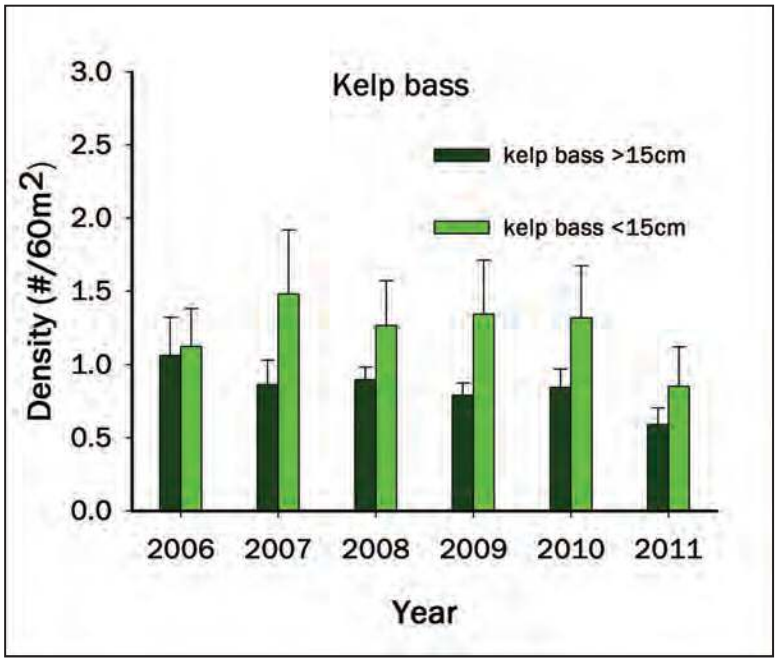


Figure 15. Kelp bass density in southern California from 2006-2011.

In contrast, the population trend for the spiny lobster, another highly targeted species, appears to be fluctuating with no clear trend, when the entire southern California region is considered (Figure 16). Besides fishing, species interactions might play a role in these trends. For example, lobsters are likely to benefit when their predators have been removed through fishing.

To ensure successful integration of RCCA's data with existing and historical datasets, the program conducts comparison studies with other monitoring groups. Results of a 2008 study in southern California comparing RCCA's data with data collected by Partnership for Interdisciplinary Studies of the Coastal Oceans (PISCO) and Vantuna Research Group showed that the datasets integrate well for informing marine management and conservation. The full article can be found in the journal Environmental Monitoring and Assessment (Gillett *et al.* 2012) as well as on Reef Check's website (www.reefcheck.org).

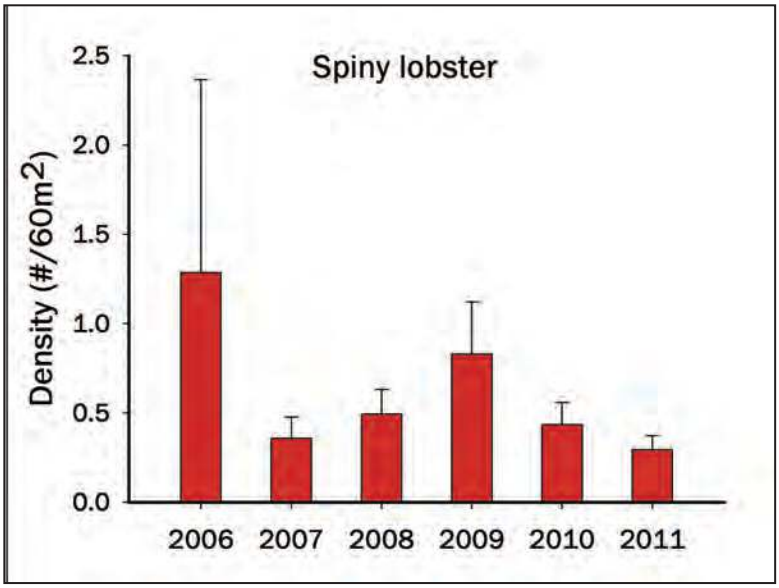


Figure 16. California spiny lobster density in southern California from 2006-2011. Large error bar in 2006 is likely due to lower number of sites in the beginning of the program.

Unusual Observations

An important goal of Reef Check is marine science education. Each year, the program trains and certifies roughly 250 divers who join the existing pool of 1000+ volunteers who carry out standardized scientific surveys of California's rocky reef ecosystem. These divers become keen observers of the natural environment who notice species that are rarely seen or are new to a geographic region. These observations allow RCCA to track changes in species ranges and to note uncommon species along the coast. RCCA citizen scientists have observed several rare species over the years. 2009 seemed to be a banner year for rarely observed species on Reef Check California surveys, especially in the southern region. Reef Check divers had the chance to observe an invertebrate and multiple sharks that are rarely seen in this region.

On November 7, 2009 a team of divers was performing a Reef Check California survey at Casino Point on Catalina Island. On the second dive of the day, RCCA Southern California Regional Manager Colleen Wisniewski and her dive buddy were swimming over to their assigned transect area when they saw a large sea cucumber on the rocks below them. This cucumber was much longer than the warty sea cucumbers (approximately 14 inches) typically seen there, and the coloring was different as well. After a bit of research, she determined it was *Holothuria zacae*, a rare tropical/sub-tropical sea cucumber usually found along the coast of Ecuador, the Galapagos and Mexico (Figure 17). Its extreme northernmost range has been listed as Ship Rock at the west end of Catalina Island, just a few miles north of where this survey team was diving.

Figure 17. Rare sea cucumber (*Holothuria zacae*) observed at Catalina Island

Other rare observations were made the same year. In early 2009, Reef Check divers in the San Diego had several encounters with large broadnose sevengill sharks (*Notorynchus cepedianu*) (Figure 18). These sightings occurred during Reef Check California training and survey dives at both La Jolla Cove and at Broomtail Reef. Since then these sharks have been seen several times a year during RCCA dives in San Diego County. The majority of the sharks that have been observed have displayed similar behavior - they swim towards the diver at a slow pace, come within 3-6 feet and then continue on their way. Most were approximately 5-7 feet in length although a shark sighted in La Jolla Cove in 2010 was estimated to be 10 feet long, which was quite exciting for the two divers performing the survey. A couple of Reef Check volunteer divers have developed a keen interest in the recent observations of sevengill sharks and have developed a photo database to track the sightings in the San Diego area.

Figure 18. Broadnose sevengill shark (*Notorynchus cepedianu*) observed near San Diego.

In September 2010, during the annual "Mega Malibu" survey, another potential species of interest was spotted: a species of abalone never before seen on a RCCA survey. This find created some excitement in the local marine research

community as RCCA worked with a number of local abalone experts to try to positively identify the species utilizing photographs taken during the survey. After some debate over the course of several days, most experts identified the specimen as a threaded abalone (*Haliotis assimilis*) (Figure 19).

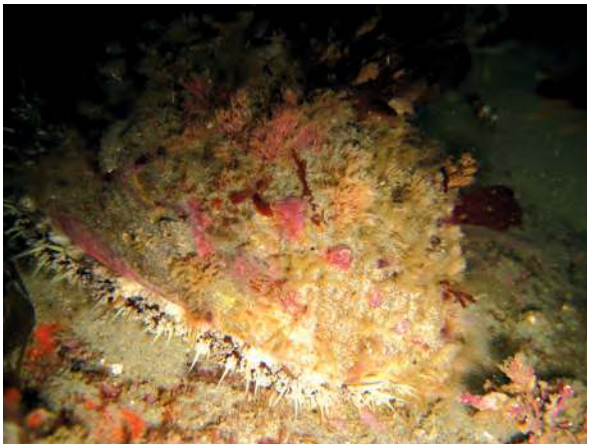


Figure 19. Threaded abalone (*Haliotis assimilis*) near Los Angeles.

In 2011, a Reef Check diver saw and filmed a white sturgeon (*Acipenser transmontanus*) swimming through the kelp forest near Monterey in central California. Individuals of this species, that start out their lives in rivers (e.g., Sacramento river) and then migrate to the ocean as they mature, are rarely seen around the Monterey Peninsula and for a diver to be able to film one in the kelp forest was particularly lucky. The video of the white sturgeon can be seen at:

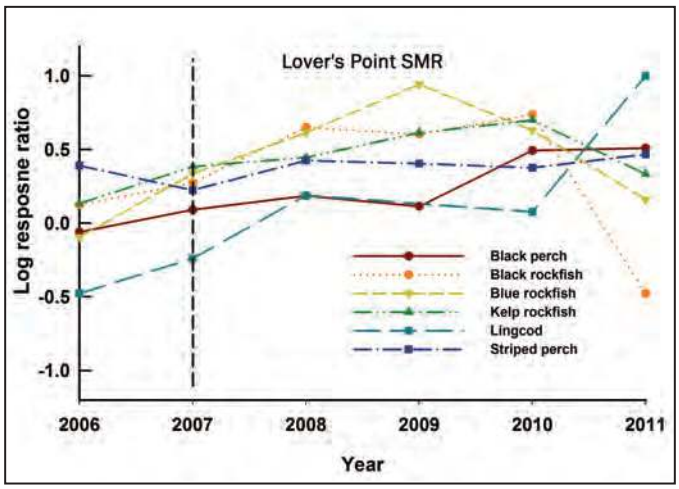
http://www.youtube.com/watch?v=lAoEnKxbmT0&list=UUQSKv43-ofZiNZHZKse SYsQ&index=5&feature=plpp_video

These examples demonstrate an important aspect of the RCCA program's approach to training divers to become experts on their local reefs. Reef Check volunteers not only collect quantitative data on rocky reef species, but also significantly increase the number of trained observers in the water, offering a great advantage for tracking species range expansions or changes in the local reef community structure.

5 Reef Check's Role in the MPA Baseline Monitoring

The first MPAs under the Marine Life Protection Act (MLPA) legislation of 1999 were implemented in central California in 2007. The Ocean Protection Council's 5-year Plan and the OPC/CDFW Joint Work Plan emphasize the fundamental importance of baseline data collection for the implementation of the MLPA, and the Central Coast Study Region MPA Monitoring Plan (DFG 2006) identifies Reef Check California as a volunteer-based program already collecting data on the focal species for the management of these new central coast MPAs. Therefore, RCCA data have been utilized for the monitoring of the new MPA networks in California since the inception of the program in 2006.

Five years after the establishment of the MPAs in the central California region, RCCA is collaborating on the first report of the baseline status of MPAs to inform the mandated five year management review. RCCA's participation demonstrates a new level of cooperation between the state and community-based NGO's in California's marine management. This development, through RCCA's work with the MPA Monitoring Enterprise and California Department of Fish and Wildlife (CDFW), has greatly increased the impact of the volunteer data collection efforts and demonstrates how ordinary citizens can participate and contribute to MPA monitoring and, eventually, adaptive management. Bringing the data, collected by community members and volunteers, to bear on the state's marine management decisions about MPAs is one of the great successes of the RCCA program. It demonstrates the usefulness and importance of community-based approaches to marine management in a state, such as California, that is at the forefront of marine



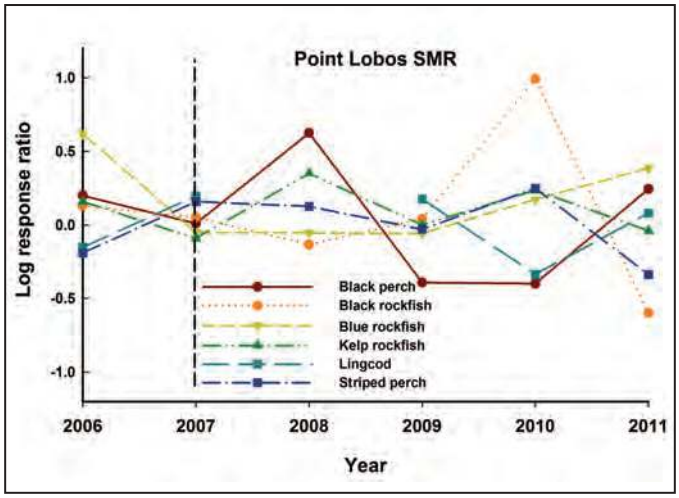


Figure 20. a.) Six fish species show an overall positive response to protection at the Lover's Point SMR after protection (2007 – vertical dashed line). These species' populations have increased inside the reserve compared to sites where fishing is allowed. Some variability in the response (e.g., 2011 decline in some species) can be seen especially in the more mobile species (e.g., blue & black rockfish). b.)The same six species do not show this overall positive response in the Point Lobos SMR.

management worldwide. Initial analysis of Reef Check's MPA data from the central coast shows a positive response to protection in the population densities of several fish species in the Lover's Point State Marine Reserve (SMR) in Monterey Bay (Figure 20). This indicates that MPAs are an effective management approach in allowing this area to return to a more natural state. Other reserves do not yet show clear trends in recovery. Differences in recovery time can be due to poaching, location and environmental conditions or historic levels of exploitation.

In 2010, RCCA became a member of a collaborative team to conduct the baseline monitoring in the North Central Coast Study Region (NCCSR) as MPAs were established between Pigeon Point, San Mateo County and Point Arena in Mendocino County. This three-year monitoring project is a coordinated effort of academic, NGO and private organizations to establish a baseline of the ecological and socio-economic conditions in the region at the time of MPA implementation. RCCA conducted surveys of its key indicator species inside and outside of MPAs and worked closely with researchers from the Partnership for Interdisciplinary Studies of the Coastal Oceans (PISCO) at the University of California Santa Cruz to establish a baseline of the size frequency distribution of commercially important invertebrates such as red abalone and sea urchins (Figure 21).

Initial results from this collaborative work on the abalone size frequency distribution demonstrates how the integration of several datasets from academic and citizen science monitoring can expand the scope of monitoring and lead to comprehensive population assessments to inform management (Figure 22). For example, data from RCCA's sites, data collected collaboratively by PISCO and RCCA and intertidal data from PISCO were combined to investigate the effect of abalone harvest on the size structure of local red abalone populations. This collaborative effort expanded the spatial scale of the monitoring and, importantly, the depth range of the monitoring effort (Figure 22). The result is an integrated picture of red abalone size frequency distributions at several local populations inside and outside of established MPAs ranging from the intertidal to the outer edge of the kelp forest.

Figure 21. RCCA (red stars) and PISCO/RCCA (circles) sites surveyed in 2010 and 2011 in the NCCSR. RCCA surveys were completed at five sites and PISCO/RCCA surveys at 34 sites.

As the MLPA process moved to new regions and new MPAs were established in southern California, RCCA again became part of the consortium conducting the baseline monitoring study in this region. The program is monitoring 50 sites inside and outside the new MPAs in this region. Overall, RCCA's participation in the state-mandated MPA baseline monitoring provides citizens and stakeholders with opportunities to stay involved in the MLPA process beyond the stakeholder-driven implementation phase. Reef Check's cost-effective data collection and commitment to data quality as well as its integration into collaborative monitoring and evaluation efforts makes the program a viable long-term approach to MPA monitoring in California.

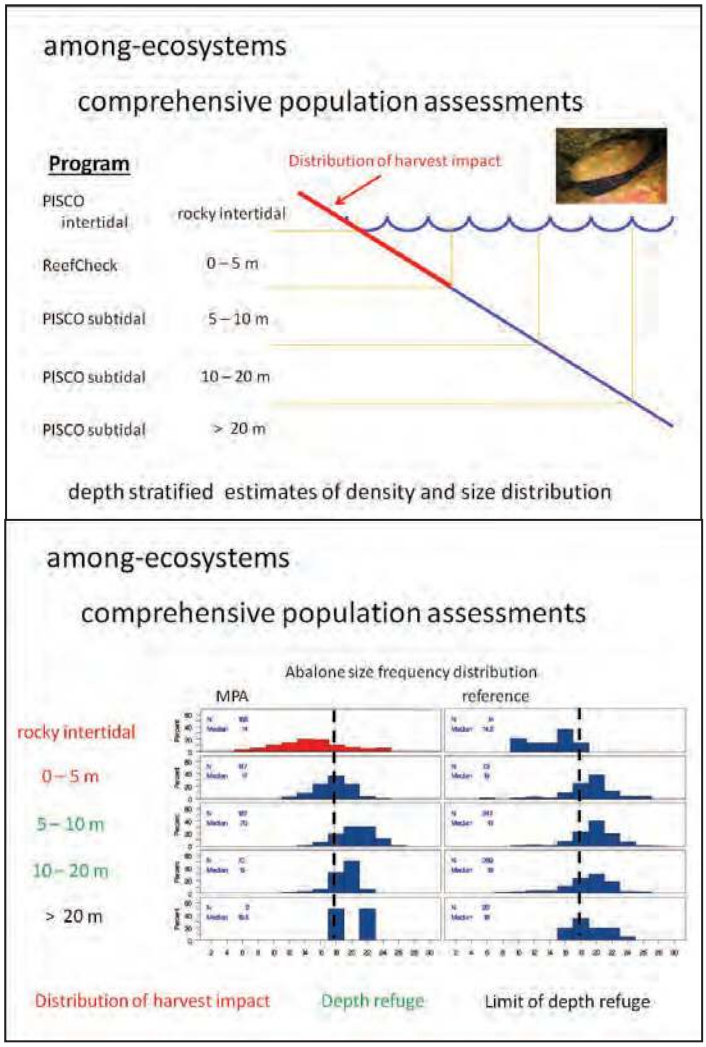


Figure 22. Presentation of results from collaborative work in the NCCSR. Collaborative approaches not only expand the geographic range of monitoring but importantly also the depth distribution of sampling (top panel). While an overall difference in size distributions inside and outside of the new MPA has not yet been observed, the collaborative assessment demonstrates a depth refuge from historic harvest at the MPA site with larger individuals found at depth beyond free diving range. From presentation at the International Marine Conservation Congress in 2011 by Mark Carr (PISCO PI).

6 Partners

Reef Check California collaborates with a number of universities, government agencies, local community groups and non-profit organizations throughout the state. These collaborations are linking existing monitoring efforts to develop the most comprehensive rocky reef monitoring network and to tap into the vast people-power of California's diving population. The synergy achieved by working with these partners is vital to RCCA's success and the particular role each partner plays in this project varies greatly. Some of RCCA'S major partners include the following:

California Department of Fish and Wildlife
California State University Monterey Bay
Catalina Island Marine Institute (CIMI)
Central and Northern California Ocean Observing System (CeNCOOS)
Humboldt State University Scientific Diving Program
Aquarium of the Pacific
Monterey Bay Aquarium
Monterey Bay and Channel Islands National Marine Sanctuaries
Moss Landing Marine Laboratories
MPA Monitoring Enterprise
Ocean Institute
Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)
Sonoma State University
Southern California Coastal Ocean Observing System (SCCOOS)
University of California, Santa Barbara and Santa Cruz
Vantuna Research Group, Occidental College
West Valley College

CDFW vessel 'Garibaldi' supporting the RCCA team at a northern Channel Island monitoring site.

Since RCCA's inception, the California Department of Fish and Wildlife (CDFW) has been one of the program's strongest supporters and partners. To formally recognize and define the collaboration, Reef Check and CDFW signed a Memorandum of Understanding in 2007. The agreement's objectives include the following: development of a long-term statewide community-based subtidal monitoring network; development and implementation of a web-based data system; and collaborative effort for effective data collection and dissemination to support the management of California's marine resources. In 2009 and 2010, further MOUs were signed with Moss Landing Marine Laboratories, the Monterey Bay Aquarium and the Central and Northern California Ocean Observing

System (CeNCOOS). These MOUs have cemented RCCA's role as a partner in California's world class network of marine research, monitoring and educational organizations.

An integral part of the collaboration with CDFW is their support for RCCA's scientific diving activities. The department has trained most of RCCA's staff as CDFW scientific divers and is functioning as the host institution for the program's American Academy of Underwater Sciences (AAUS) accreditation. Further, CDFW provides boat time for surveys, specifically to reach the northern Channel Island sites. RCCA has been granted several days each year on the R/V *Garibaldi*, typically in a mix of single day excursions as well as multi-day overnight trips. This vessel provides a safe and spacious dive platform for small teams of experienced Reef Check divers. Chartering a comparable boat for this work would be expensive and would greatly impede the program's ability to get out to these remote island locations on a regular basis.

Since 2008, RCCA has been working with the Catalina Island Marine Institute (CIMI), an outdoor science camp for elementary, middle and high school students. Over the last three years, 38 of their science instructors were trained in RCCA methodology. Their teams have established and adopted several Catalina Island sites, which they monitor twice a year. The training and subsequent surveys provide CIMI staff with a hands-on marine research experience that they can pass on when working with their students. Every year CIMI provides space and accommodations for RCCA's annual retreat, at which RCCA staff and associated instructors meet to discuss monitoring protocol updates, policy changes and to perform their annual recertification of survey methods.

RCCA staff and instructors at annual retreat at CIMI on Catalina Island.

Additional programmatic support is provided by aquarium partners. The Monterey Bay Aquarium (MBA), the Aquarium of the Pacific (AOP) and the Ocean Institute at Dana Point provide valuable teaching opportunities and meeting space for volunteer trainings and other events. These facilities are excellent venues for trainings as students can familiarize themselves with many of the indicator species they are learning to identify in the aquarium exhibits. This cooperation greatly increases the efficacy of the classroom component of the trainings and provides hands-on experience with live organisms before volunteers even get into the water. Additionally, the AOP and MBA have incorporated RCCA methodology into their Scientific Diver trainings and AOP has adopted several survey sites in the Orange County area.

RCCA has a strong connection with many academic scientific diving programs in the state. One of the strongest collaborations exists with the Scientific Diving Program at Humboldt State University (HSU). RCCA methods are taught to HSU divers and over 100 students have been Reef Check certified over the years. Not only are these divers trained, their dive teams have adopted 7 sites in northern California and Catalina Island. HSU dive teams accomplish a tremendous amount of work in the field each year and the students are highly involved in the entire monitoring process including survey planning, logistics, site layout, surveying and data entry. According to Rich Alvarez, HSU's Diving Safety Officer, students talk frequently about the increased awareness that the training has brought them, including

the identification and life histories of local species, the status of their favorite dive spots and the complexities of the MLPA process.

"RCCA requires students to become familiar with commonly used scientific diving techniques. I partnered with RCCA because there is a need for more surveying in northern California and we have a large program that needs to be kept active….Our involvement with RCCA has also made the classes more aware of the MLPA process. Students know that their efforts are helping shape the direction of MPAs and understand the need for future monitoring." – Rich Alvarez

HSU students being taught RCCA survey methods in the field in 2010.

RCCA is also working with academic science diving programs at the University of California Santa Barbara, Moss Landing Marine Laboratories, California State University Monterey Bay, West Valley Community College, and is in the process of establishing collaborations with several other institutions. This integration of RCCA survey methods into university courses makes RCCA one of the prime examples of subtidal field research that undergraduate students at California's universities are exposed to. Overall, RCCA has greatly benefited from the cooperation with this diverse group of partners and a significant amount of the work RCCA accomplishes each year would not be possible without their collaboration.

In order to reach out to the diving community and to create benefits for volunteer divers, RCCA has created the 'Buddy Breathing Program'. This program rewards Reef Check certified divers with free air fills and discount incentives from popular dive shops. RCCA's Buddy Breathing program is supported by 14 dive shops across the state (Table 2) and RCCA continues to expand this program every year. Through cooperation with these dive shops and individual dive instructors, RCCA has developed off-season training programs for its volunteers for provide them the opportunity to further their diving skills or take specialty courses.

In addition to our Buddy Breathing program, RCCA has received other types of support from the commercial dive community and local businesses throughout California. For example, various dive shops including World Aquatic Adventures in Bakersfield and San Diego Underwater Adventures provided free teaching and meeting space for Reef Check classes and events. Marissa Dive Charters offers free boat charters in San Diego to enable teams of volunteer divers and staff to monitor local survey sites. The Scubapro representative allotted a part of her annual budget to support RCCA by donating dive gear to Reef Check field staff. Additionally, numerous businesses throughout the state support the program by donating prizes (scuba air fill cards, boat trips, kayak rentals, whale watching trips, restaurant gift cards, etc) for volunteer appreciation and fundraising events. These incentives are an important way for RCCA to thank its volunteers and to keep them engaged in the program.

Table 2. Summary of Buddy Breathing partners and diver benefits

	During RCCA Surveys			At all times		
	Free Air	Gear Rental	Nitrox	Air	Nitrox	All purchases
Aqua Adventures Unlimited	YES	20%		20%		10%
Aquarius Dive Shop	YES	10%				10%
Aqua Safaris	YES	20%	20%	20%	20%	10%
Bamboo Reef	YES					
Depth Perceptions	YES	20%	10%			10%
Diver Dan's	YES					
Eco Dive Center	YES	100%	100%	100%	100%	10%
Hollywood Divers	YES	50%	100%	50%	20%	10%
Ocean Adventure	YES					
OEX	YES	50%	10%	20%	10%	20%
Santa Barbara Aquatics	YES					10%
Scuba Haus	YES					
Scuba Schools of America	YES					
Seven Seas Scuba	YES	50%	50%	20%	20%	20%
Tropical Adventures	YES	10%	10%	10%	10%	10%

7 Outreach and Media

A key objective of Reef Check California (RCCA) is to educate community members about the issues facing the rocky reefs of California as well as the importance of sound science in improving marine management. To help accomplish this task the program connects with the community in a multitude of forums outside of regular training activities. For example, during the onset of the new MPAs in southern California, RCCA staff participated in workshops to inform the public about these new regulations. Additionally, throughout the year Reef Check staff make guest presentations to various dive clubs throughout the state, outlining the importance of monitoring data in improving marine management. During the winter months, RCCA organizes seminar series for volunteer extended learning at the Monterey Bay Aquarium and the Aquarium of the Pacific on various topics in marine science and policy or diving safety. RCCA staff have also made presentations at several conferences and symposia including the World Ocean Conference, the Implementing MPAs in Southern California Symposium, and the Northern California Informational Diving Conference. RCCA's citizen scientists have been featured by news outlets including the *San Jose Mercury*, *Del Mar Times*, *Malibu Times*, *Santa Barbara Independent*, *The California Majority Report*, *San Diego Union-Tribune*, the *Santa Cruz Sentinel*, *California Diving News*, and the *Independent Coast Observer*.

In an effort to introduce the California survey protocol to both children and non-divers RCCA created a modified survey protocol focusing on a small subset of indicator organisms that could be observed and counted while snorkeling. In 2008 and 2009, in conjunction with the Ocean Futures Society, RCCA staff trained groups of secondary school teachers to conduct the modified protocol as an introduction to underwater research. The teachers found the training to be very rewarding as they employed new quantitative measurement techniques and experienced firsthand some of the challenges and joys of collecting data underwater.

In 2009, RCCA took part in the filming of an episode of the PBS series SciGirls aimed at introducing children to the world of underwater surveys. RCCA marine biologist Colleen Wisniewski taught two middle school girls the modified California methods off Catalina Island. The girls discovered that changes in the populations of indicator species are interconnected through predator-prey relationships on the reefs. This program was so successful in introducing children to science that the show and Colleen won an Emmy Award for outstanding new approaches to daytime children's programming. The program aired in 2010 nation-wide and can be seen at:
http://pbskids.org/scigirls/video2?asset=show109

To further expand opportunities to collaborate with the business community, Reef Check has recently launched an Adopt-A-Reef program in California. Under this program, companies such as four founding partners: the St. Regis Monarch Beach, the Ritz-Carlton-Laguna Niguel, the Doubletree Suites by Hilton Doheny Beach, Dana Point, and the Laguna Cliffs Marriott Resort & Spa, agree to sponsor annual surveys of selected rocky reefs. They can then share the results with their customers through video, brochures and on-line media. Through these corporate partnerships, the Adopt-A-Reef program allows the California business community to participate directly in local marine conservation throughout the state.

8 Training and Data Collection Procedures

Reef Check's California monitoring program (RCCA) measures the densities and size distributions of a suite of selected indicator species of fishes, invertebrates and algae and how these parameters change over time. This assessment permits the evaluation of population and community attributes and their temporal dynamics. It also provides insight into how different sites respond to newly implemented management measures, such as MPAs, and will continue to do so in the future. In addition, RCCA facilitates early detection of abnormal changes, such as the spread of invasive species, by familiarizing large numbers of divers throughout the state with the common community assemblages within their local reef ecosystems, thus increasing the number of trained observers in the water.

Survey Methods

The ultimate goal of RCCA is to monitor rocky subtidal communities twice per year at representative sites along the entire California mainland and island coasts. An RCCA site is defined as the reefs adjacent to 250 meters of linear coastline. A complete survey at a site includes eighteen 30 meter transects allocated equally between two zones (inshore and offshore reef) (Figure 23). At six of these transects (core transects) divers assess the densities of selected fishes, invertebrates, seaweeds and characterize the substrate. At the other 12 transects divers survey only fish. Due to field logistics and safety, reef habitats deeper than 18 meters (~60 ft) are not sampled. A complete description of the RCCA protocol can be found in (Shuman *et al.* 2011).

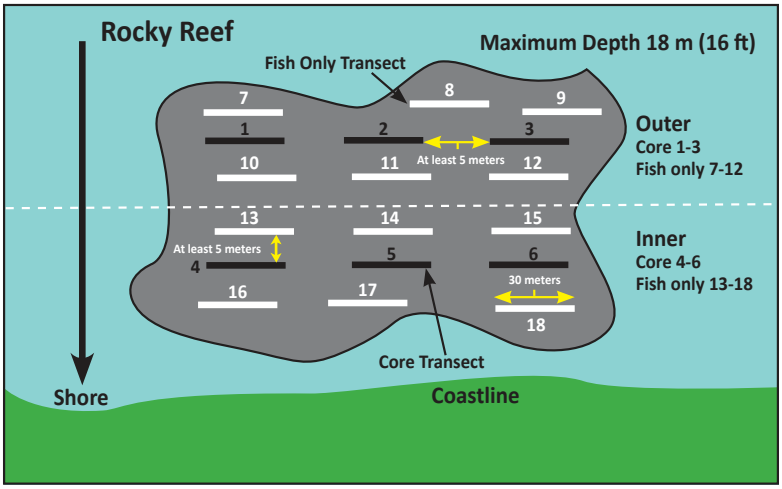


Figure 23. Layout of Reef Check California transects on a rocky reef.

A standard Reef Check California survey at each site includes:

- Site description
  - Anecdotal, observational, historical, weather and other data
- Fish transects
  - The density, size (3 size classes) and sex (when possible) of target fish species is recorded along 30 m long, 2 m wide, and 2 m high transects along the seafloor
- Invertebrate transects
  - Target invertebrates are counted along each of the core 30 x 2 m transects, and all abalone are sized to the nearest centimeter

- Seaweed transects
  - The density of target macro-algae is estimated along each of the core 30 x 2 m transects, giant kelp stipes are counted and four invasive algal species are noted as present or absent anywhere on the site
- Substrate Uniform Point Contact transects (UPC)
  - Substrate type, biological substrate cover, and rugosity (vertical relief) are recorded at 30 uniformly spaced points along each of the core transects
- Urchin size frequency survey
  - The sizes of approximately 100 red and 100 purple urchins are recorded to generate a size frequency distribution of the respective urchin populations at each site where densities are high enough to obtain the required sample size

Site Selection and Sampling Frequency

Monitoring sites are selected based on a variety of factors including, but not limited to, the coverage of other monitoring programs, logistic feasibility, presence of volunteer teams in the region, or recommendations by resource managers. Priority has been given to sites inside and outside of planned or existing MPAs. This approach has led to the selection of 82 sites. While there are some clusters of sites, overall there are sites long the entire California coast from Humboldt County to San Diego (Figure 4). Sites are sampled at least once a year, or twice a year if ocean conditions and volunteer availability allow. Each site is surveyed during the same time of year, every year, once it has been established. The purpose of this standardization of sampling time is to reduce inter-annual variability in the data due to seasonal changes in the rocky reef communities. If sites are sampled twice a year they are sampled during spring and in late summer/fall to capture both prevalent oceanic seasons (i.e. upwelling / non-upwelling) present along the California coast.

Selection of Target Species

A specific set of indicator species was chosen with the goal of informing marine management as well as to facilitate successful data collection by trained volunteers. Therefore, the following criteria were used in species selection:

- Species commonly targeted by recreational and commercial fishing activities
- Ecologically important species
- Species of special interest or concern (i.e. protected species, species known to be endangered, overfished and/or seriously depleted)
- Commonly observed by divers in shallow subtidal rocky reef habitat
- Ease of identification

Following extensive field-testing, the final Reef Check California target species list was created containing 31 species of invertebrates, 35 fish species and eight species and one genus of algae (Appendix 1). The Reef Check California protocol utilizes a single list of indicator species for the entire state. Although RCCA recognizes the distinct biological breaks along the California coast and the associated community compositions, a single species list enhances the ability of the monitoring program to detect shifts in the geographic ranges of target species. In addition, a statewide list permits volunteers trained in any region to participate in surveys along the entire coast. In early 2010, the survey protocol underwent an extensive review and several aspects were updated and clarified based on past data collection experience, comparison of the data with other monitoring programs and management needs in the state. Changes to the protocol are summarized in Appendix 2.

Diver Training

To ensure the RCCA protocol is continually and accurately followed by volunteer divers statewide, a comprehensive diver training and testing program was created as the backbone of the program. The training curriculum offers an opportunity for volunteer divers from a wide range of backgrounds to collect high quality and scientifically useful data on species and habitats. The testing standards and Quality Assurance/Quality Control Procedures ensure that the data collected by Reef Check California volunteers are scientifically robust. The training consists of a 16-hour classroom module and a two-day field-training component. During classroom lessons volunteers are educated about marine management in California, learn about the important role of monitoring in resource management and conservation and are taught biological sampling theory, sampling techniques and species identification. Classroom trainings include a pool session and whenever possible, a visit to one of our partner aquariums for species identification practice. During the field training, volunteers conduct six dives to practice and be evaluated on survey techniques, species identification, and data collection methods. For a detailed description of the training see RCCA's training manual (Shuman *et al.* 2011).

To ensure volunteer safety and ability to handle the multiple tasks associated with underwater data collection as well as data quality, divers are required to meet several prerequisites before they can become part of the RCCA survey team. Before participating in a RCCA training volunteers must have a:

- Minimum of 30 logged lifetime dives,
- Minimum of 15 dives in water temperatures below 65° F
- Minimum of six dives within the previous 12 months

After four days of RCCA training participants must pass written and field tests on:

- Safety, buoyancy, and survey methods
- Invertebrate, algae, and fish field identification
- Substrate sampling, species counts, and fish sizing
- Data quality assurance

RCCA only accepts survey data from divers who complete the required training and testing in each transect type and have demonstrated proficiency in data collection activities. This tiered approach allows volunteers to collect data for certain taxa once they completed testing for those transect types and enables volunteers with differing abilities to participate in the program without adversely affecting data quality. Upon successful completion of the training course, RCCA's citizen scientists receive a NAUI specialty certification card and are recorded in the database as eligible to submit data. A one-day annual recertification at the beginning of each survey season is required of all divers to maintain their accreditation and eligibility to submit data for inclusion in RCCA's database.

Data Management and Nearshore Ecosystem Database

In 2008, Reef Check California (RCCA) developed and implemented a public online data entry, storage, analysis, and distribution system called Nearshore Ecosystem Database (NED). Through NED, all RCCA data and simple charts are made available to the public, stakeholders, scientists, managers, and policymakers alike. NED has streamlined data flow from volunteers, through the organization, to the end users. RCCA volunteers enter their data through an online interface. These data then undergo quality assurance and control (QA/QC) procedures implemented by RCCA staff scientists, and are then made publically available in NED's interactive map viewer -- typically a few weeks after collection. User-friendly data entry, automated error checking, and input controls make it possible to transfer the data entry process from staff to volunteers and interns, greatly reducing staff work load and the time lag between data collection and data availability.

At the end of every survey season RCCA's long-term dataset is updated with the year's monitoring data and is made available for download as an Access database as well as a flat file format on NED. This allows users to choose the type of data file they are most familiar with. The flat files are in a comma delimited format (.cvs) and can be used within any statistical software. The Access database contains some additional functionality with pre-built queries to quickly explore the database for certain data and species groups.

Since its inception, NED has been integrated into several other data portals and web-based data tools throughout the state. One example of the ways in which NED has been used in the California management process is its integration into the MLPA Initiative decision support tool, Marine Map, to provide data on shallow rocky reef habitats. The user-friendly NED map viewer was utilized during the designation of new MPAs along the northern and southern coasts of the state. During this stakeholder driven process it was essential to have data on the habitats and biological communities readily available to inform the placement and sizing of MPAs. Being linked into Marine Map, NED enabled stakeholders to visualize RCCA's data and use it in combination with other datasets to make informed decisions about the placement of future MPAs in these regions. Further, NED is integrated into monitoring portals such as the California's Coastal Oceans Observation Systems (COOS) and available through the website of the Sanctuary Integrated Monitoring Network (SIMON) of the three National Marine Sanctuaries in central California. These collaborations ensure that RCCA's database is widely distributed and available for the interested public as well as managers statewide. Additionally, NED is a convenient and effective means for providing the data to RCCA's partners. Annually the entire database is submitted to the California Department of Fish and Wildlife (CDFW), the MPA Monitoring Enterprise, and several research laboratories at University of California and California State University campuses.

When RCCA partnered with the MPA Monitoring Enterprise and other collaborators to conduct the baseline surveys of California's new MPAs, Ecological Metadata Language (EML) was adopted for the standardization of the statewide dataset. Metadata consists of all information that is necessary to interpret and understand the dataset, the methods used for data collection, and the way in which data are stored. Using an accepted language ensures that RCCA data are documented in a standardized way so that they can be utilized by parties not familiar with the program and its protocols and procedures. Metadata have become a necessary component of monitoring data because only when the data are thoroughly and clearly documented and accessible for those not intimately familiar with the program will it be useful to future research and management efforts. The coordination with the MPA Monitoring Enterprise ensures that metadata are compatible between monitoring programs in the state and makes data from different programs available for integration and analyses across habitats and ecosystems.

RCCA's successful implementation of a data entry, management, and distribution system has greatly increased the impact that the volunteer collected data have and will have on the management and conservation of California's marine resources. RCCA's entire dataset can be viewed and downloaded at: http://ned.reefcheck.org/.

9 Conclusions

In California there has been a downward trajectory of populations of marine organisms living in association with rocky reefs and kelp forests – smaller and fewer fish and shellfish. Our data show that between the 1970s and now, 19 of 25 species of fish have declined in abundance, and several show declines in sizes. Abalone are still abundant in northern California where no commercial fishery has been allowed, but populations have crashed in southern California where a compressed air commercial and recreational fishery formerly operated. There have been several disastrous declines and closures of previously important fisheries such as abalone and giant seabass. Sadly, similar declines have been seen throughout the world, with UN Food and Agriculture Organization estimating that over 85% of the worlds commercial fisheries have either collapsed or are fully exploited (FAO 2012). As commercial fishing technologies have improved and as the number of recreational fishermen has increased, the level of fishing has far exceeded the ability of most fish and shellfish to reproduce.

In 2012, the state of California completed an historic and unprecedented 12-year process of establishing its first network of marine protected areas. This has resulted in approximately 16% of state waters being protected from many human activities including commercial and recreational fishing. Reef Check data already indicate that the rocky reef ecosystems included in MPAs are starting to recover. Over the next 20 years, Californians, especially commercial and recreational fishermen, will look back at the 1999 landmark legislation (the MLMA and the MLPA), and will be grateful that the state's leaders agreed to take a logical, scientific approach to marine conservation that will lead to the rehabilitation of marine life and the reversal of the long trend of decline.

Without objective scientific monitoring, the improvements in California's marine ecosystem over the next two decades cannot be tracked, and the state of California has a limited capacity to carry out this task. Therefore, the establishment of Reef Check's volunteer monitoring program in 2006, just as the first MPAs were being implemented, was timely. Over the first six years, Reef Check California (RCCA) has grown into a statewide citizen-science monitoring network focused on rocky reef and kelp forest ecosystems. The program is now monitoring over 80 sites along the entire length of California's coast. This rapid growth was accomplished through the training of over 1000 volunteer citizen scientists and collaboration with academic, state and private institutions and organizations. The program is now well established and sustains a dedicated body of about 250 active volunteers annually, many of whom have been with Reef Check since its early years. Reef Check data are used by government agencies and academic researchers because quality of the data is ensured by a rigorous volunteer training program, strong commitment to data quality and efforts to integrate with ongoing monitoring and research programs. Reef Check partners with seventeen universities, research programs, private organizations, state agencies and private businesses to conduct volunteer training and reef monitoring. This large network creates synergies and provides opportunities for resource sharing thereby increasing the program's efficiency in accomplishing its task of statewide rocky reef monitoring. This approach has allowed us to:

- Conduct over 25 annual training courses statewide
- Train or recertify over 1,300 volunteers
- Establish over 80 monitoring sites along the California coast
- Conduct a total of 377 surveys on California's rocky reefs

Reef Check California's data are contributing to our understanding of California's nearshore ocean. Our collaborative work with the California Department of Fish and Wildlife (CDFW) and the MPA Monitoring Enterprise is providing a public service to the people of California by insuring that our shared marine resources are managed and conserved based on available science as mandated by the state. As such, RCCA's data have been used to inform marine management and conservation on an ongoing basis. The data were used for the siting of the new MPAs under the Marine Life Protection Act Initiative and RCCA's data and analyses have been part of the ongoing baseline monitoring in all regions where MPAs are in place. The data that Reef Check's citizen scientists collected were also used when a large-scale invertebrate die-off along the Sonoma county coast was detected in 2011. Reef Check was able to immediately mobilize dive teams of trained citizen scientists who documented this event and provided data to CDFW. The Department used these data in concert with other datasets to inform its immediate response to this event that resulted in a partial closure of the red abalone fishery in northern California.

In this report, we have highlighted some of the declines of fish and invertebrate species on California's reefs over the past 40 years. For a few species such as the white abalone, it may be too late. But many species will have the opportunity to recover although there will be a natural lag time as newly protected populations slowly begin to grow and reproduce. We have also illustrated some early signs of positive responses of fish populations to the establishment of MPAs along the coast. In light of this and the anticipated changes to the marine environment due to climate change and growing human populations along the California coast, the value of Reef Check California's data will increase in the years to come. Therefore, we need to grow the Reef Check program in its spatial extent and establish more monitoring sites to fill in the monitoring gaps on California's reefs. With roughly 1000 kilometers of coastline and about 80 monitoring sites we still have a long way to go to reach comprehensive monitoring coverage of California's rocky reefs.

Having trained over 1000 citizen scientists and educated many more about marine resource management and conservation issues, Reef Check has created a body of well-informed citizens who have taken action to improve marine management in California. Participation in trainings and surveys is fostering a sense of stewardship for the marine environment in volunteers and their communities by involving them in the monitoring process and giving them the opportunity to contribute to California's marine resource management and conservation. As management and conservation issues are likely to remain controversial, this aspect of the program will help to build an educated and active constituency that can demand sound and science-based management and conservation. As issues such as the effects of climate change come to the forefront of the state's resource management and conservation policies this will serve California well.

Reef Check's important role in rocky reef monitoring, as well as its approach to network building, collaboration and the use of citizen science to build a comprehensive monitoring, education and outreach program, have been recognized by the many foundations that have supported our work over the years. For this we are thankful to our major funders, California Ocean Protection Council and State Coastal Conservancy through California Sea Grant, Resource Legacy Fund Foundation (RLFF), the Keith Campbell Foundation, the former Goldman Foundation, and the Douglas and Lisa Goldman Foundation as well as the many other funders, supporters and the volunteers that enable us to do this important work.

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- Keith Campbell Foundation for the Environment
- Laguna Cliffs Marriott Resort and Spa
- Lisa and Douglas Goldman Fund
- Los Angeles Port Police
- Make Yourself Foundation
- Pacific Life Foundation
- PADI Foundation
- Patagonia
- Quiksilver Foundation
- Resource Legacy Fund Foundation
- Richard and Rhoda Goldman Fund
- The Ritz-Carlton-Laguna Niguel
- St. Regis Monarch Beach
- Santa Monica Bay Restoration Commission
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Appendix 1

Reef Check California seaweed species

Common Name	Scientific Name	Rationale
giant kelp*	*Macrocystis pyrifera*	C, E, EI
southern sea palm**	*Eisenia arborea*	C, EI
Pterygophora**	*Pterygophora californica*	C, EI
bull kelp**	*Nereocystis luetkeana*	C, EI
Laminaria**	*Laminaria* spp.	EI
Sargassum†	*Sargassum muticum, S. filicinum*	I, EI
Undaria†	*Undaria pinnatifida*	I, EI
Caulerpa†	*Caulerpa taxifolia*	I, EI

* Number of stipes greater than 1 meter per holdfast are recorded
** Must be taller than 30 cm to be recorded
† Recorded if identified anywhere on site (on or off transect)

C = commonly observed, E = species exploited by recreational and commercial fishing, EI = ecologically important species (as food or habitat for the community), SI = species of interest or concern (protected, endangered, overfished, etc.), I = invasive

Species and rationale of Reef Check California indicator invertebrate species

Common Name	Scientific Name	Rationale
red abalone*	*Haliotis rufescens*	E, SI
pinto abalone*	*Haliotis kamtschatkana*	E, SI
flat abalone*	*Haliotis walallensis*	E, SI
black abalone*	*Haliotis cracherodii*	E, SI
green abalone*	*Haliotis fulgens*	E, SI
pink abalone*	*Haliotis corrugata*	E, SI
white abalone*†	*Haliotis sorenseni*	E, SI
CA spiny lobster	*Panulirus interruptus*	E
CA sea cucumber	*Parastichopus californicus*	E
warty sea cucumber	*Parastichopus parvimensis*	E
bat star	*Patiria miniata*	EI
short spined star	*Pisaster brevispinus*	EI
giant spined star	*Pisaster giganteus*	EI
sunflower star	*Pycnopodia helianthoides, Solaster* spp.	EI
chestnut cowry	*Cypraea spadicea*	E
Kellet's whelk	*Kelletia kelletii*	E
rock crab	*Cancer* spp.	E
sheep and masking crabs	*Loxorhynchus grandis, L. crispatus*	E
wavy and red turban snails	*Lithopoma undosum, L. gibberosum*	E
giant keyhole limpet	*Megathura crenulata*	E
gumboot chiton	*Cryptochiton stelleri*	C, EI
rock scallop	*Crassedoma giganteum*	E
red urchin	*Strongylocentrotus franciscanus*	E, EI
purple urchin	*Strongylocentrotus purpuratus*	EI
crowned urchin	*Centrostephanus coronatus*	C
CA golden and brown gorgonians**	*Muricea californica, M. fruticosa*	C
red gorgonians**	*Lophogorgia chilensis*	C
large anemones**	Order Actiniaria	C

* Size estimated to nearest centimeter
** To be recorded, anemones must be 10 cm or larger (height or width); gorgonians must be 10 cm or greater in height
† Recorded if identified anywhere on site (on or off transect)

All organisms must be greater than 2.5 cm to be counted

C = commonly observed, E = species exploited by recreational and commercial fishing, EI = ecologically important species (trophically important species), SI = species of interest or concern (protected, endangered, overfished, etc.)

Species, measurement criteria and rationale of Reef Check California indicator fishes.

Common Name	Scientific Name	Measured Specifics (cm)	Rationale
blacksmith	*Chromis punctipinnis*	<15, 15-30, >30	C
opaleye	*Girella nigricans*	<15, 15-30, >30	C, E
garibaldi	*Hypsypops rubicundus*	Juv, adult, <15, 15-30, >30	C, SI
sargo	*Anisotremus davidsoni*	<15, 15-30, >30	C
black perch	*Embiotoca jacksoni*	<15, 15-30, >30	C,E
striped seaperch	*Embiotoca lateralis*	<15, 15-30, >30	C, E
rubberlip seaperch	*Rhacochilus toxotes*	<15, 15-30, >30	C, E
pile perch	*Rhacochilus vacca*	<15, 15-30, >30	C, E
rainbow seaperch	*Hypsurus caryi*	<15, 15-30, >30	C, E
CA sheephead*	*Semicossyphus pulcher*	Juv, female, male, <15, 15-30, >30	C, E, EI
rock wrasse	*Halichoeres semicinctus*	Juv, female, male, <15, 15-30, >30	C
senorita	*Oxyjulis californica*	<15, 15-30, >30	C
kelp bass	*Paralabrax clathratus*	<15, 15-30, >30	C, E
barred sand bass	*Paralabrax nebulifer*	<15, 15-30, >30	E
cabezon*	*Scorpaenichthys marmoratus*	<30, 30-50, >50	E
lingcod	*Ophiodon elongatus*	<30, 30-50, >50	E, SI
giant sea bass†	*Stereolepis gigas*	None	SI
kelp greenling*	*Hexagrammos decagrammus*	Male, female, <15, 15-30, >30	E
rock greenling*	*Hexagrammos lagocephalus*	<15, 15-30, >30	E
horn shark	*Heterodontus francisci*	<30, 30-50, >50	EI, E
kelp rockfish*	*Sebastes atrovirens*	<15, 15-30, >30	E
grass rockfish*	*Sebastes rastrelliger*	<15, 15-30, >30	E
brown rockfish*	*Sebastes auriculatus*	<15, 15-30, >30	E
gopher rockfish*	*Sebastes carnatus*	<15, 15-30, >30	E
Black-and yellow rockfish*	*Sebastes chrysomelas*	<15, 15-30, >30	E
China rockfish*	*Sebastes nebulosus*	<15, 15-30, >30	E
yellowtail rockfish & olive rockfish*	*Sebastes flavidus/Sebastes serranoides*	<15, 15-30, >30	E
copper rockfish*	*Sebastes caurinus*	<15, 15-30, >30	E
vermilion rockfish and canary rockfish	*Sebastes miniatus/Sebastes pinniger*	<15, 15-30, >30	E
black rockfish*	*Sebastes melanops*	<15, 15-30, >30	E
blue rockfish*	*Sebastes mystinus*	<15, 15-30, >30	E
bocaccio	*Sebastes paucispinis*	<30, 30-50, >50	E, SI
treefish*	*Sebastes serriceps*	Juvenile, Adult, <15, 15-30, >30	E

* Fin fishes included in the Nearshore Fishery Management Plan (www.dfg.ca.gov/mrd/nfmp/)
† Recorded if identified anywhere on site (on or off transect) C = commonly observed, E = species exploited by recreational and commercial fishing, EI = ecologically important species (trophically important species), SI = species of interest or concern (protected, endangered, overfished, etc.)

Appendix 2

The following pages contain summaries of the data for each Reef Check California site. A map indicates the geographic location of each site in California. Marine protected areas (MPAs) are shown on the maps and if a site is located inside an MPA, then regulations are summarized. For the complete set of regulations for each MPA please consult the California Department of Fish and Wildlife's website: http://www.dfg.ca.gov/mlpa/.

For each site the dates of all RCCA surveys are listed and the depth range of the surveys is indicated. Additionally, the number of RCCA's indicator species that have been observed at the site is listed.

For each site, graphs are presented showing the substrate type, rugosity, and densities of three fish, three invertebrate and three seaweed species.

1. The substrate graph represents the substrate at the site as characterized during RCCA's uniform point contact (UPC) transects.
2. The rugosity graph shows the physical complexity of the rocky reef, in the four relief categories recorded along each core transect.
3. Densities of three fish, invertebrate and seaweed species are shown in line graphs. Species densities are plotted for each year that a site has been surveyed. The three species in each of these taxonomic groups are selected from the RCCA species list, either because of their abundance or ecological importance and differ for sites in northern, central and southern California.

Reef Check California 2006-2011

Trinidad

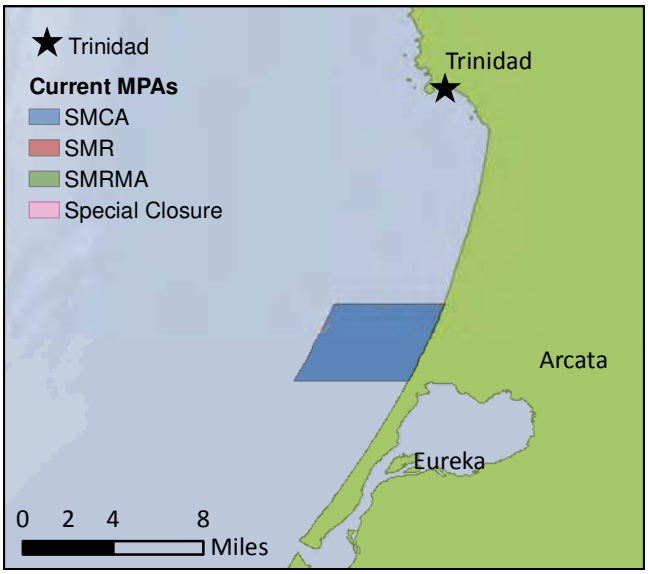
County: Humboldt

Marine Protected Area: None

Restrictions: None

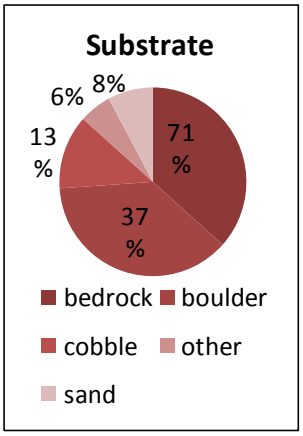
Survey history: 4/5/2008

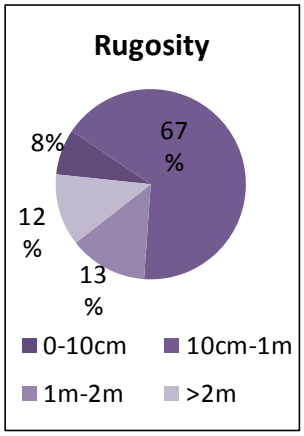
Survey Depths (ft): 14 - 24



Indicator Species Observed: 11 of 35 fishes surveyed, 11 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

Invasive Algae: None





One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

Reef Check California 2006-2011

Caspar

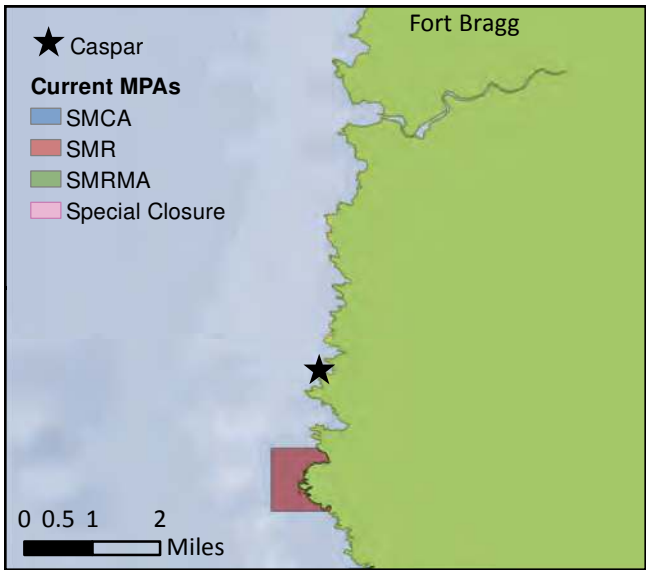
County: Mendocino

Marine Protected Area: None

Restrictions: None

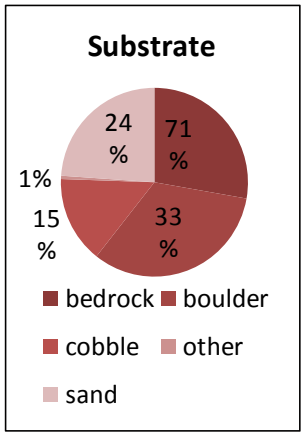
Survey history: 10/11/2008 8/7/2010

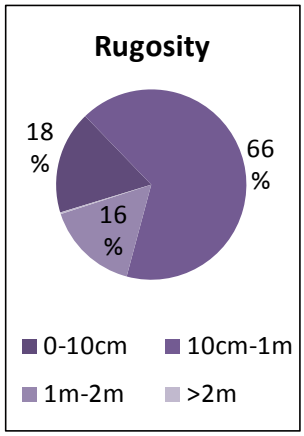
Survey Depths (ft): 6 - 21

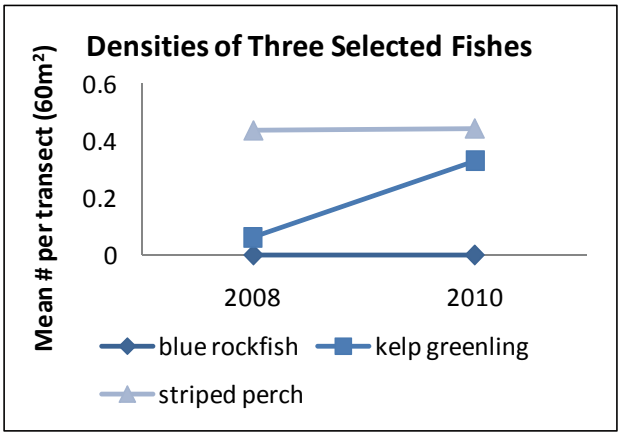


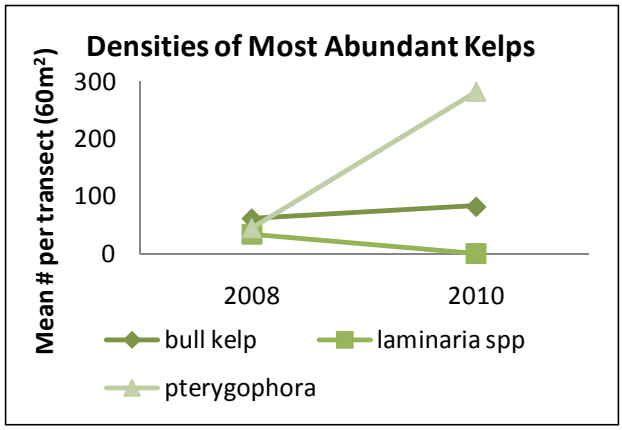
Indicator Species Observed: 10 of 35 fishes surveyed, 10 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

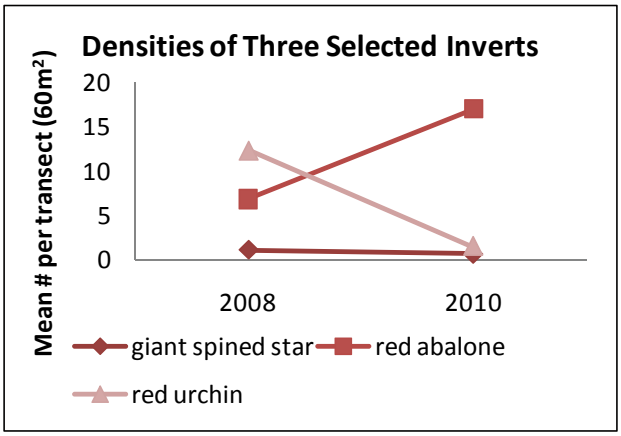
Invasive Algae: None











Reef Check California 2006-2011

Mendocino Headlands

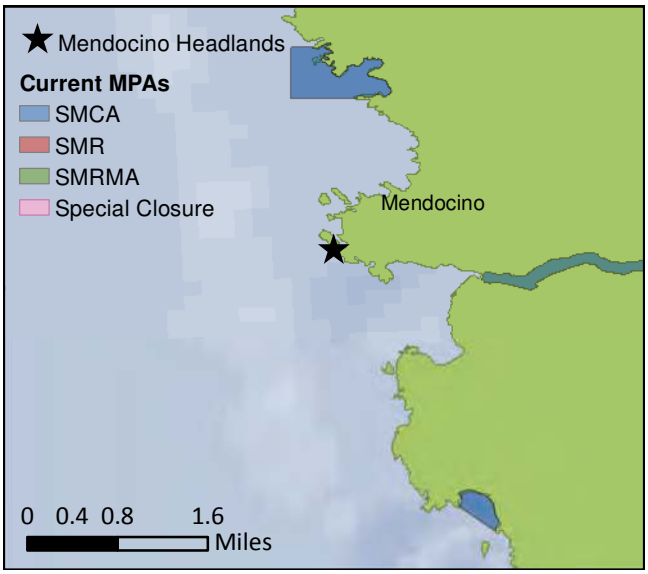
County: Mendocino

Marine Protected Area: None

Restrictions: None

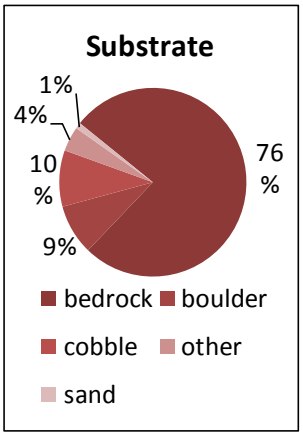
Survey history: 5/16/2007 10/7/2007 9/28/2008 10/18/2009 5/18/2010 6/12/2011 10/22/2011

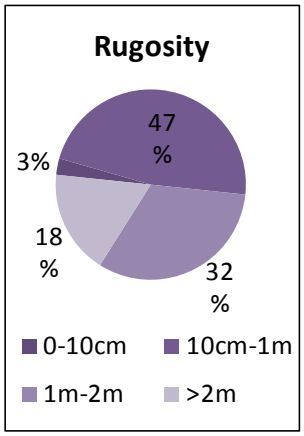
Survey Depths (ft): 14 - 56

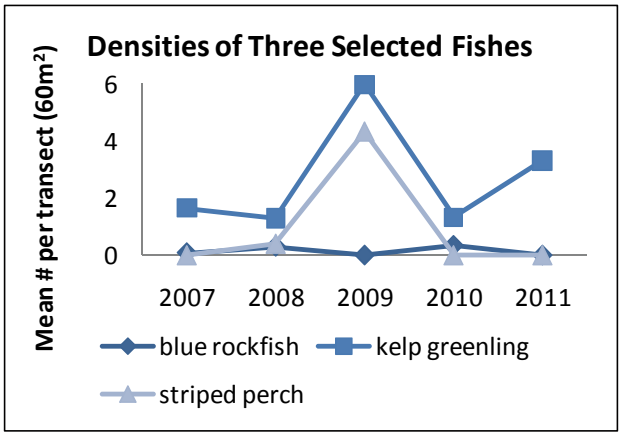


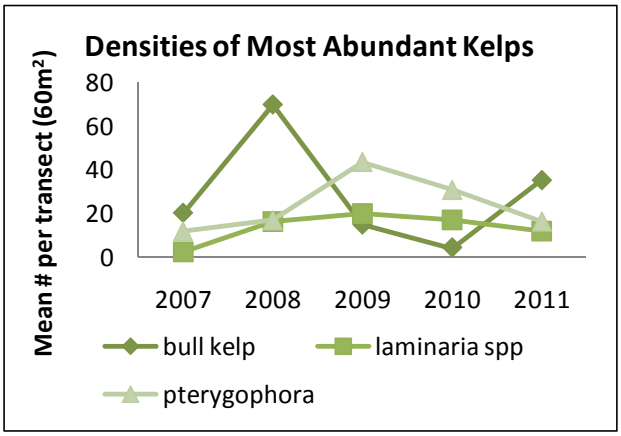
Indicator Species Observed: 13 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

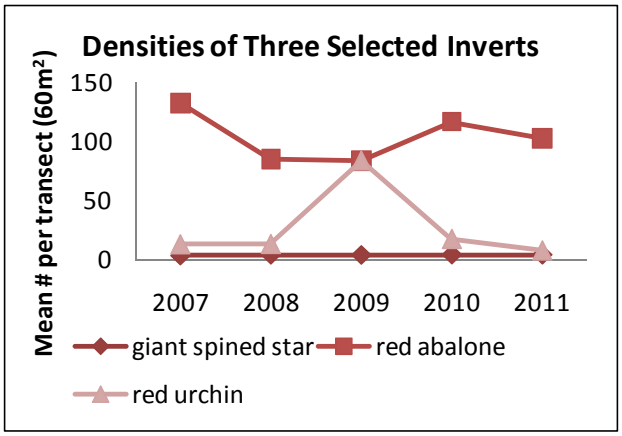
Invasive Algae: None











Reef Check California 2006-2011

Portuguese Beach

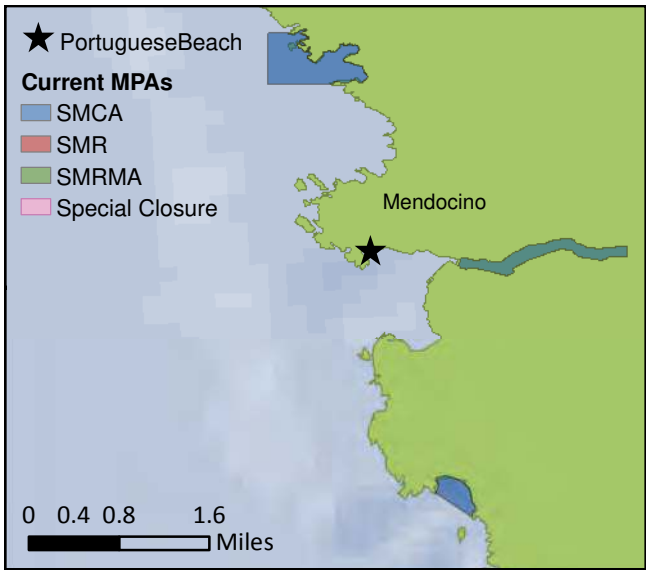
County: Mendocino

Marine Protected Area: None

Restrictions: None

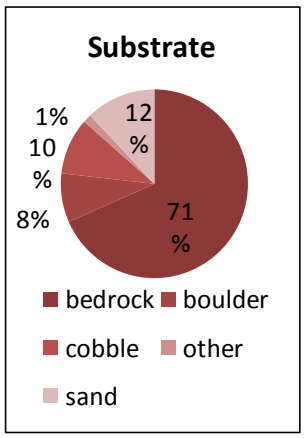
Survey history: 10/7/2007 9/28/2008 6/16/2009 10/18/2009 5/19/2010 5/18/2011

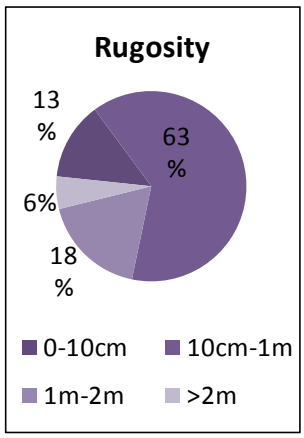
Survey Depths (ft): 10 - 42

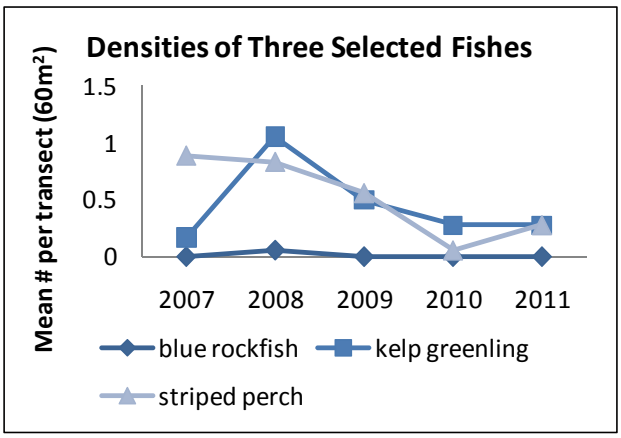


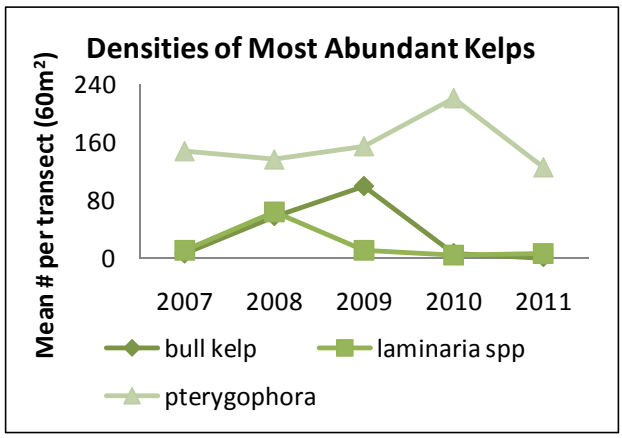
Indicator Species Observed: 19 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

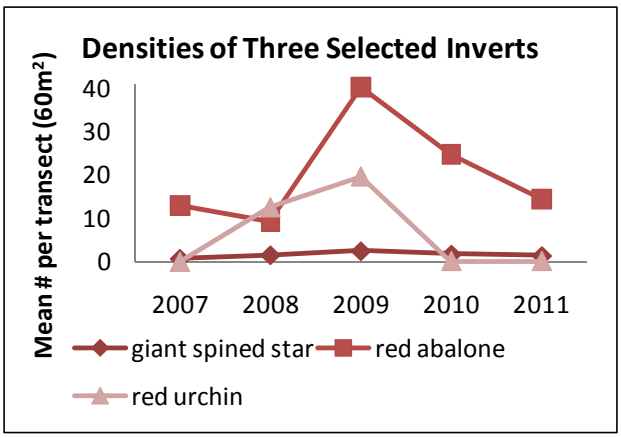
Invasive Algae: None











Reef Check California 2006-2011

Van Damme

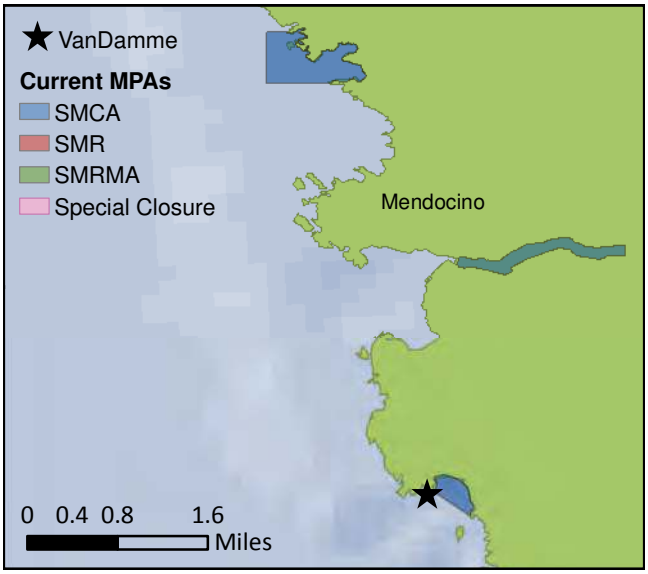
County: Mendocino

Marine Protected Area: Van Damme SMCA

Restrictions: No recreational take of aquatic plants. No commercial take of kelp (giant or bull) or various inverts

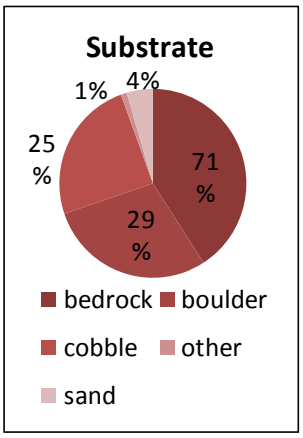
Survey history: 5/15/2007 10/6/2007 9/27/2008 6/17/2009 10/17/2009 5/19/2010 5/19/2011 10/29/2011

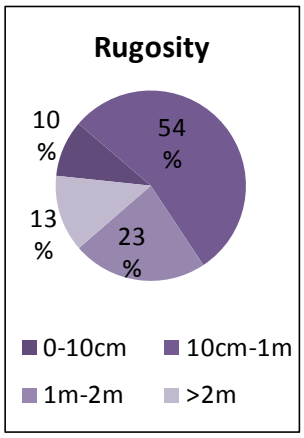
Survey Depths (ft): 6 - 46

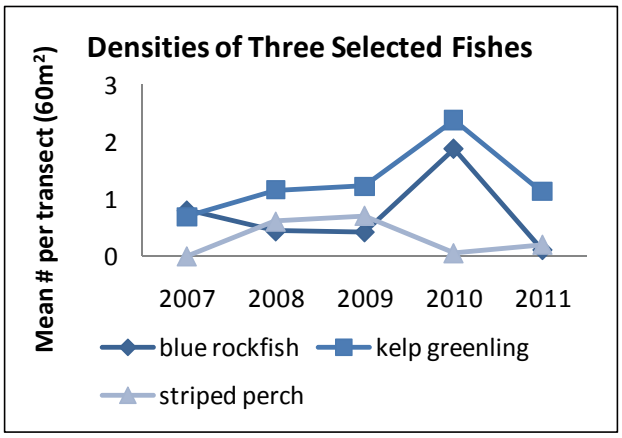


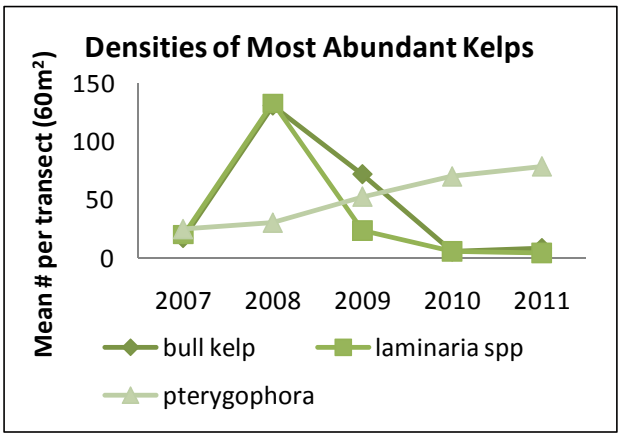
Indicator Species Observed: 18 of 35 fishes surveyed, 18 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

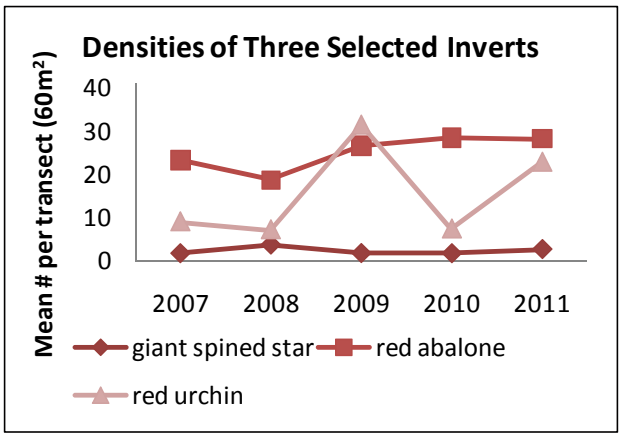
Invasive Algae: None











Reef Check California 2006-2011

Stornetta

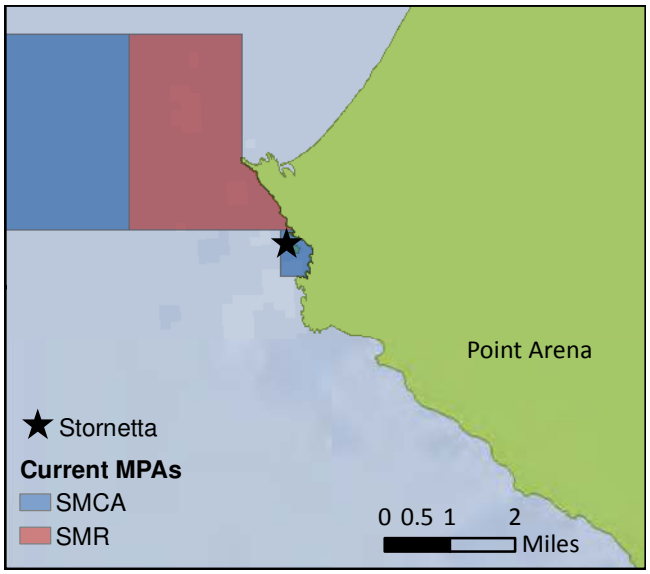
County: Mendocino

Marine Protected Area: Sea Lion Cove SMCA (since 5/1/10)

Restrictions: No take of marine invertebrates or aquatic plants.

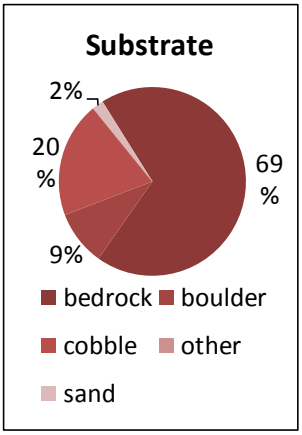
Survey history: 9/12/2007 10/9/2010

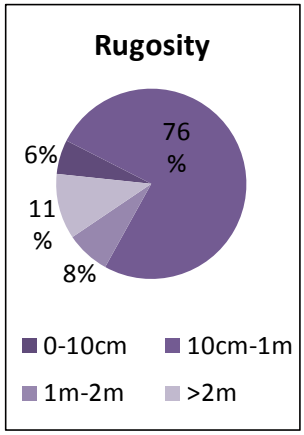
Survey Depths (ft): 8 - 56

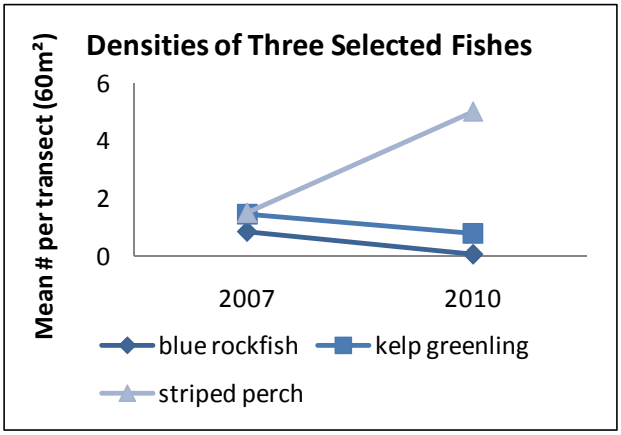


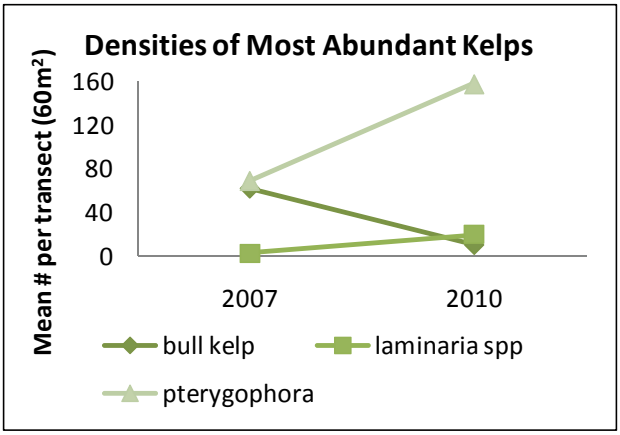
Indicator Species Observed: 14 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

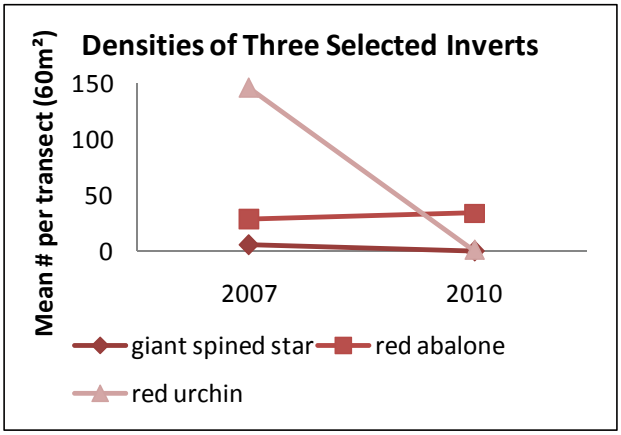
Invasive Algae: None











Reef Check California 2006-2011

Gerstle Cove

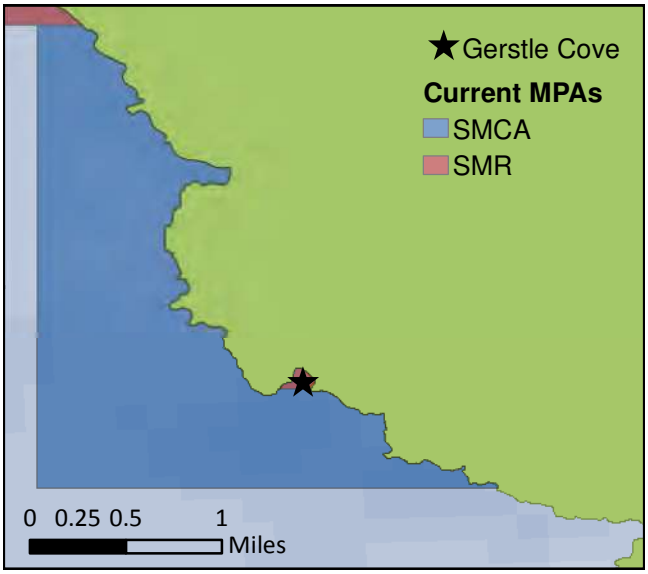
County: Sonoma

Marine Protected Area: Gerstle Cove SMR

Restrictions: Take of all living marine resources is prohibited.

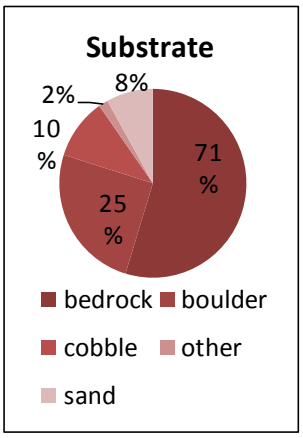
Survey history: 11/4/06 3/10/07 10/13/07 3/8/08 10/18/08 6/27/09 10/3/09 6/19/10 10/17/10 4/17/11 9/24/11

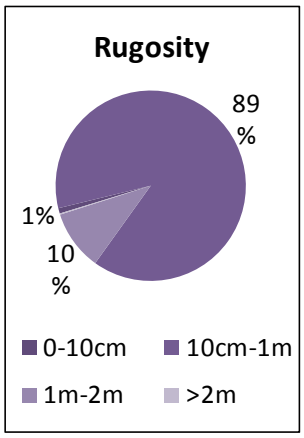
Survey Depths (ft): 4 - 38

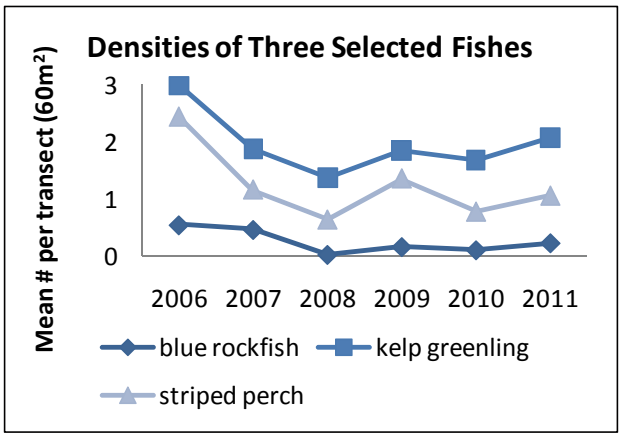


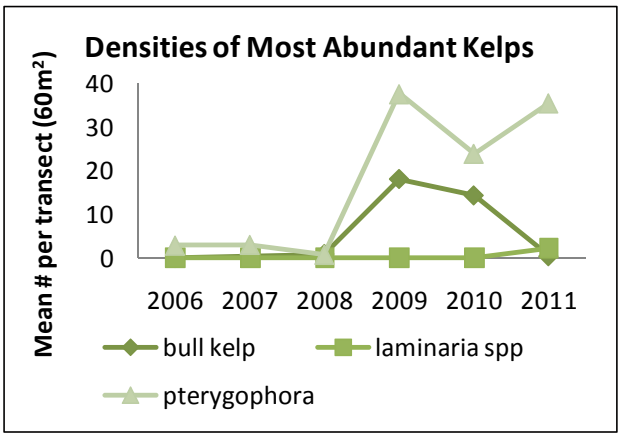
Indicator Species Observed: 19 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 2 of 5 seaweeds surveyed

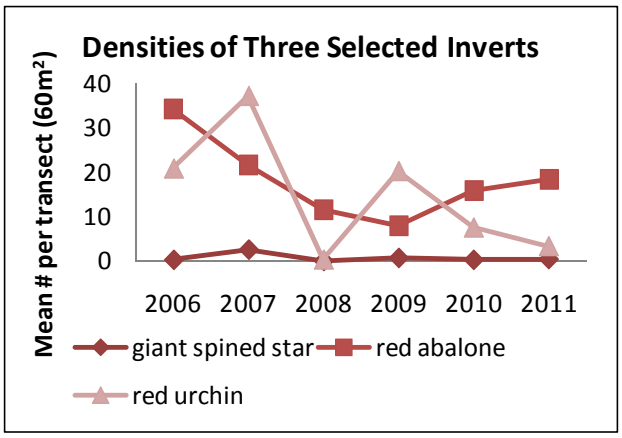
Invasive Algae: None











Reef Check California 2006-2011

Ocean Cove

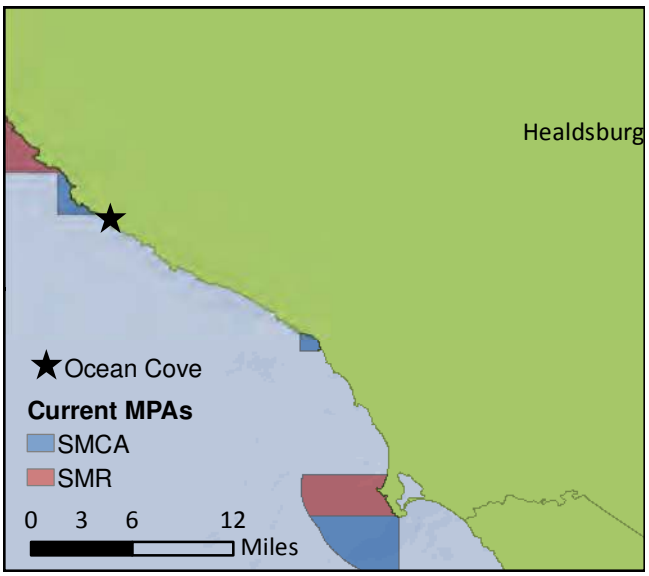
County: Sonoma

Marine Protected Area: None

Restrictions: None

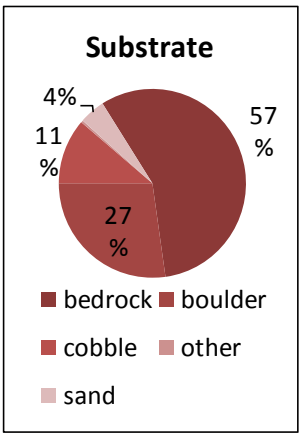
Survey history: 10/14/2007 11/23/2008 10/4/2009 10/20/2011

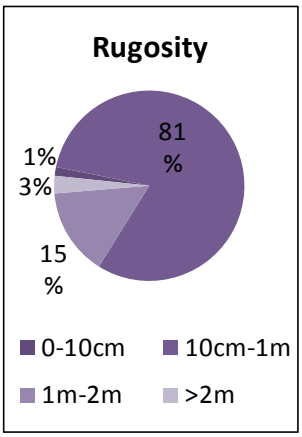
Survey Depths (ft): 6 - 43

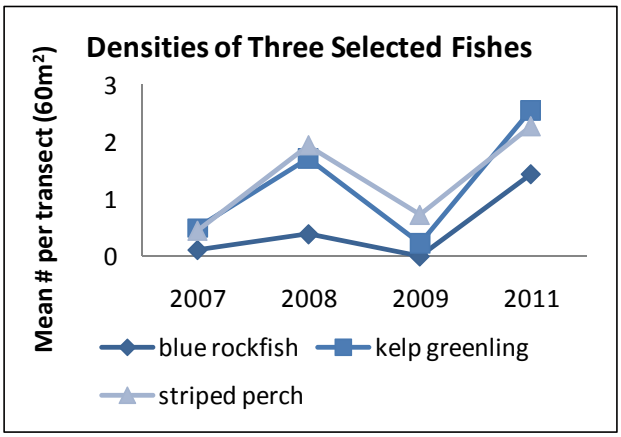


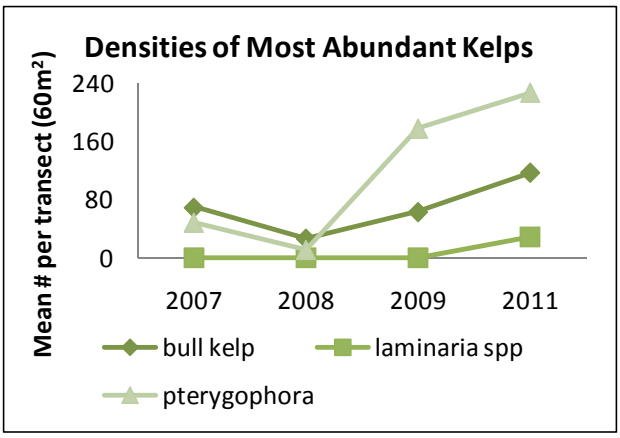
Indicator Species Observed: 16 of 35 fishes surveyed, 11 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

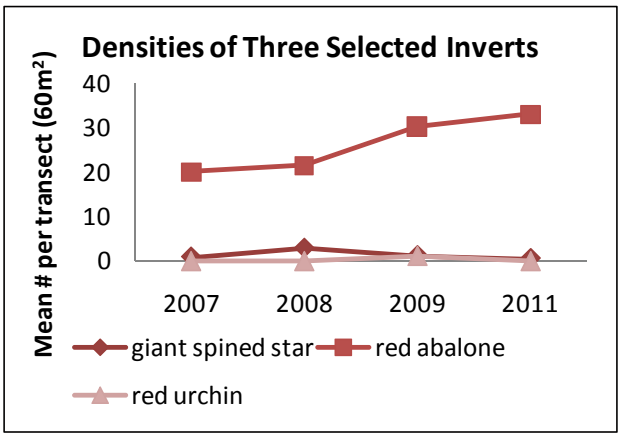
Invasive Algae: None





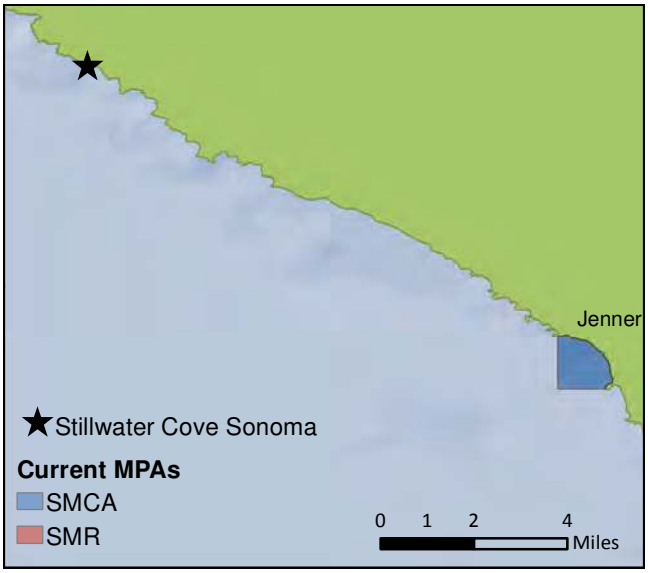






Reef Check California 2006-2011

Stillwater Cove Sonoma



County: Sonoma

Marine Protected Area: None

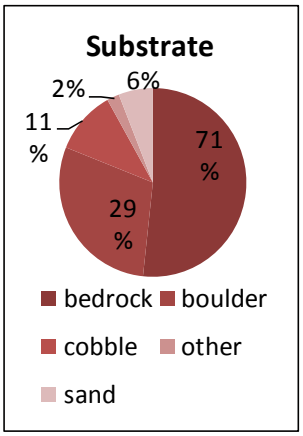
Restrictions: None

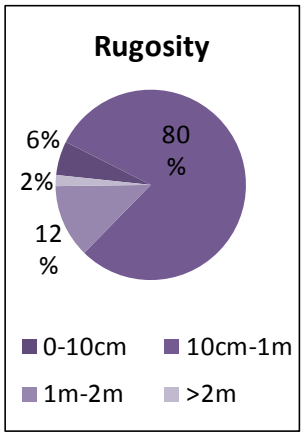
Survey history: 10/14/2007 10/19/2008 7/11/2009 7/10/2010 10/9/2010 10/22/2011

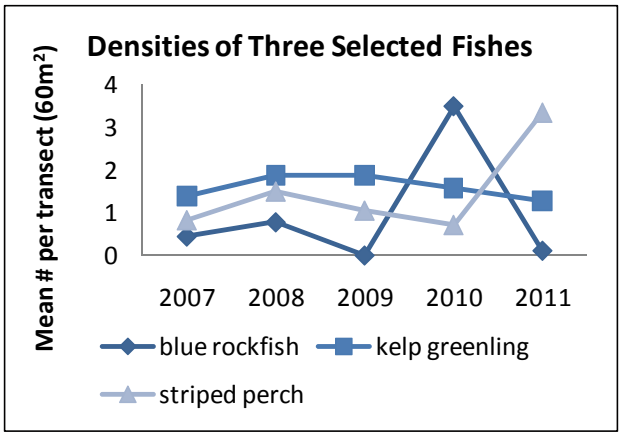
Survey Depths (ft): 8 - 40

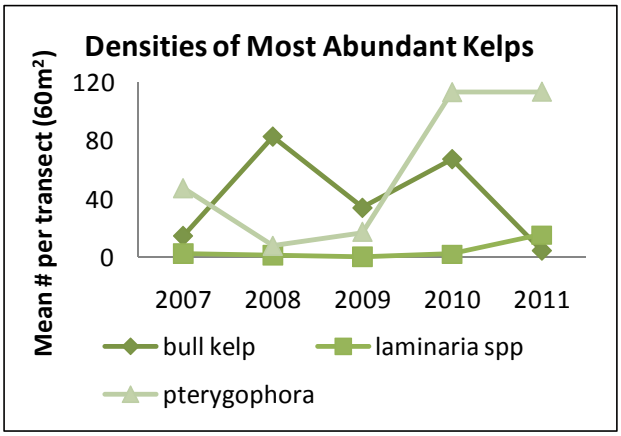
Indicator Species Observed: 18 of 35 fishes surveyed, 13 of 30 invertebrates surveyed, 5 of 5 seaweeds surveyed

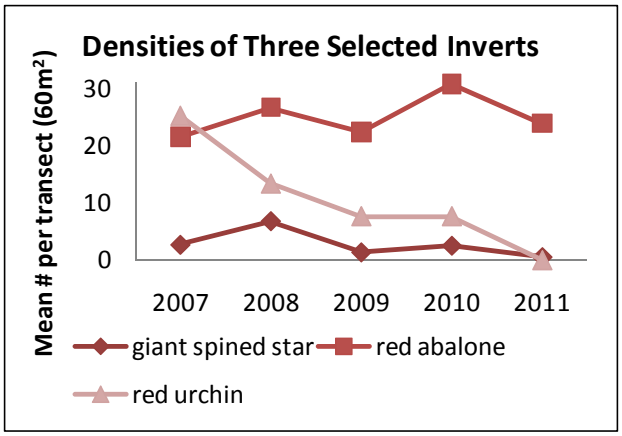
Invasive Algae: None











Reef Check California 2006-2011

Fort Ross

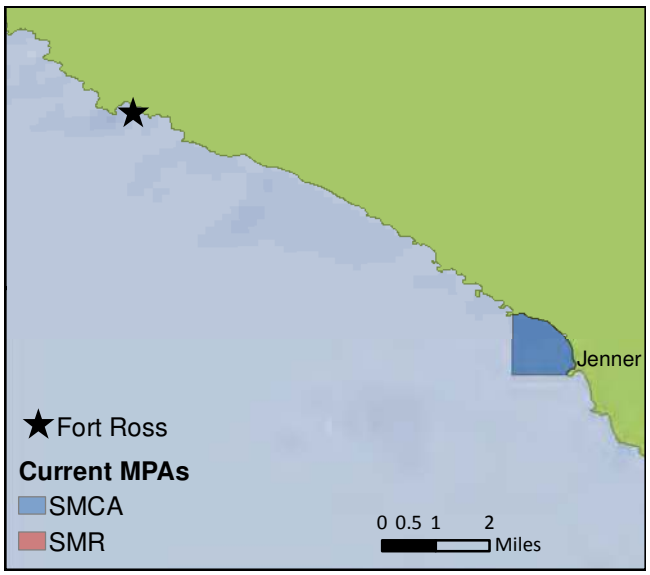
County: Sonoma

Marine Protected Area: None

Restrictions: None

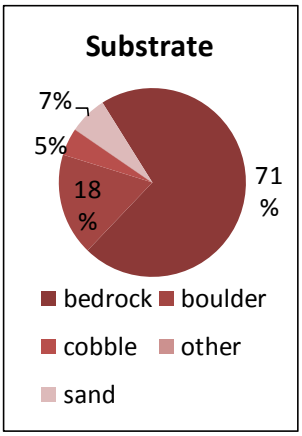
Survey history: 8/14/2007 10/11/2008 10/3/2009 9/11/2010 10/21/2011

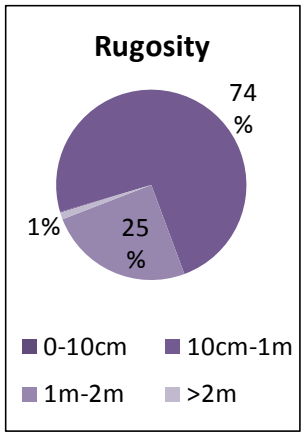
Survey Depths (ft): 12 - 42

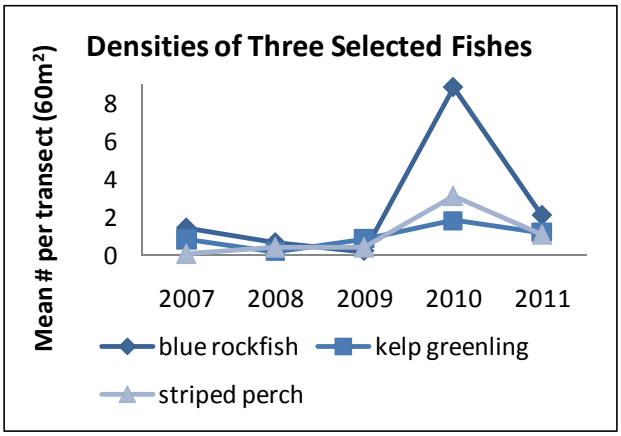


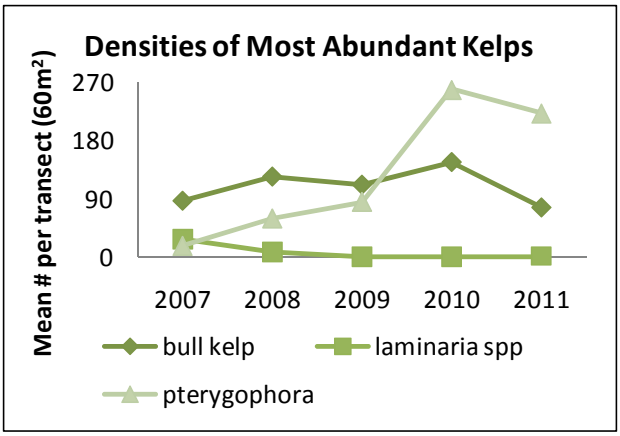
Indicator Species Observed: 20 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

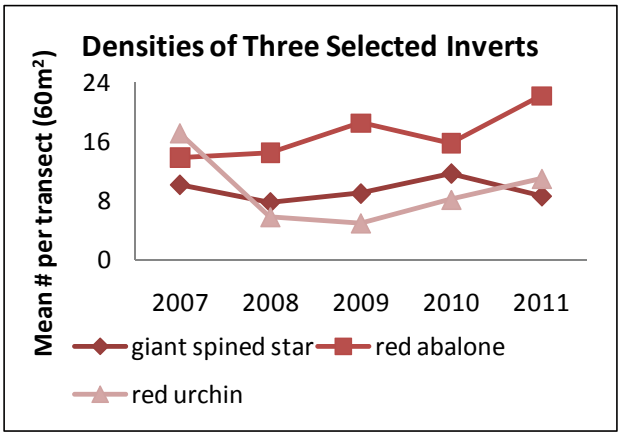
Invasive Algae: None





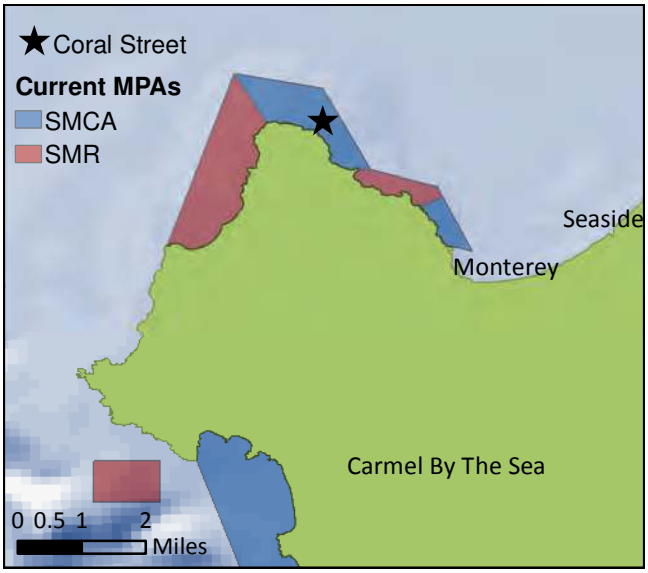






Reef Check California 2006-2011

Coral Street, Lucas Point



County: Monterey

Marine Protected Area: Pacific Grove Marine Gardens SMCA (since 9/21/2007)

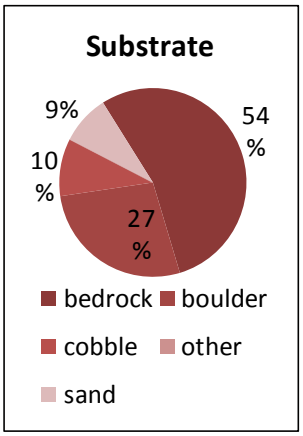
Restrictions: No take EXCEPT: 1) Finfish recreationally and 2) Kelp by hand commercially

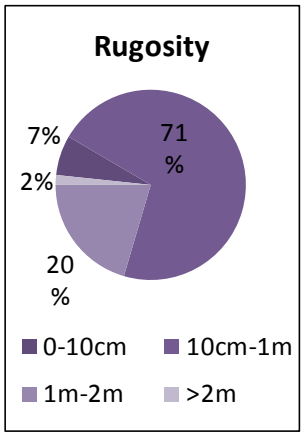
Survey history: 6/11/06 6/9/07 8/15/07 6/14/08 9/21/08 7/18/09 7/17/10 10/3/10 7/7/11 9/18/11

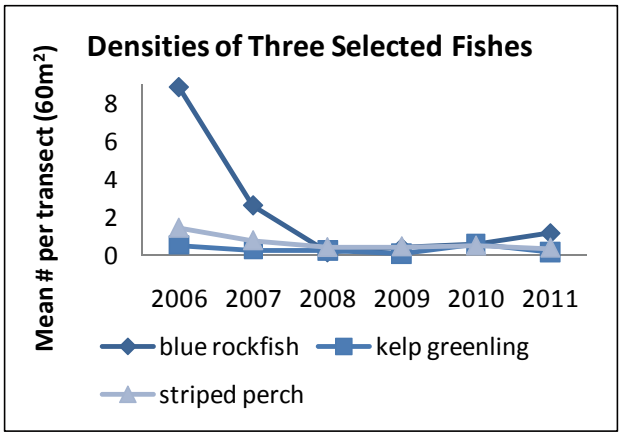
Survey Depths (ft): 8 - 57

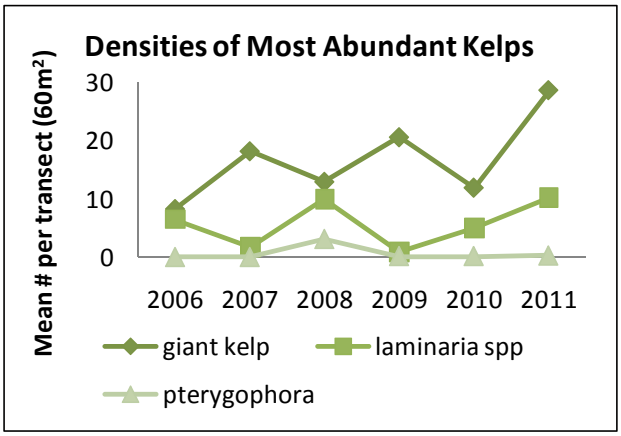
Indicator Species Observed: 25 of 35 fishes surveyed, 18 of 30 invertebrates surveyed, 5 of 5 seaweeds surveyed

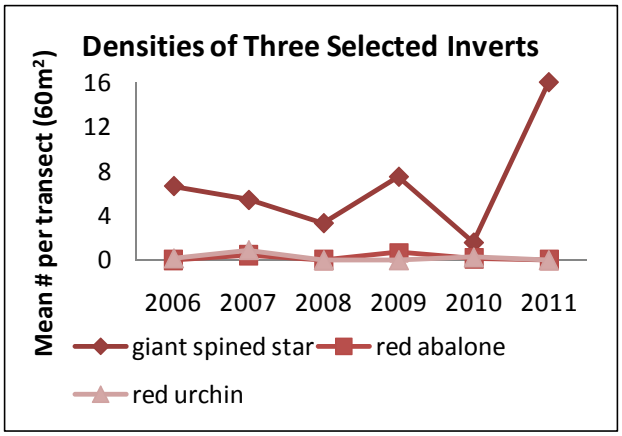
Invasive Algae: None





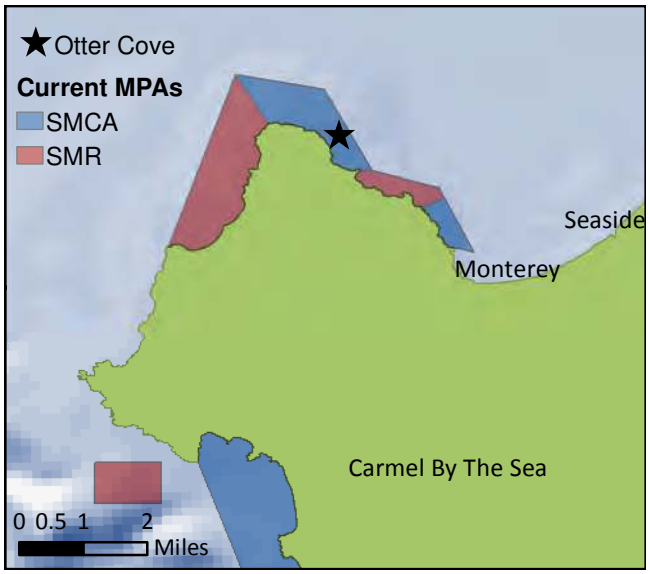






Reef Check California 2006-2011

Otter Cove



County: Monterey

Marine Protected Area: Pacific Grove Marine Gardens SMCA (since 9/21/2007)

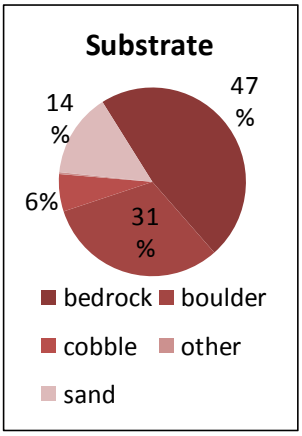
Restrictions: No take EXCEPT: 1) Finfish recreationally and 2) Kelp by hand commercially

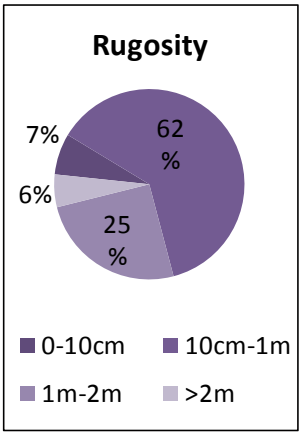
Survey history: 9/17/2006 10/16/2007 8/3/2008 6/27/2009 6/5/2010 6/22/2011

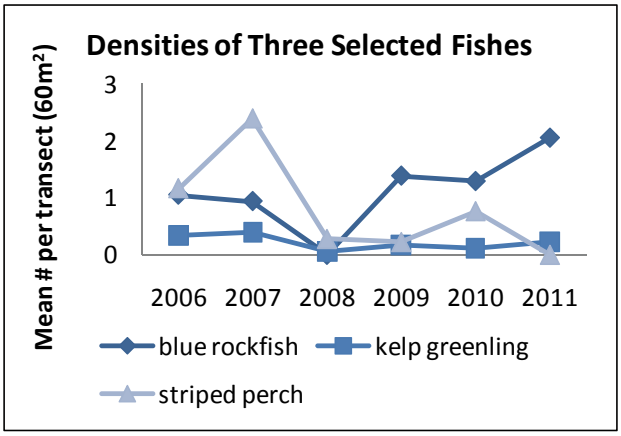
Survey Depths (ft): 18 - 49

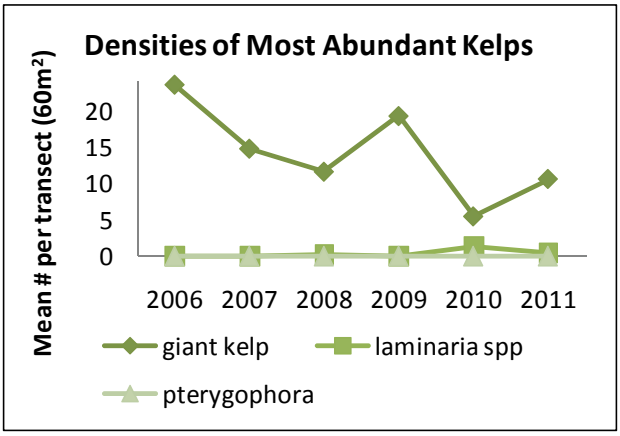
Indicator Species Observed: 19 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 2 of 5 seaweeds surveyed

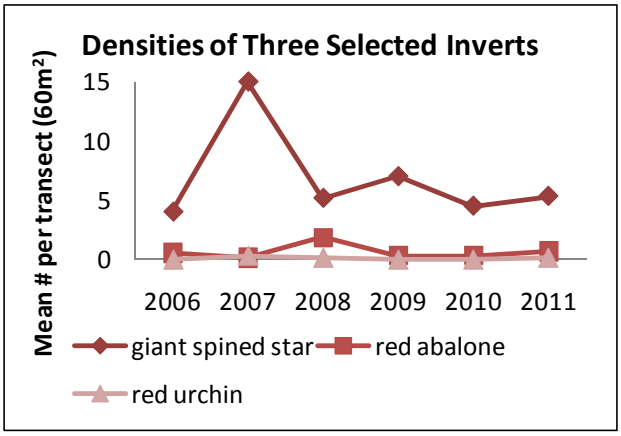
Invasive Algae: None











Reef Check California 2006-2011

Lovers Point

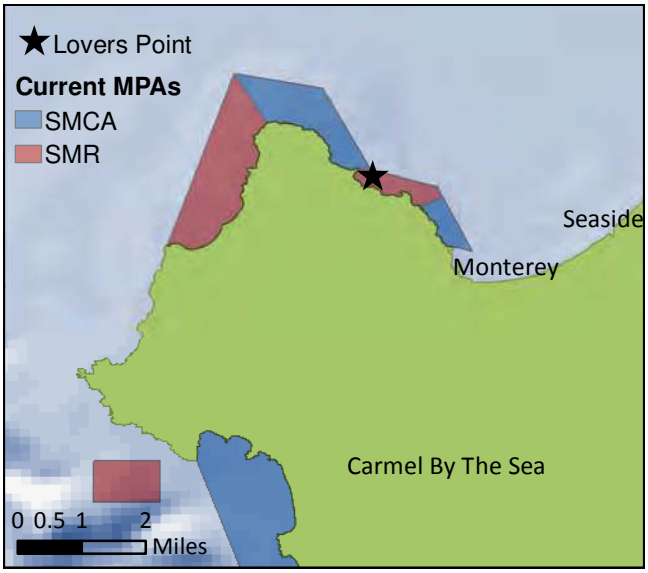
County: Monterey

Marine Protected Area: Lovers Point SMR (since 9/21/2007)

Restrictions: Take of all living marine resources is prohibited.

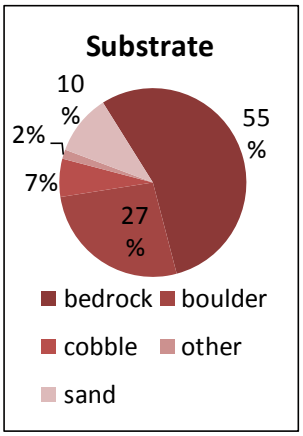
Survey history: 8/20/06 6/10/07 7/27/07 10/20/07 7/12/08 11/2/08 7/11/09 10/23/10 6/11/11

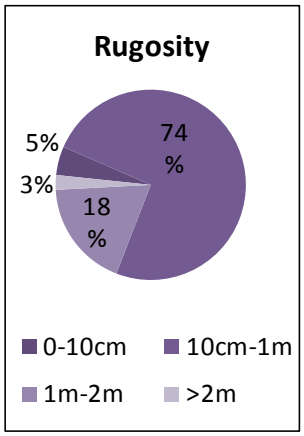
Survey Depths (ft): 20 - 48

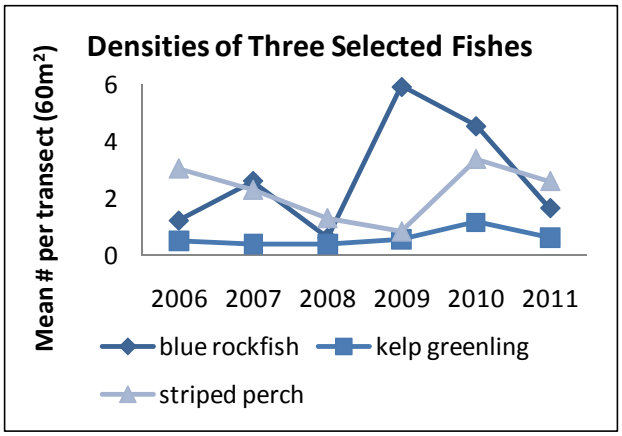


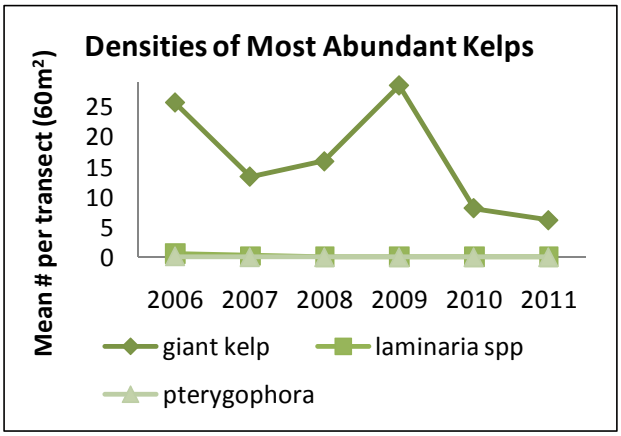
Indicator Species Observed: 27 of 35 fishes surveyed, 19 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

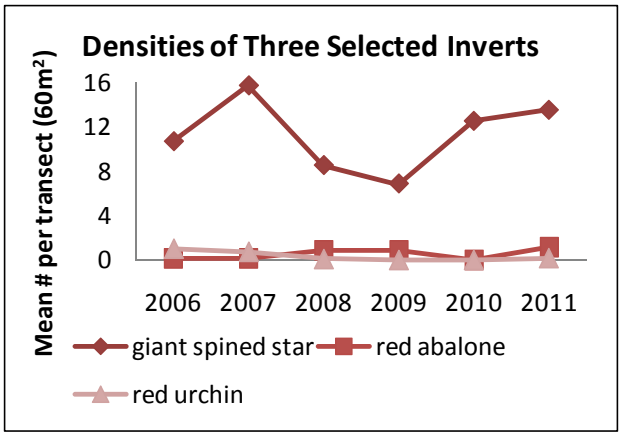
Invasive Algae: None











Reef Check California 2006-2011

Hopkins

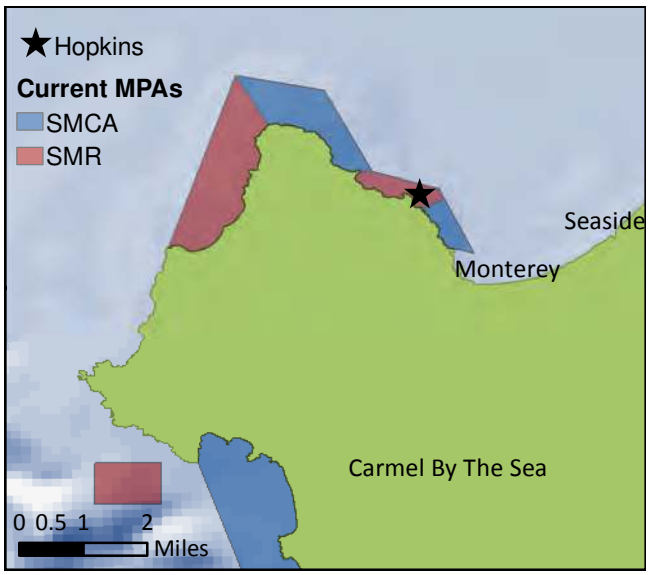
County: Monterey

Marine Protected Area: Lovers Point SMR

Restrictions: Take of all living marine resources is prohibited.

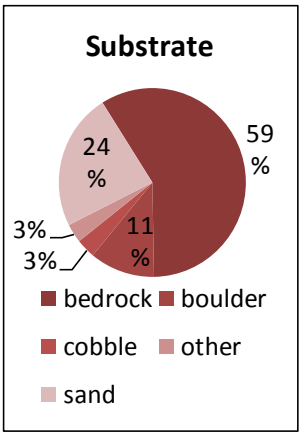
Survey history: 8/26/2006 9/29/2007 7/12/2008 11/2/2008 6/27/2009 7/31/2010 10/22/2011

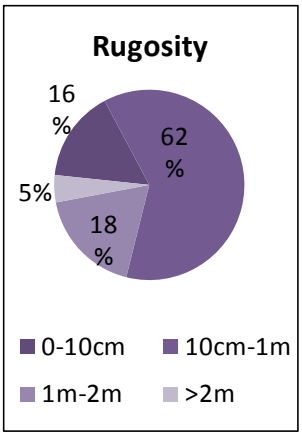
Survey Depths (ft): 9 - 53

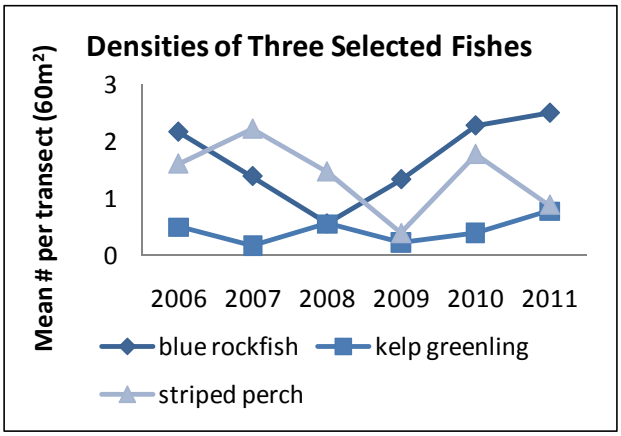


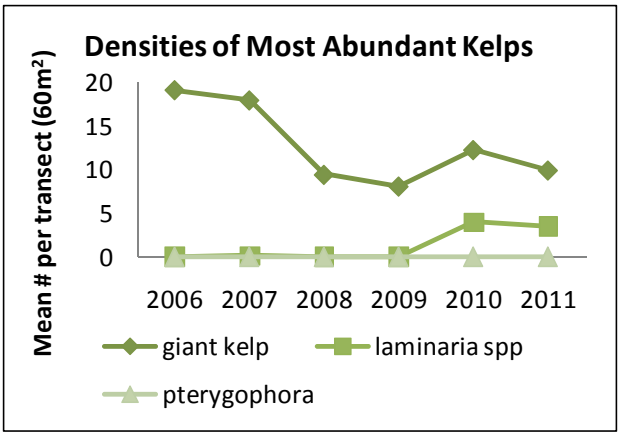
Indicator Species Observed: 29 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 2 of 5 seaweeds surveyed

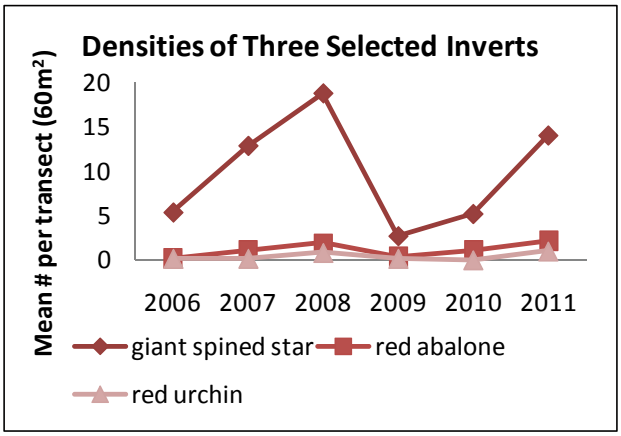
Invasive Algae: None











Reef Check California 2006-2011

Aquarium

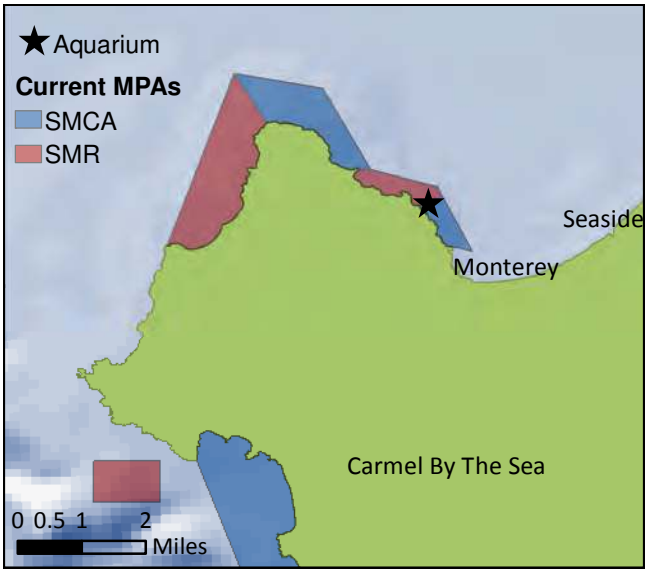
County: Monterey

Marine Protected Area: Lovers Point SMR (since 9/21/2007)

Restrictions: Take of all living marine resources is prohibited.

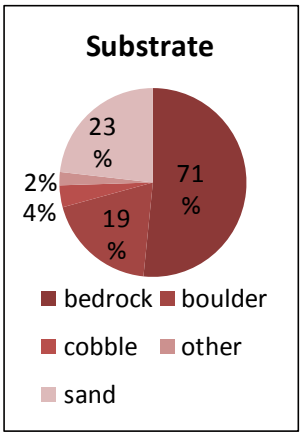
Survey history: 5/19/07 7/28/07 10/2/07 5/17/08 10/4/08 5/24/09 10/17/09 7/10/10 10/23/10 5/14/11

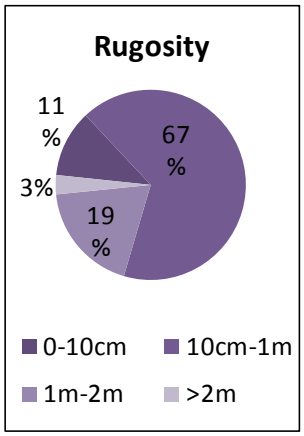
Survey Depths (ft): 10 - 55

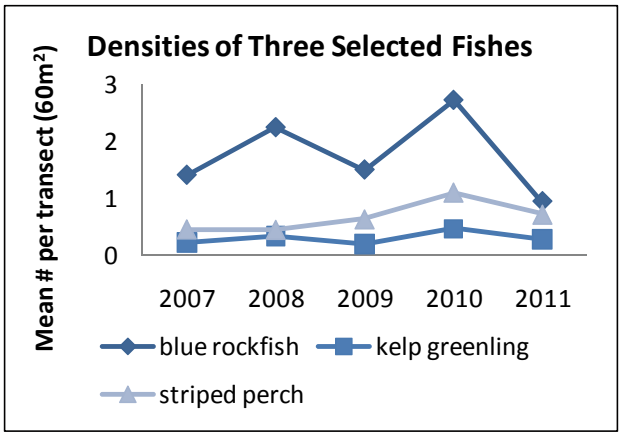


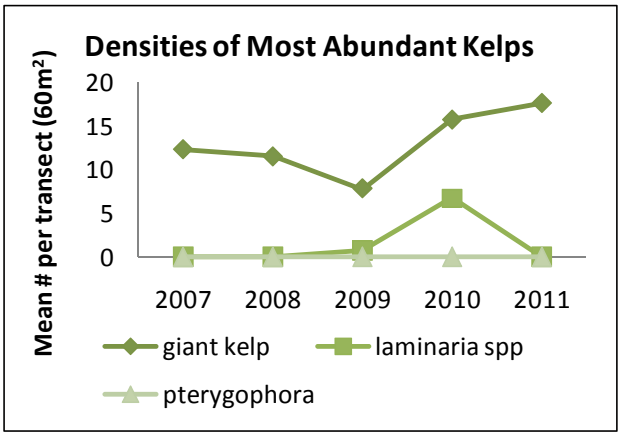
Indicator Species Observed: 31 of 35 fishes surveyed, 22 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

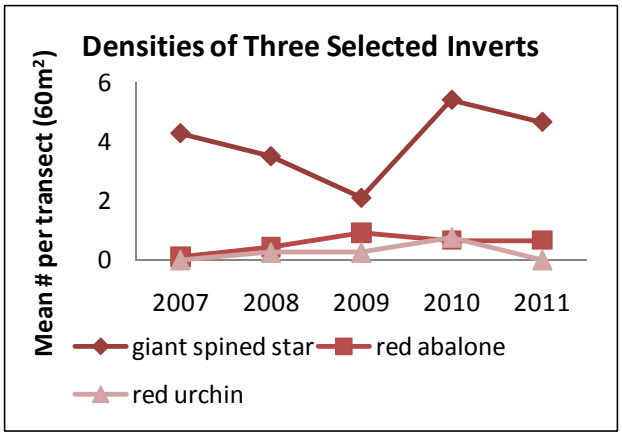
Invasive Algae: None





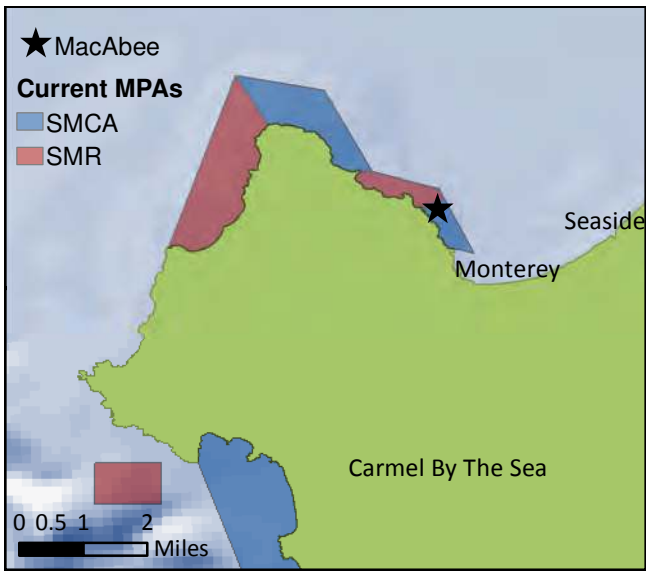






Reef Check California 2006-2011

MacAbee



County: Monterey

Marine Protected Area: Edward F. Ricketts SMCA (since 9/21/2007)

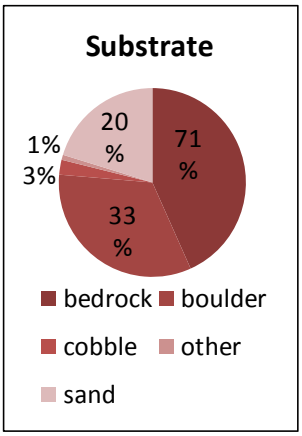
Restrictions: No take EXCEPT: 1) Finfish recreationally and 2) Kelp (giant and bull) by hand commercially

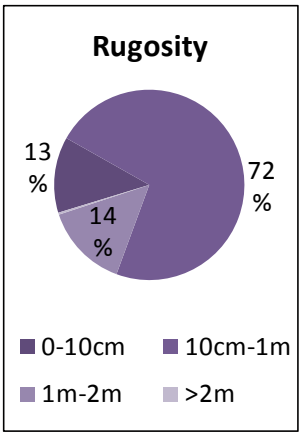
Survey history: 8/25/2006 9/29/2007 8/23/2008 7/11/2009 7/31/2010 6/4/2011

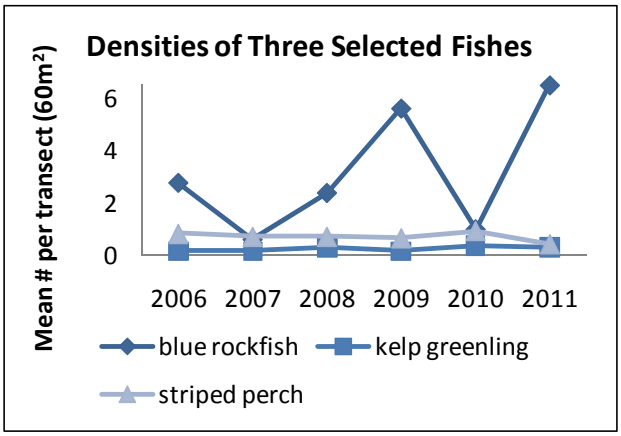
Survey Depths (ft): 10 - 52

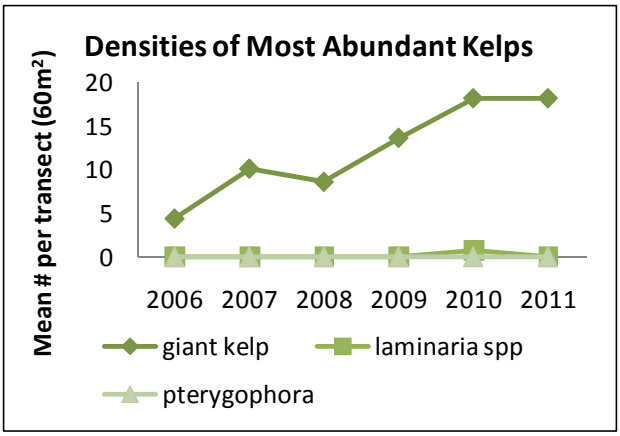
Indicator Species Observed: 25 of 35 fishes surveyed, 19 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

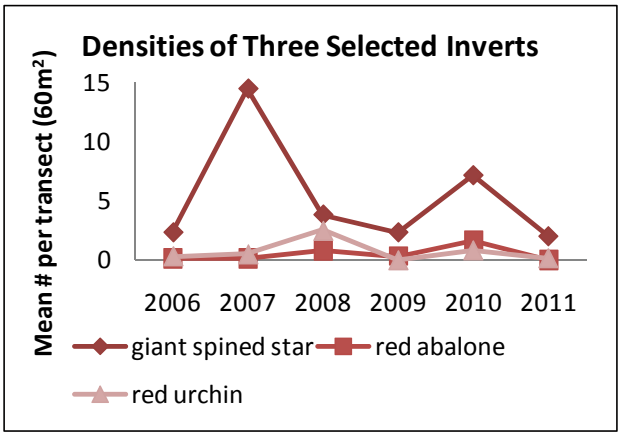
Invasive Algae: None











Reef Check California 2006-2011

Point Joe

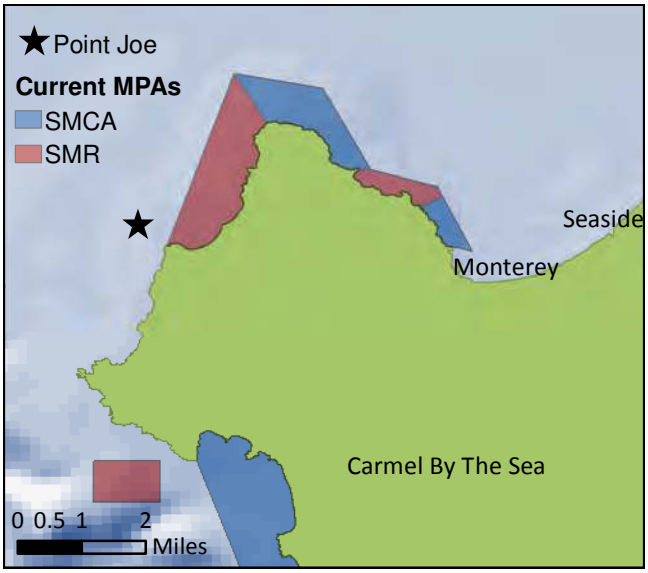
County: Monterey

Marine Protected Area: None

Restrictions: None

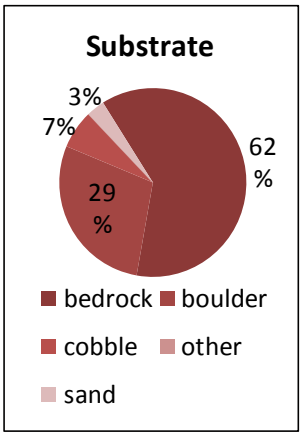
Survey history: 9/26/2008 10/21/2009 10/19/2010 10/22/2011

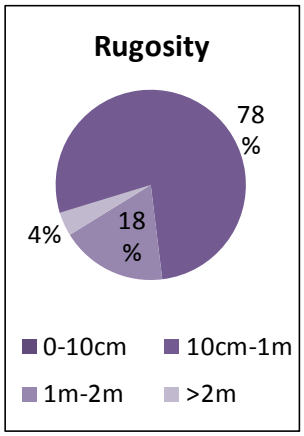
Survey Depths (ft): 26 - 62

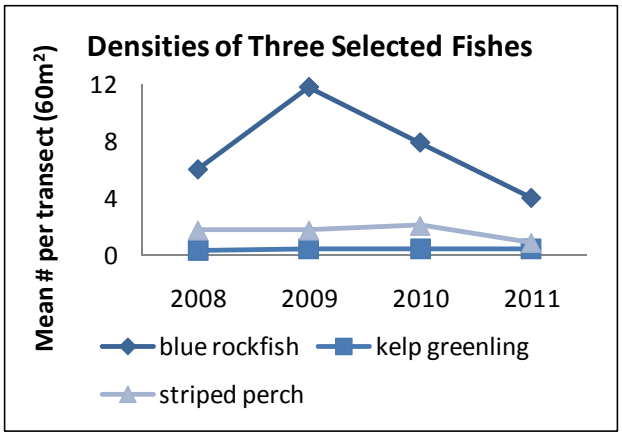


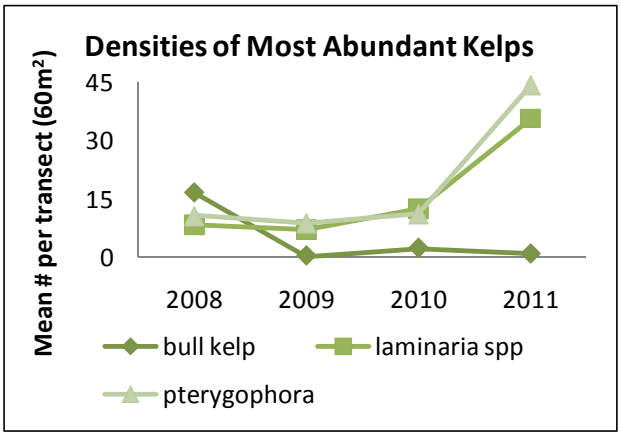
Indicator Species Observed: 18 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

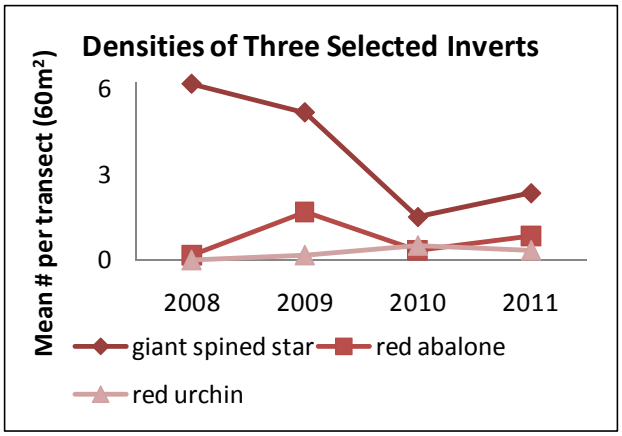
Invasive Algae: None











Reef Check California 2006-2011

Breakwater

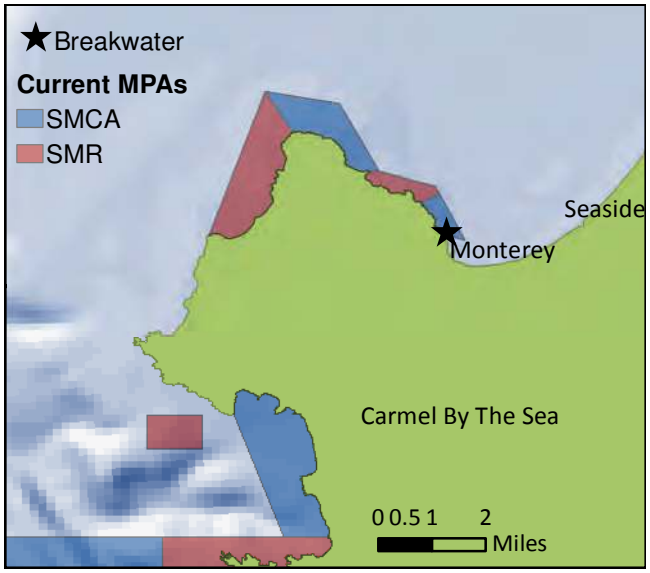
County: Monterey

Marine Protected Area: Edward F. Ricketts SMCA (since 9/21/2007)

Restrictions: No take EXCEPT: 1) Finfish recreationally and 2) Kelp (giant and bull) by hand commercially

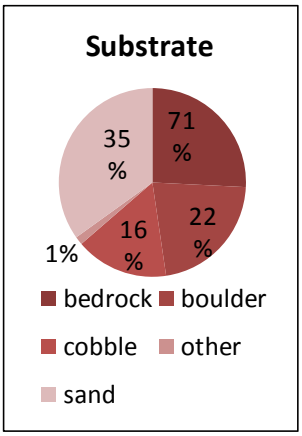
Survey history: 10/5/06 6/8/07 8/24/07 4/24/08 9/5/08 5/29/09 9/18/09 6/18/10 9/10/10 5/2/11 8/22/11

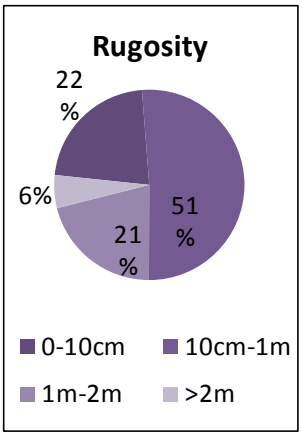
Survey Depths (ft): 6 - 40

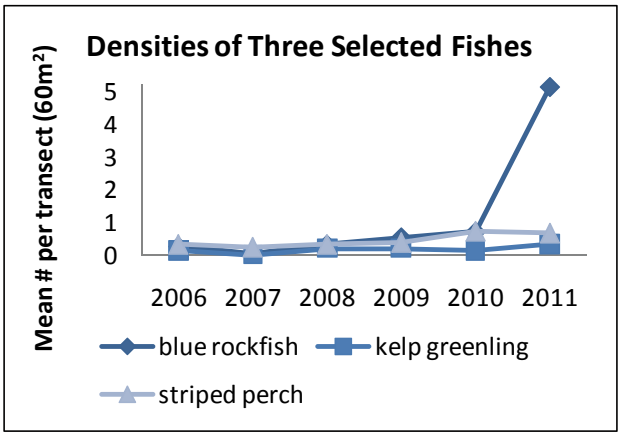


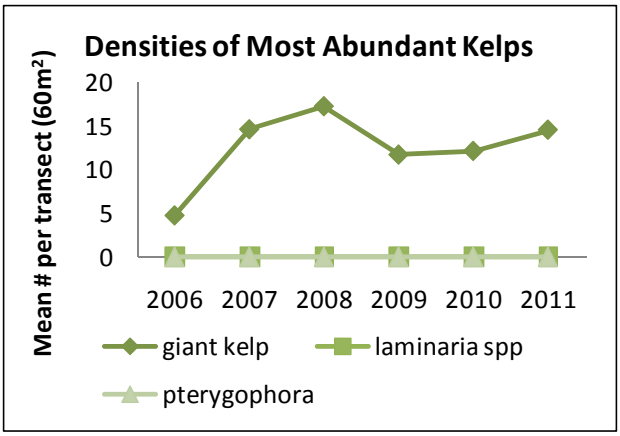
Indicator Species Observed: 23 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 1 of 5 seaweeds surveyed

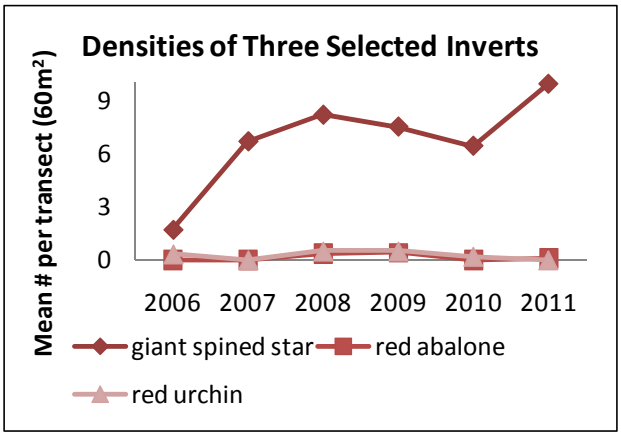
Invasive Algae: None











Reef Check California 2006-2011

Pescadero

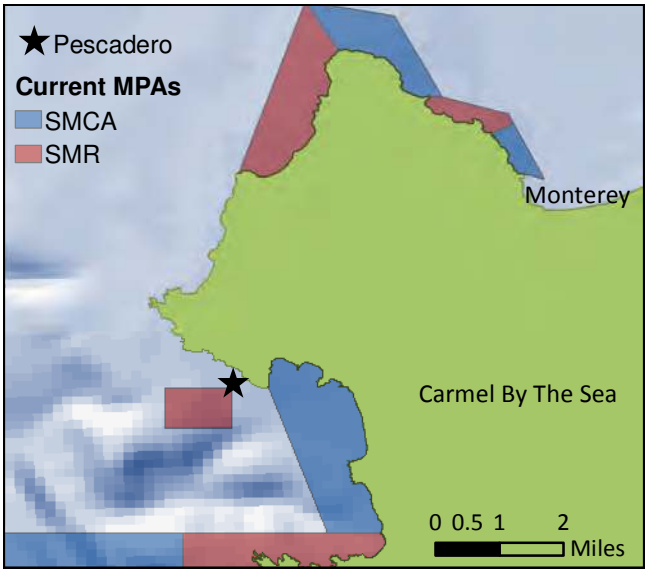
County: Monterey

Marine Protected Area: None

Restrictions: None

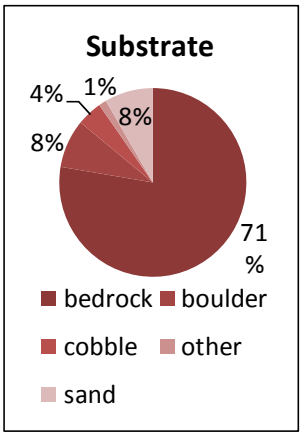
Survey history: 10/22/2006 8/19/2007 6/21/2008 8/1/2009 5/8/2010 8/28/2010 7/16/2011

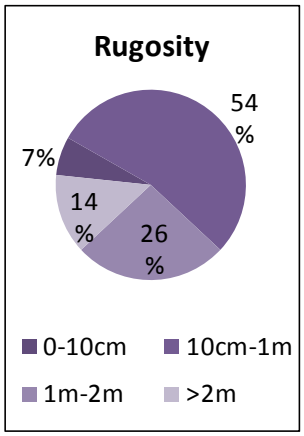
Survey Depths (ft): 18 - 70

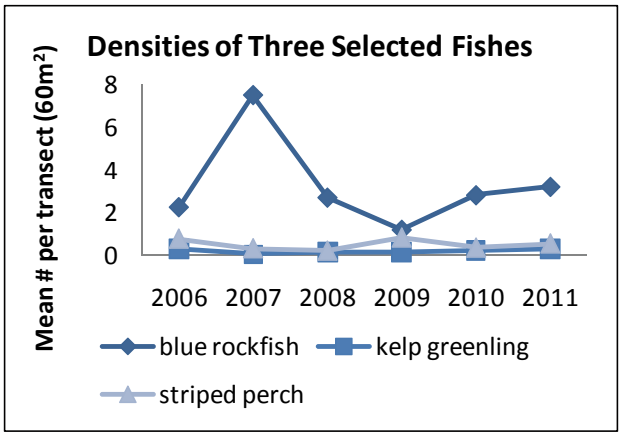


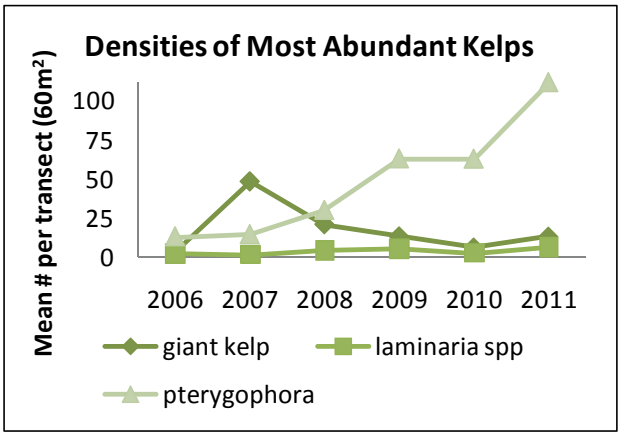
Indicator Species Observed: 25 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 5 of 5 seaweeds surveyed

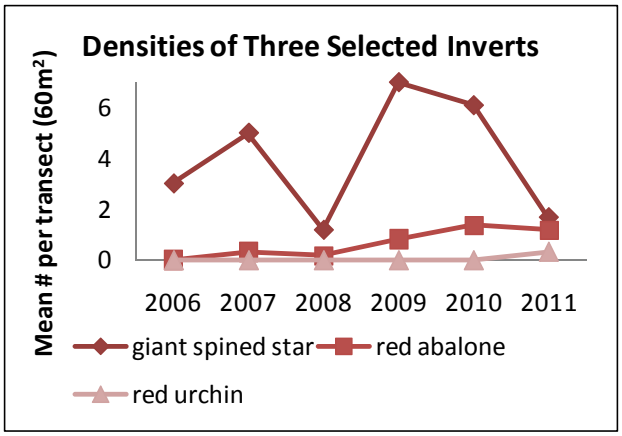
Invasive Algae: None





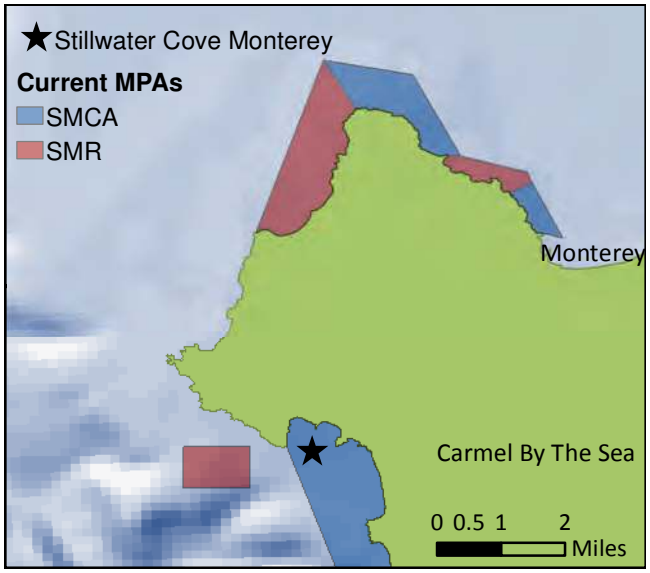






Reef Check California 2006-2011

Stillwater Cove Monterey



County: Monterey

Marine Protected Area: Carmel Bay SMCA (since 9/21/2007)

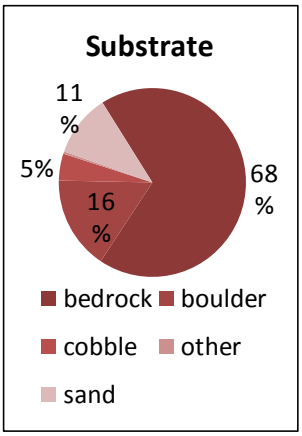
Restrictions: No take EXCEPT: 1) Finfish recreationally and 2) Kelp (giant and bull) by hand commercially

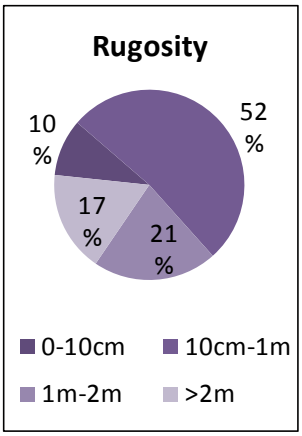
Survey history: 9/8/2007 5/17/2008 8/3/2008 5/24/2009 8/23/2009 5/8/2010 8/28/2010 7/9/2011

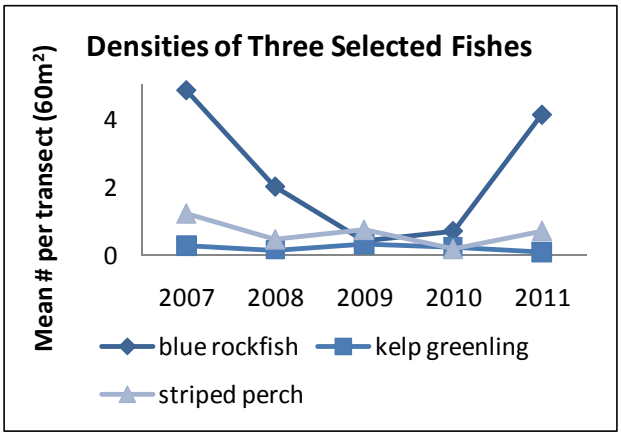
Survey Depths (ft): 5 - 68

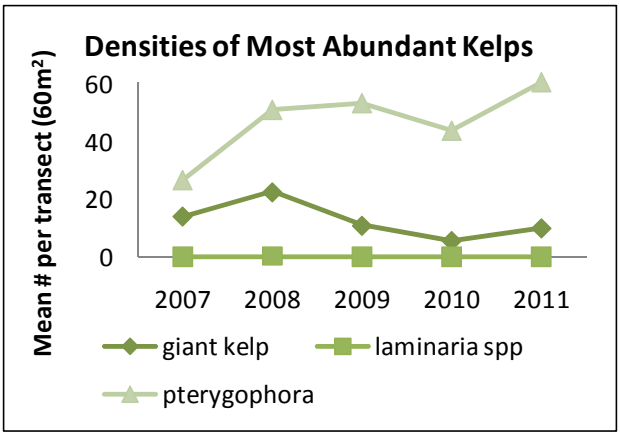
Indicator Species Observed: 25 of 35 fishes surveyed, 19 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

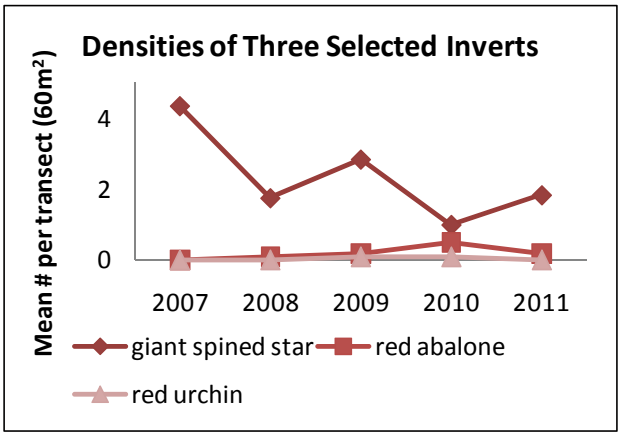
Invasive Algae: None





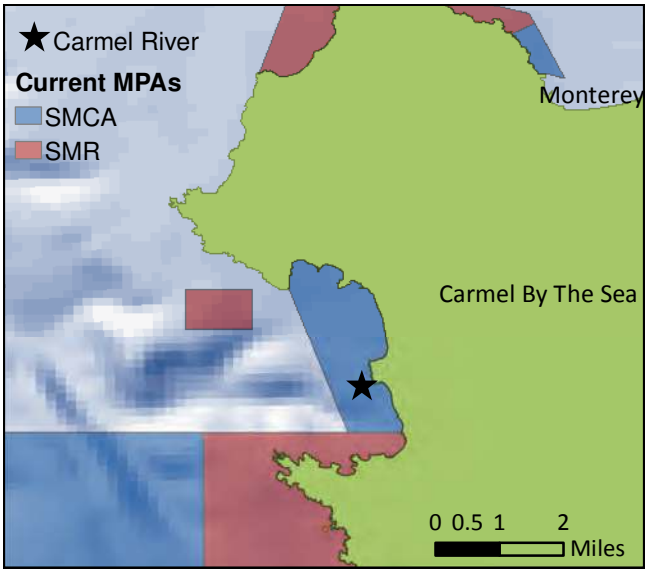






Reef Check California 2006-2011

Carmel River



County: Monterey

Marine Protected Area: Carmel Bay SMCA (since 9/21/2007)

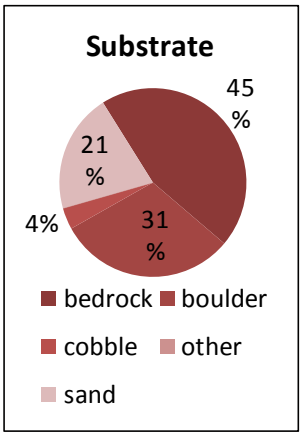
Restrictions: No take EXCEPT: 1) Finfish recreationally and 2) Kelp (giant and bull) by hand commercially

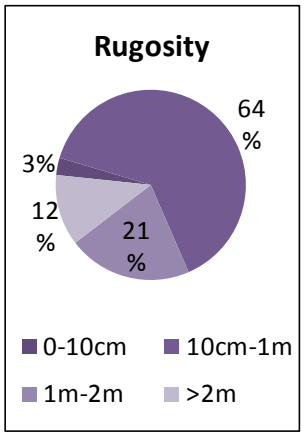
Survey history: 6/16/2007 6/21/2008 8/1/2009 6/5/2010 8/6/2011

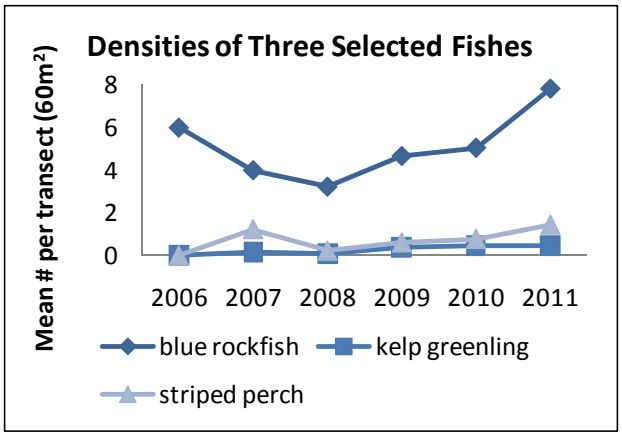
Survey Depths (ft): 16 - 76

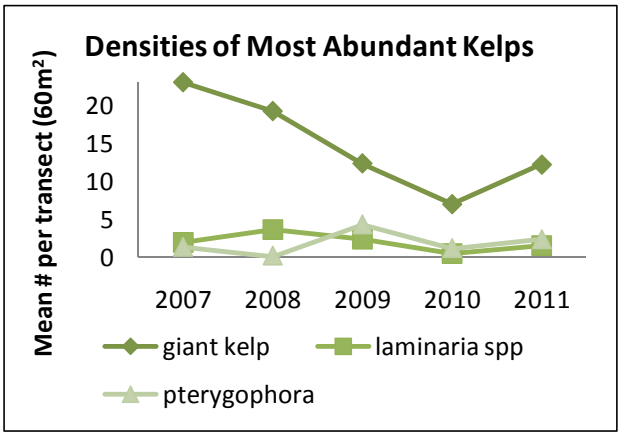
Indicator Species Observed: 22 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 5 of 5 seaweeds surveyed

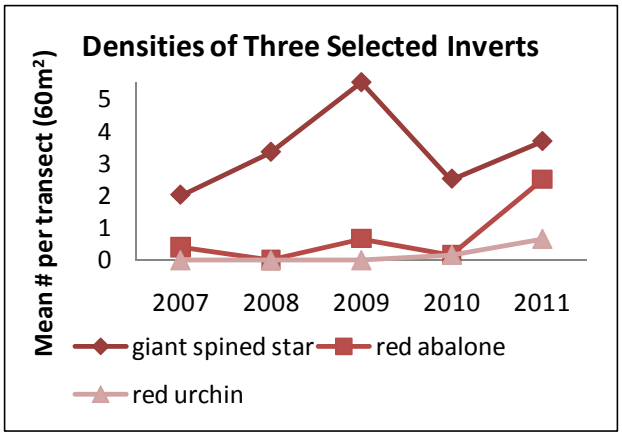
Invasive Algae: None





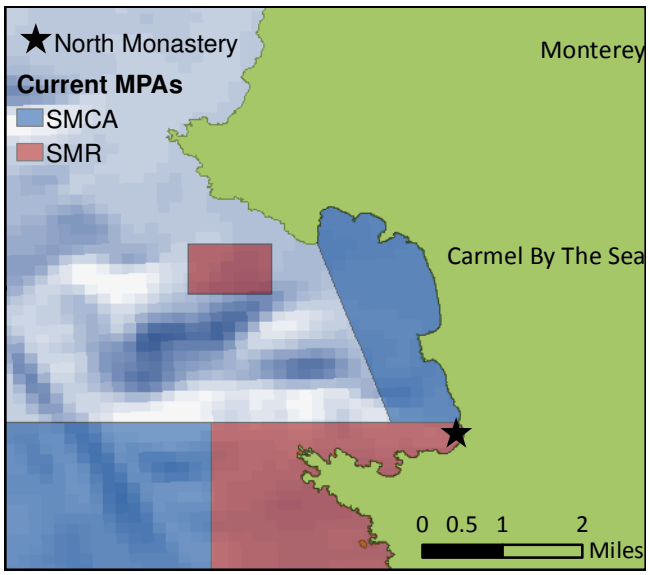






Reef Check California 2006-2011

North Monastery



County: Monterey

Marine Protected Area: Point Lobos SMR (since 9/21/2007)

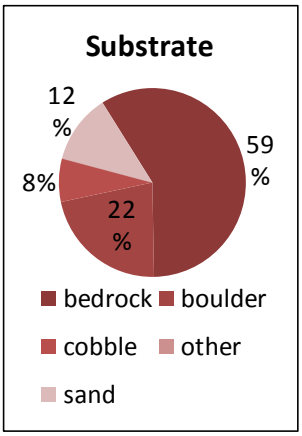
Restrictions: Take of all living marine resources is prohibited.

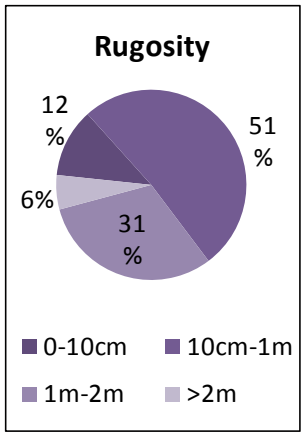
Survey history: 8/9/2008 9/24/2010 7/30/2011

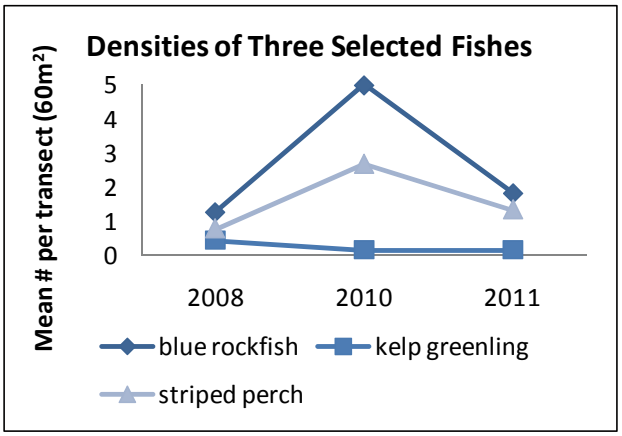
Survey Depths (ft): 10 - 44

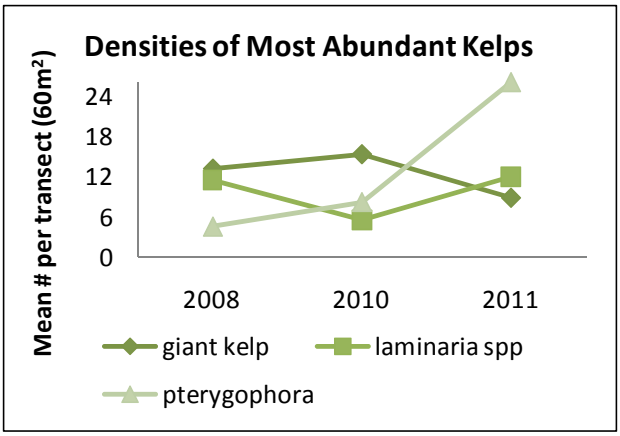
Indicator Species Observed: 18 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

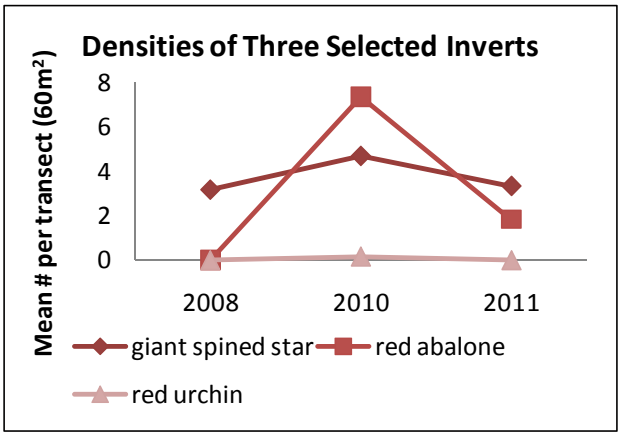
Invasive Algae: None











Reef Check California 2006-2011

South Monastery

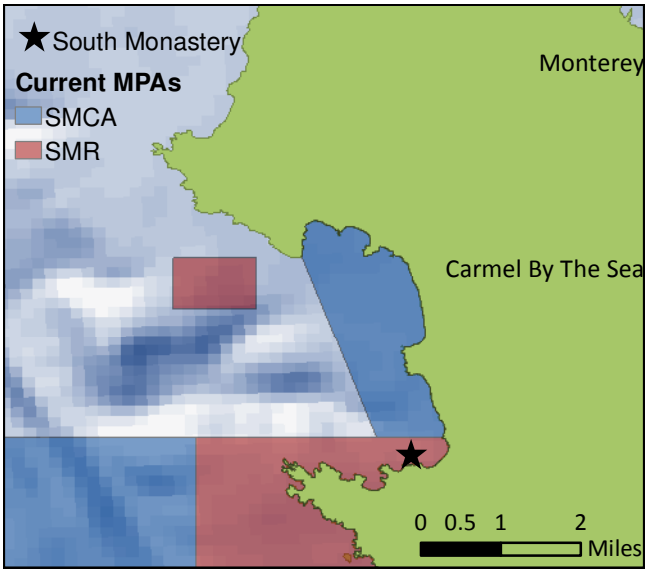
County: Monterey

Marine Protected Area: Point Lobos SMR (since 9/21/2007)

Restrictions: Take of all living marine resources is prohibited.

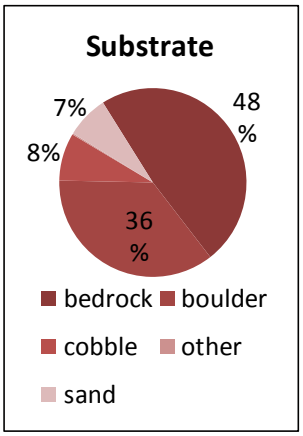
Survey history: 9/8/2007 8/23/2008 11/1/2008 8/23/2009 7/10/2010 8/6/2011

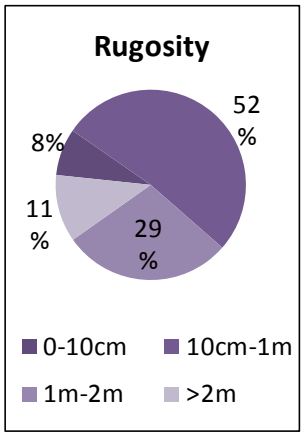
Survey Depths (ft): 18 - 69

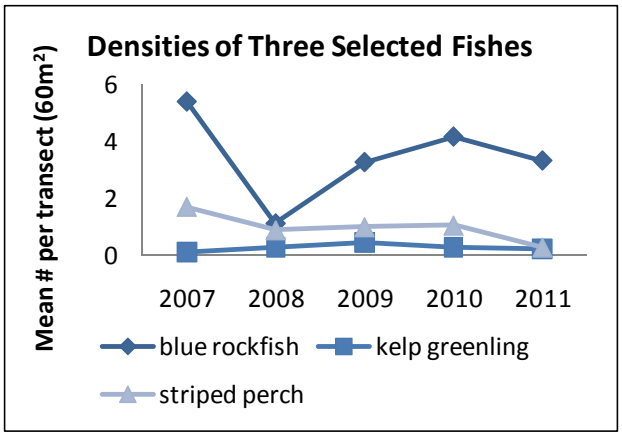


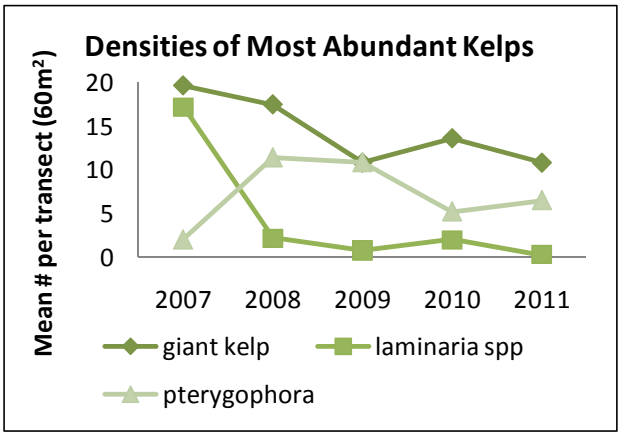
Indicator Species Observed: 22 of 35 fishes surveyed, 19 of 30 invertebrates surveyed, 5 of 5 seaweeds surveyed

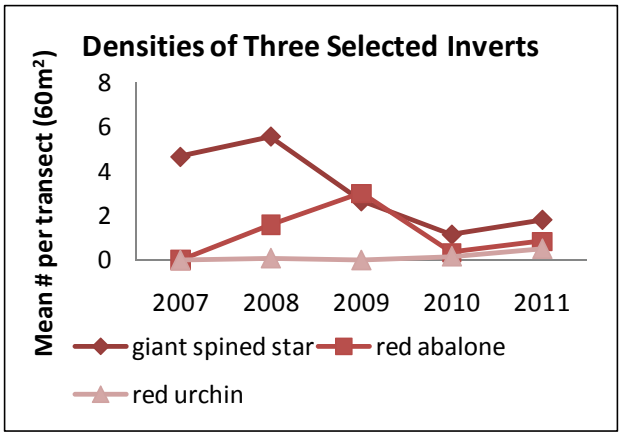
Invasive Algae: None





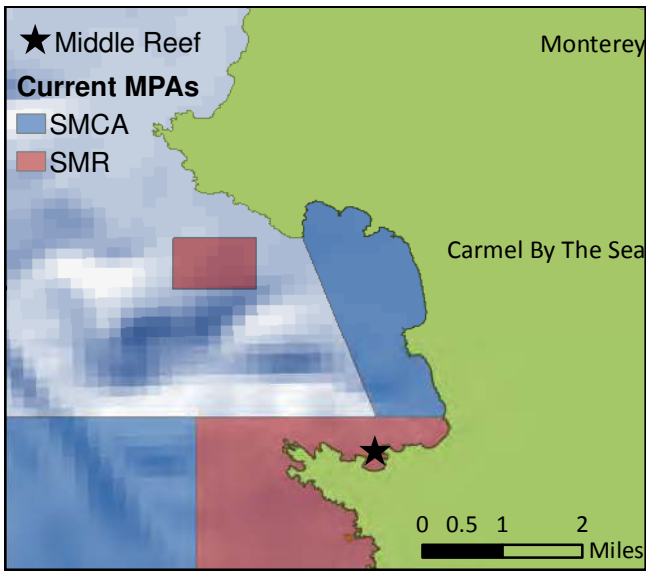






Reef Check California 2006-2011

Middle Reef



County: Monterey

Marine Protected Area: Point Lobos SMR (since 1973, expanded 9/21/2007)

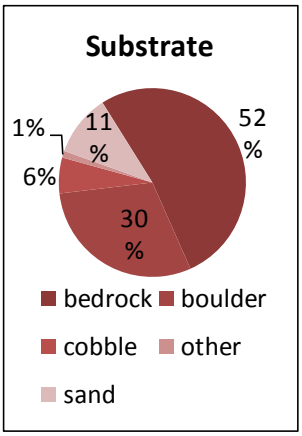
Restrictions: Take of all living marine resources is prohibited.

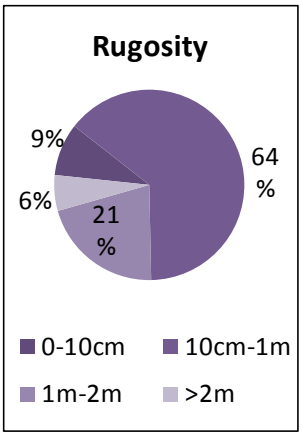
Survey history: 10/21/06 9/22/07 6/22/08 9/27/08 9/5/09 5/28/10 9/18/10 5/26/11 9/11/11

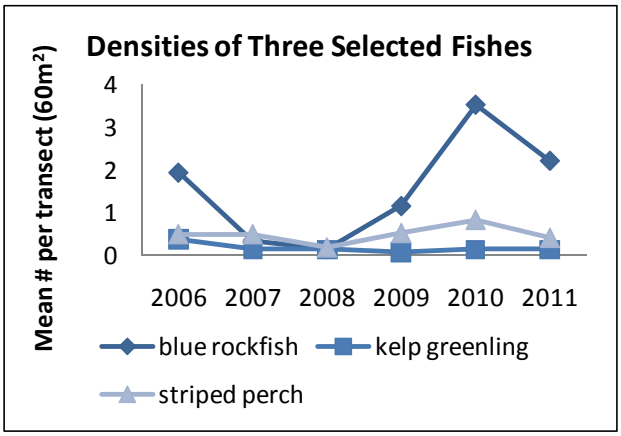
Survey Depths (ft): 16 - 62

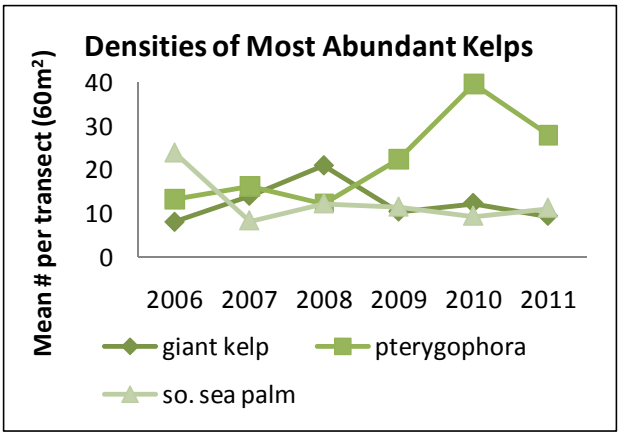
Indicator Species Observed: 27 of 35 fishes surveyed, 18 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

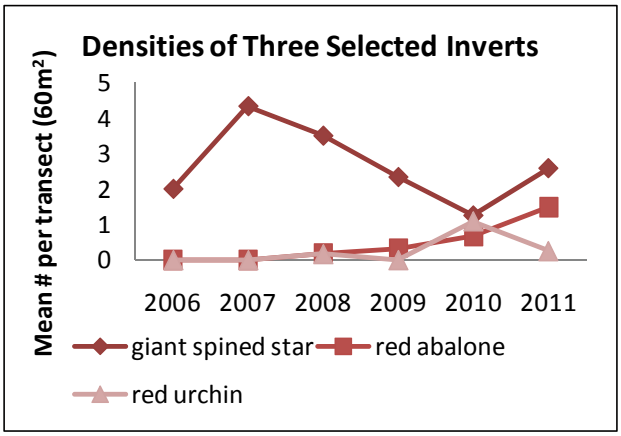
Invasive Algae: None











Reef Check California 2006-2011

Weston

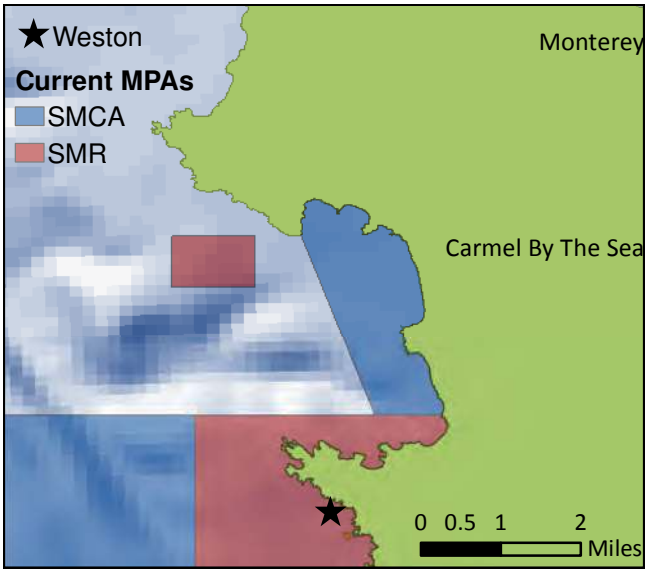
County: Monterey

Marine Protected Area: Point Lobos SMR (since 1973, expanded 9/21/2007)

Restrictions: Take of all living marine resources is prohibited. No dive area.

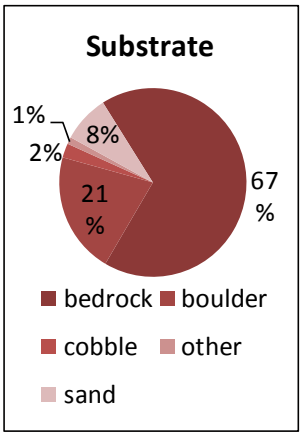
Survey history: 10/21/2006 9/22/2007 9/27/2008 9/5/2009 9/18/2010 9/11/2011

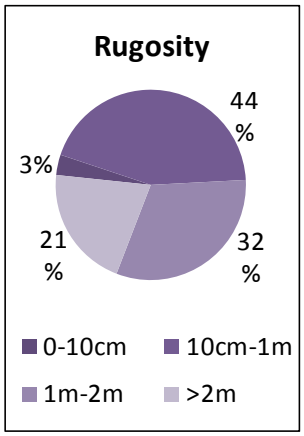
Survey Depths (ft): 25 - 76

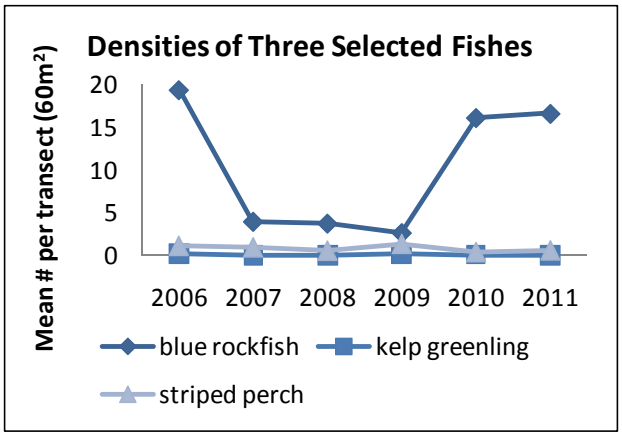


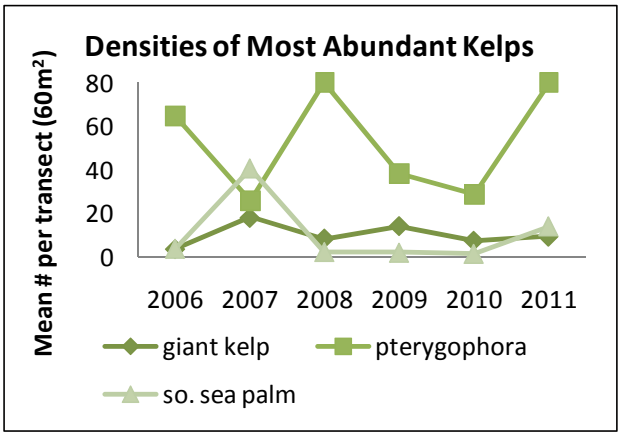
Indicator Species Observed: 25 of 35 fishes surveyed, 19 of 30 invertebrates surveyed, 5 of 5 seaweeds surveyed

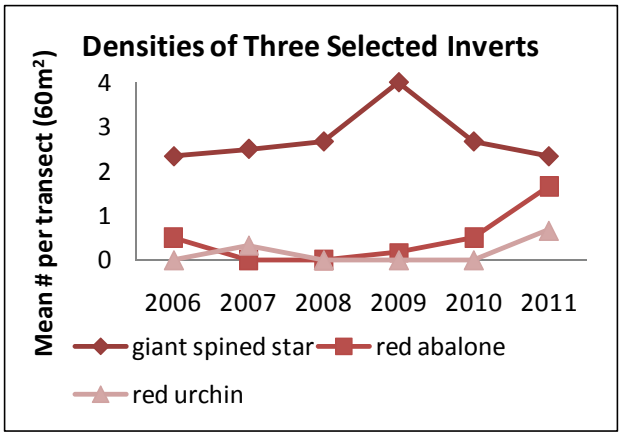
Invasive Algae: None





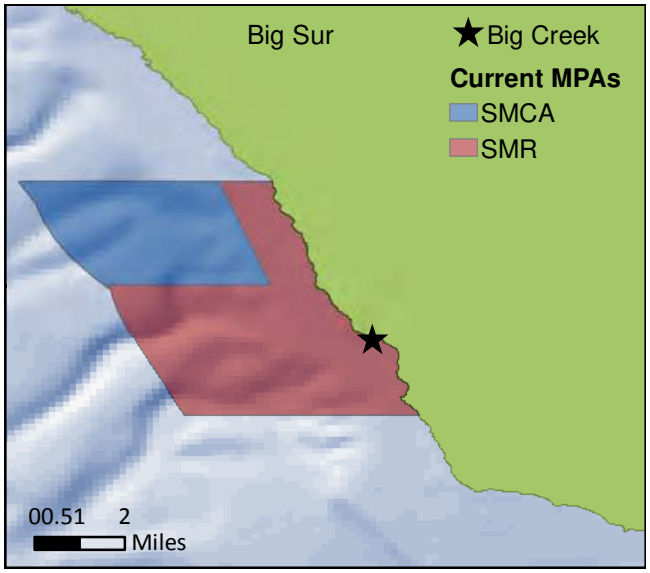






Reef Check California 2006-2011

Big Creek



County: Monterey

Marine Protected Area: Big Creek SMR (since 9/21/2007)

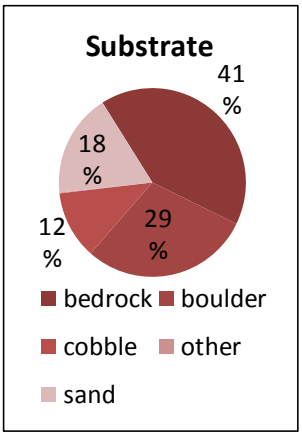
Restrictions: Take of all living marine resources is prohibited.

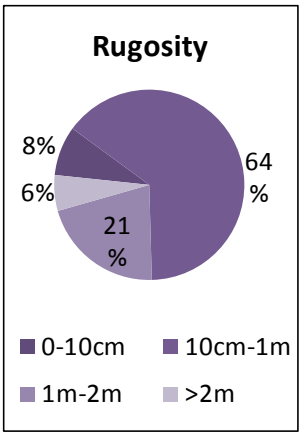
Survey history: 8/18/2007 8/16/2008 8/14/2009 8/14/2010 8/20/2011

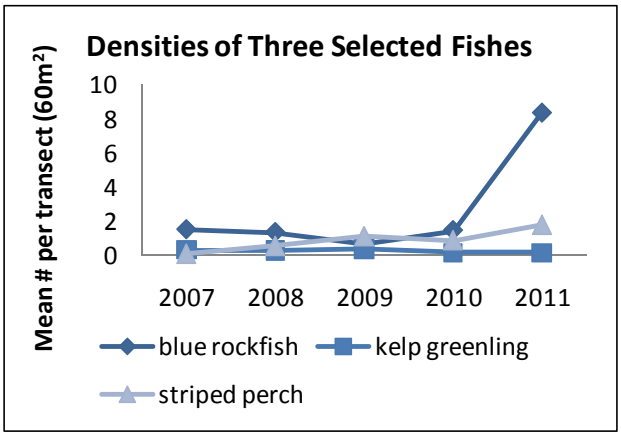
Survey Depths (ft): 20 - 65

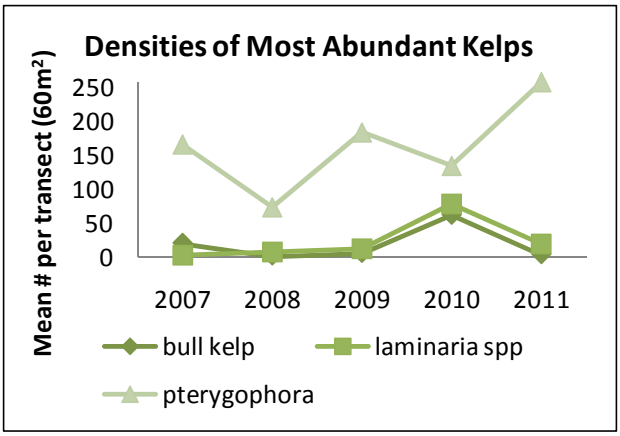
Indicator Species Observed: 24 of 35 fishes surveyed, 14 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

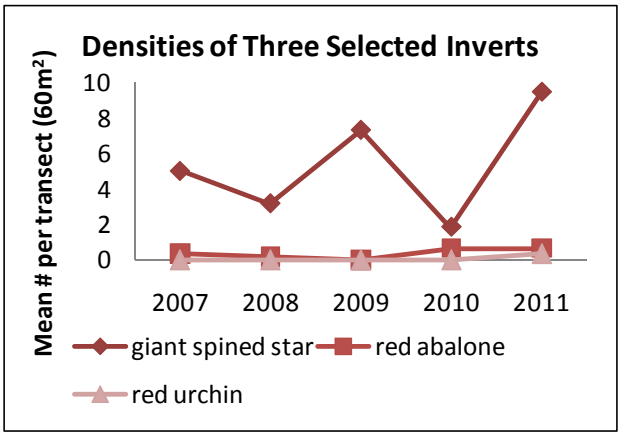
Invasive Algae: None











Reef Check California 2006-2011

Spooner's Cove

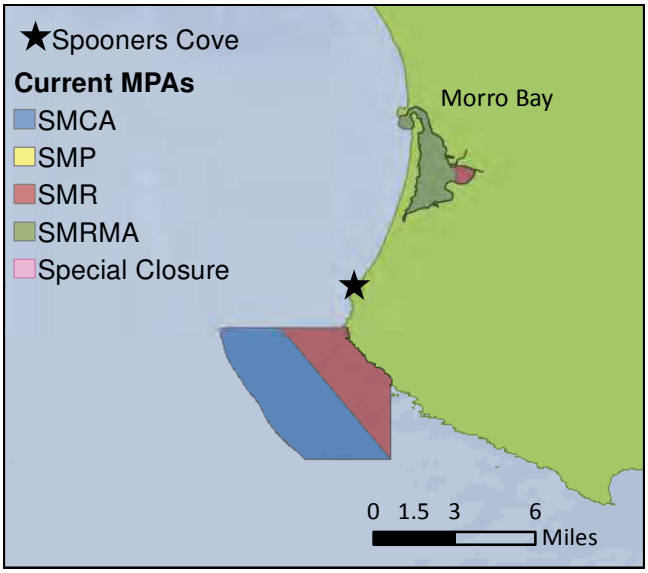
County: San Luis Obispo

Marine Protected Area: None

Restrictions: None

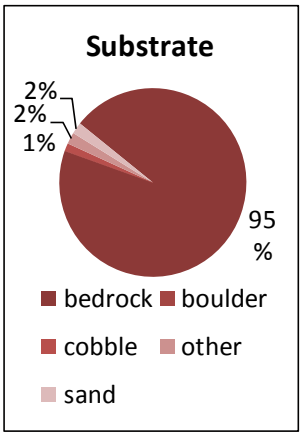
Survey history: 9/21/2008 10/11/2009 8/27/2011

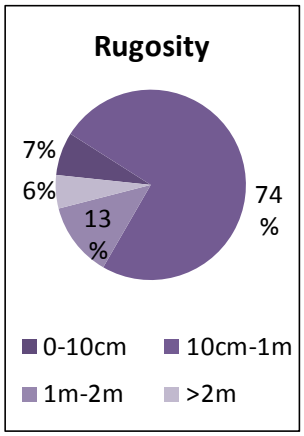
Survey Depths (ft): 24 - 48

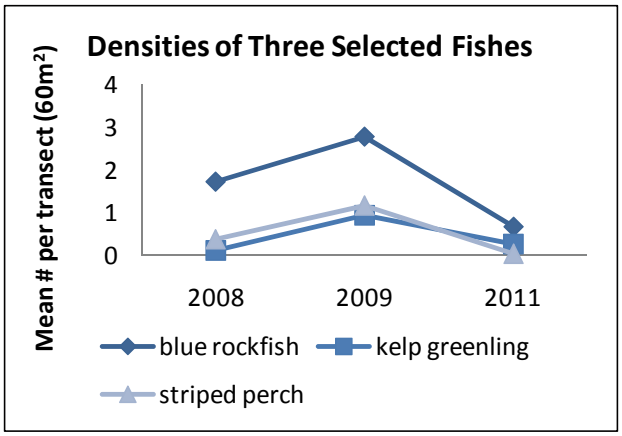


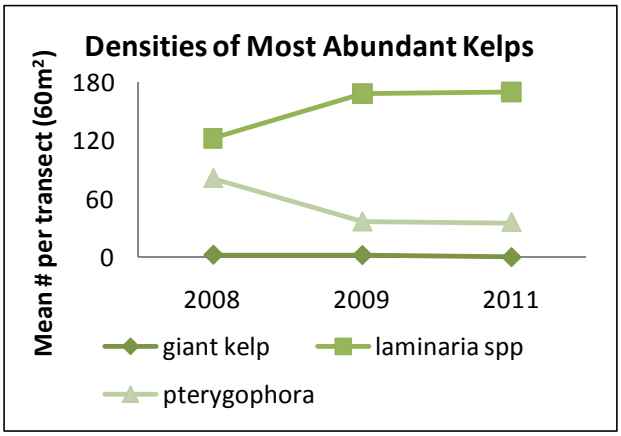
Indicator Species Observed: 20 of 35 fishes surveyed, 14 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

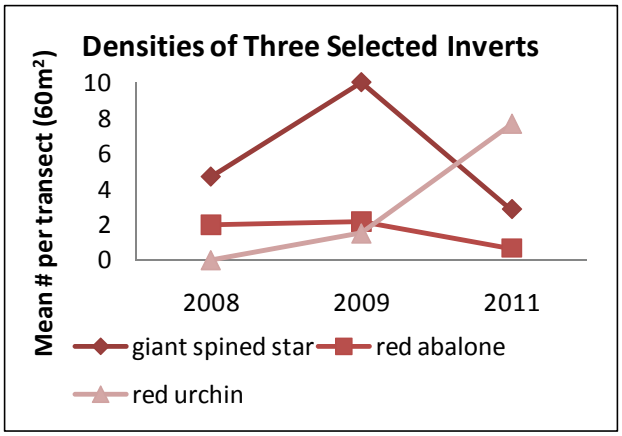
Invasive Algae: None











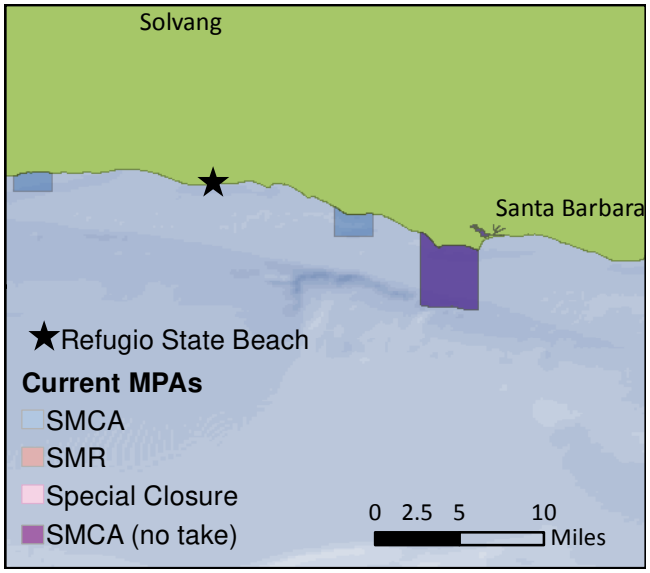
Reef Check California 2006-2011

Refugio State Beach

County: Santa Barbara

Marine Protected Area: None
(SMCA since 1998, MPA removed 1/1/12)

Restrictions: None

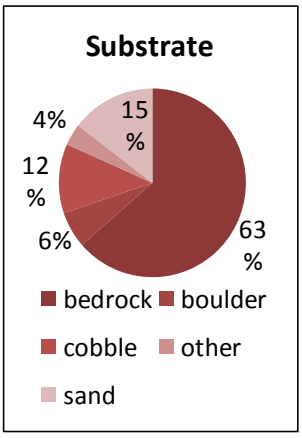


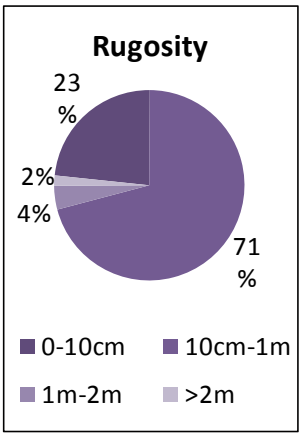
Survey history: 6/3/2006 9/8/2007 9/28/2008 5/31/2009 10/31/2009 6/13/2010 12/12/2010 7/16/2011

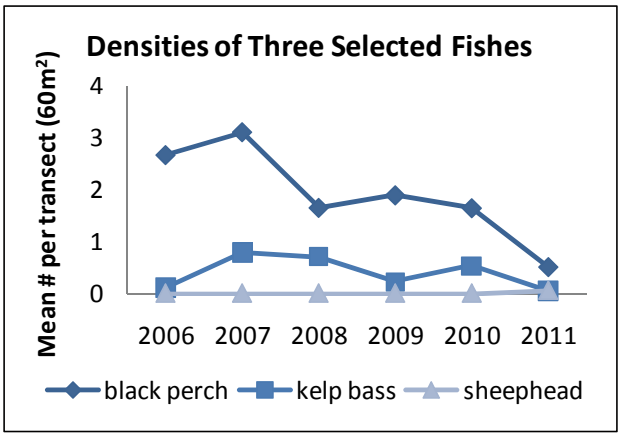
Survey Depths (ft): 9 - 24

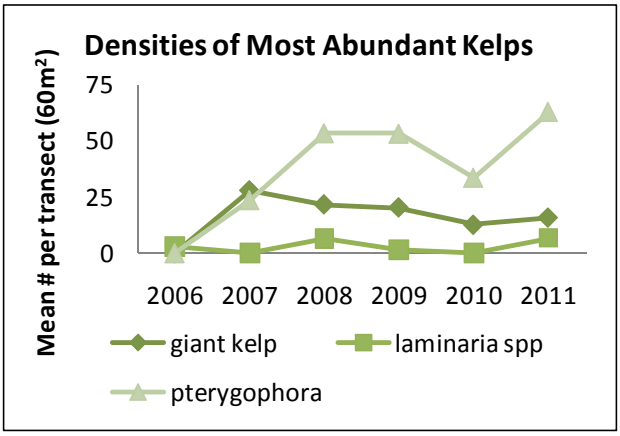
Indicator Species Observed: 20 of 35 fishes surveyed, 18 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

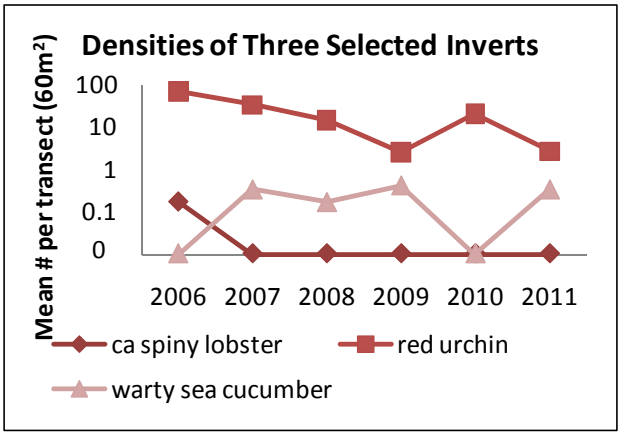
Invasive Algae: *Sargassum muticum, S. filicinum*











Reef Check California 2006-2011

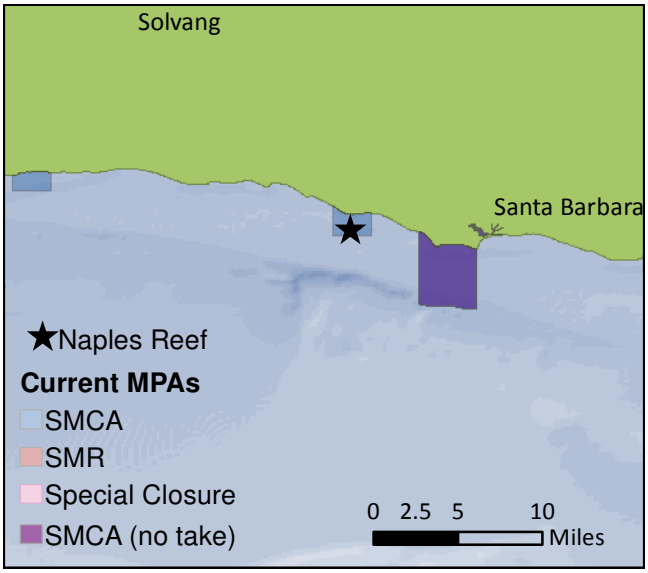
Naples Reef

County: Santa Barbara

Marine Protected Area: Naples SMCA (since 1/1/12)

Restrictions: All take prohibited except recreational take of pelagic finfish and commercial take of giant kelp by hand

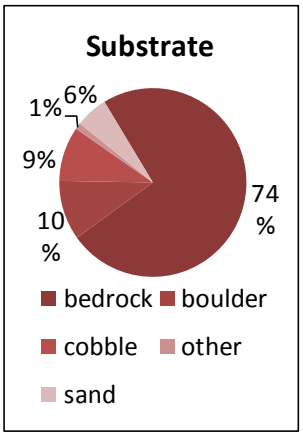
Survey history: 11/12/2007 10/18/2008 5/23/2009 7/18/2010

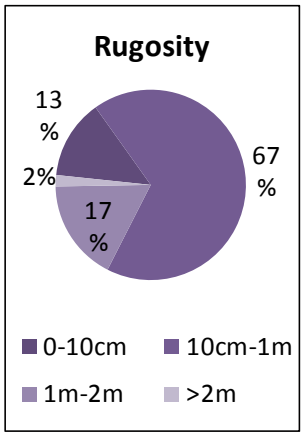


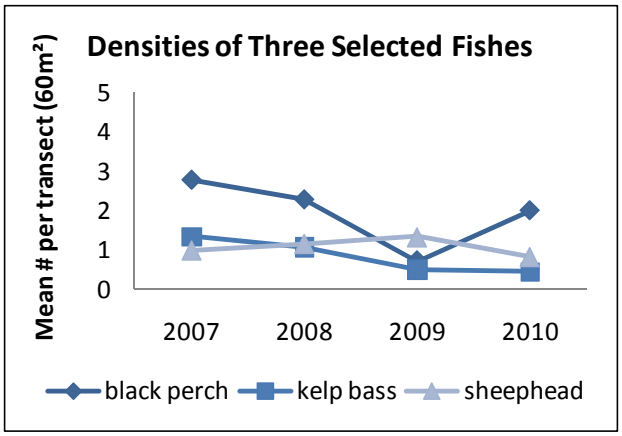
Survey Depths (ft): 21 - 57

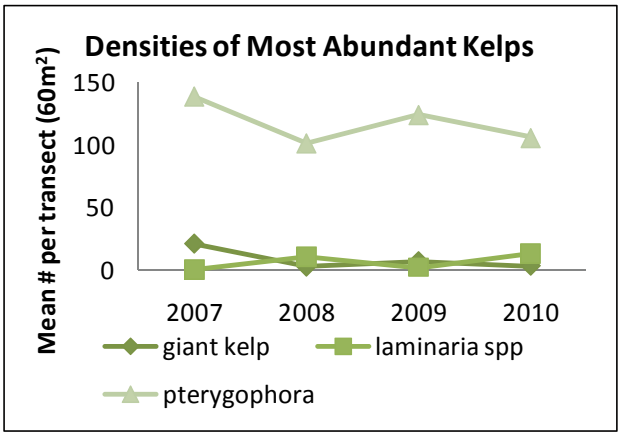
Indicator Species Observed: 28 of 35 fishes surveyed, 20 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

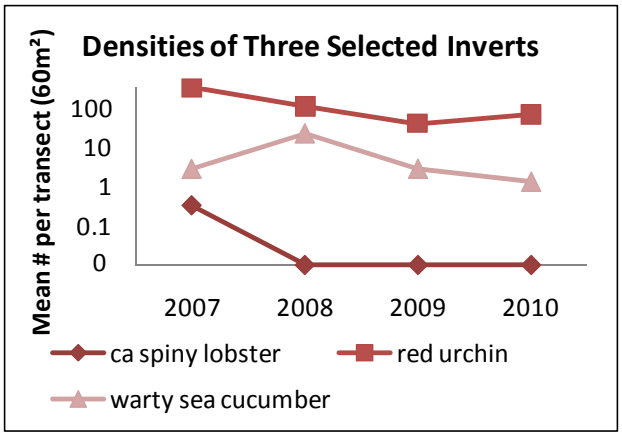
Invasive Algae: None











Reef Check California 2006-2011

IV Reef

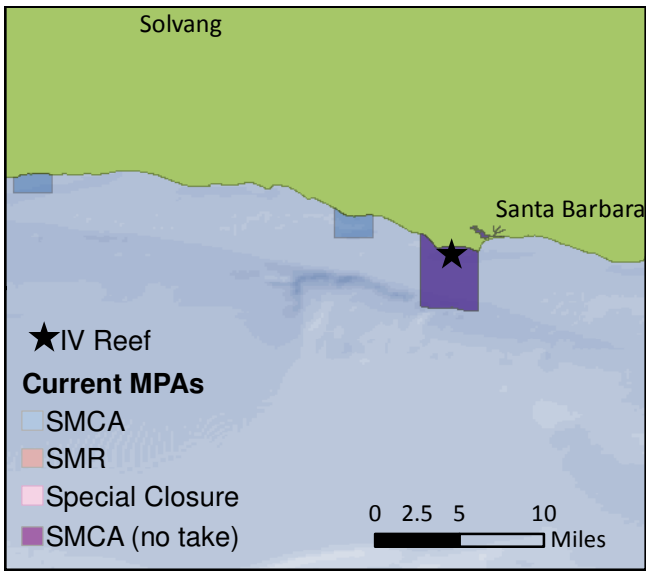
County: Santa Barbara

Marine Protected Area: Campus Point SMCA (since 1/1/12)

Restrictions: Take of all living marine resources is prohibited.

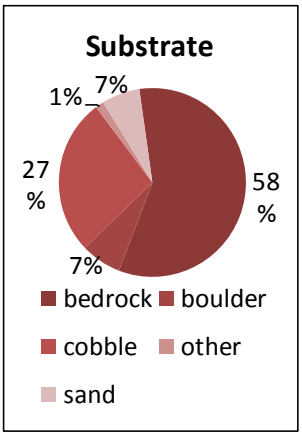
Survey history: 10/23/2006 5/28/2007 10/19/2008 5/24/2009 7/18/2010

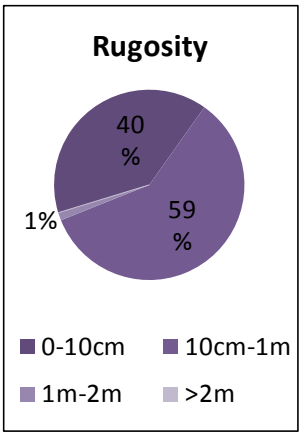
Survey Depths (ft): 18 - 45

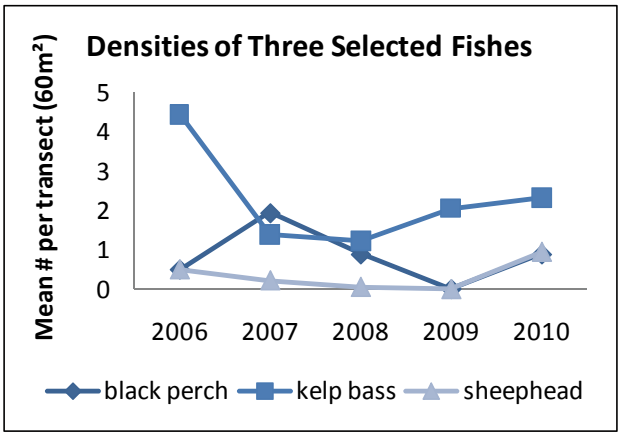


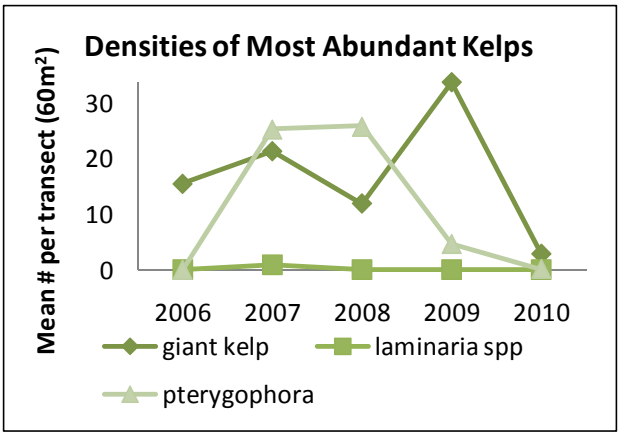
Indicator Species Observed: 25 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

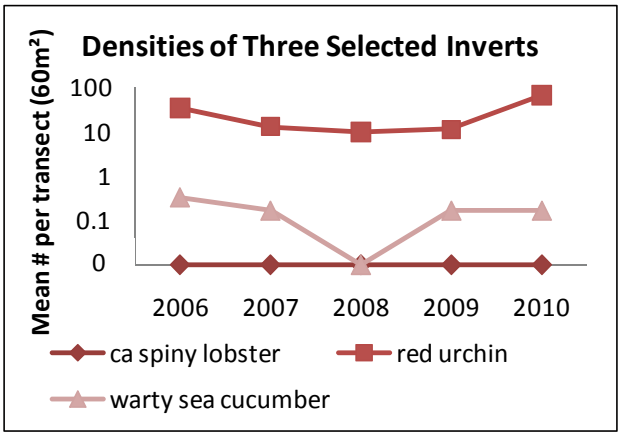
Invasive Algae: None











Reef Check California 2006-2011

Cueva Valdez

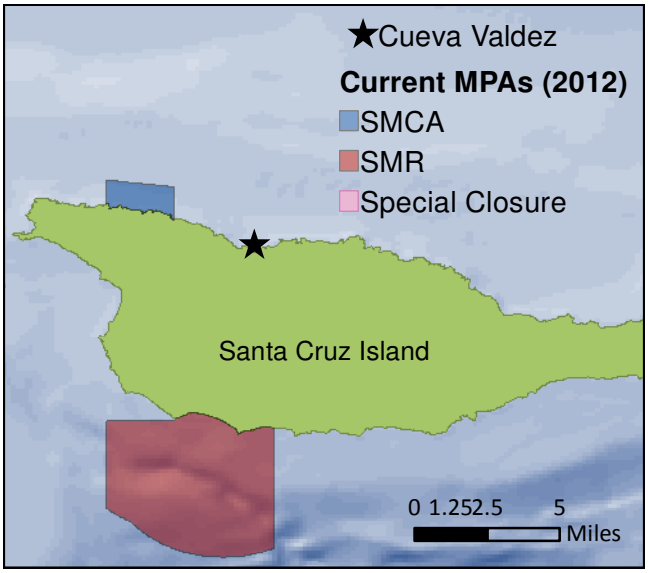
County: Santa Barbara

Marine Protected Area: None

Restrictions: None

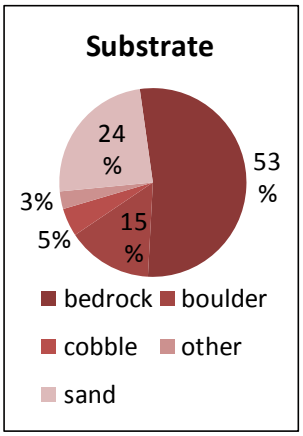
Survey history: 5/4/2008 10/29/2008 9/23/2009 11/19/2010 10/11/2011

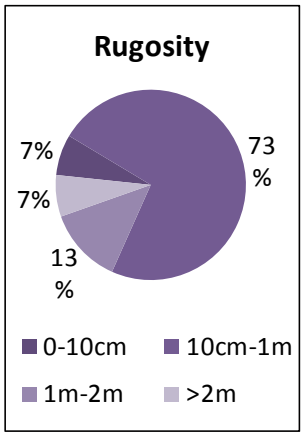
Survey Depths (ft): 12 - 51

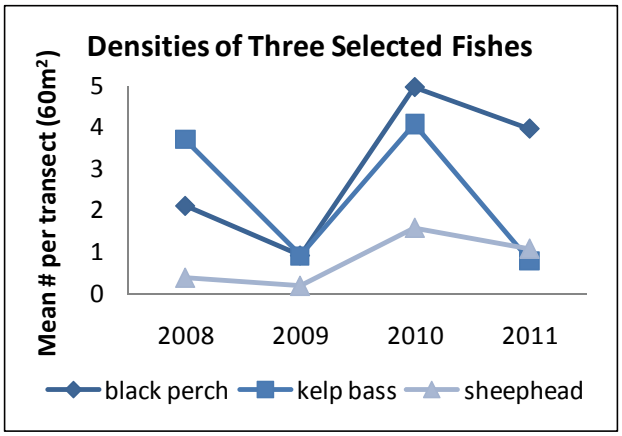


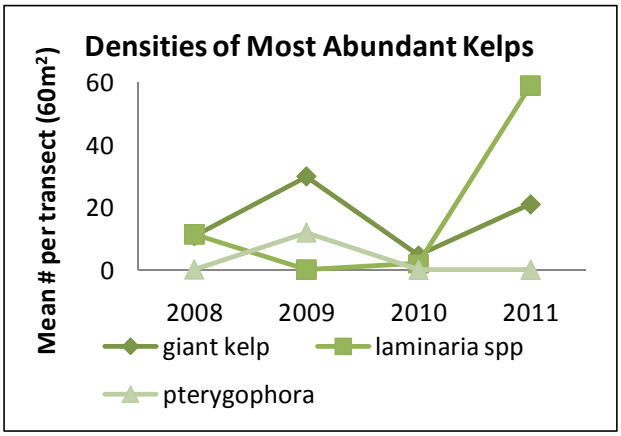
Indicator Species Observed: 28 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

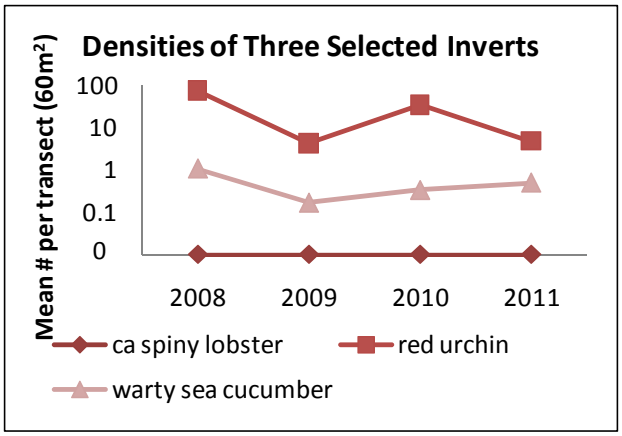
Invasive Algae: *Sargassum muticum*











Reef Check California 2006-2011

Fry's Anchorage

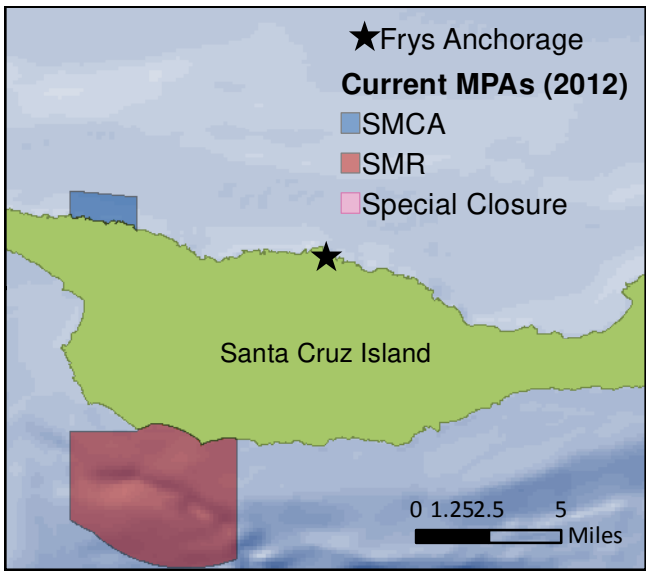
County: Santa Barbara

Marine Protected Area: None

Restrictions: None

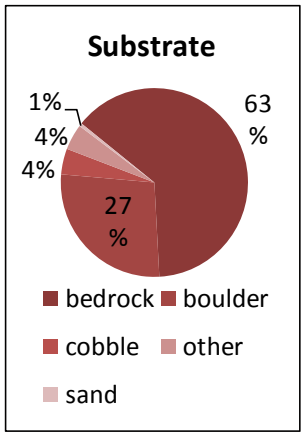
Survey history: 5/23/2010 8/17/2011

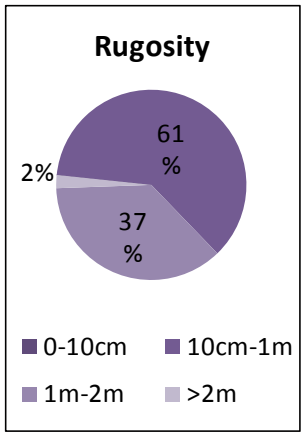
Survey Depths (ft): 18 - 54

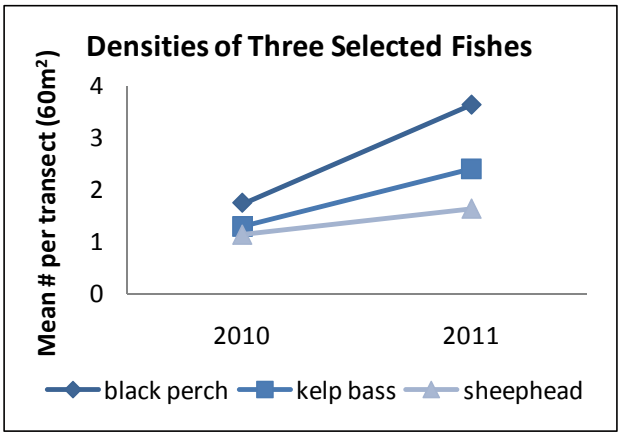


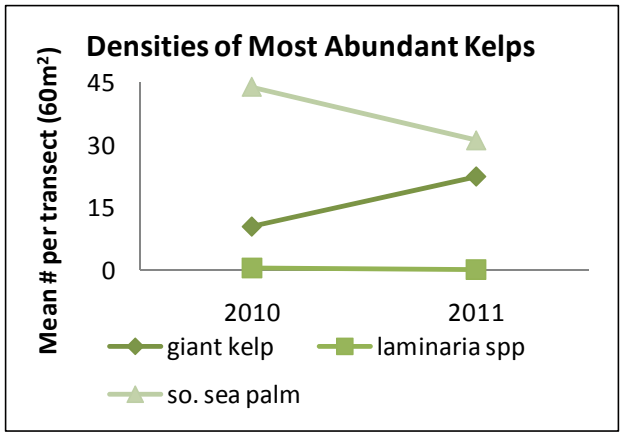
Indicator Species Observed: 25 of 35 fishes surveyed, 12 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

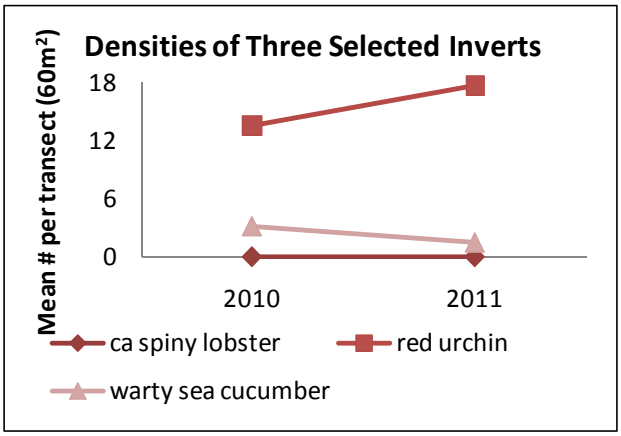
Invasive Algae: None











Reef Check California 2006-2011

Scorpion Anchorage

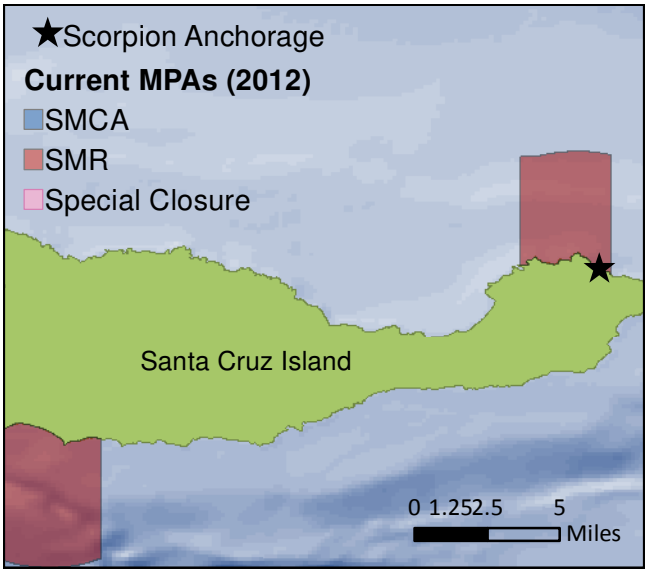
County: Santa Barbara

Marine Protected Area: Scorpion SMR (since 2003)

Restrictions: Take of all living marine resources is prohibited.

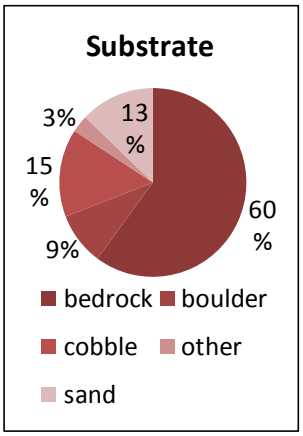
Survey history: 10/29/2008 9/26/2009 11/17/2010 11/1/2011

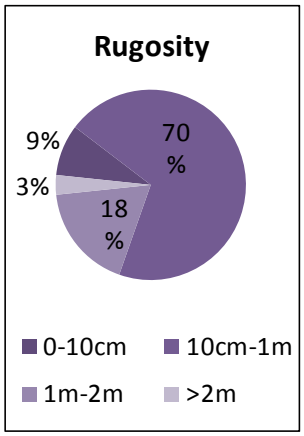
Survey Depths (ft): 16 - 56

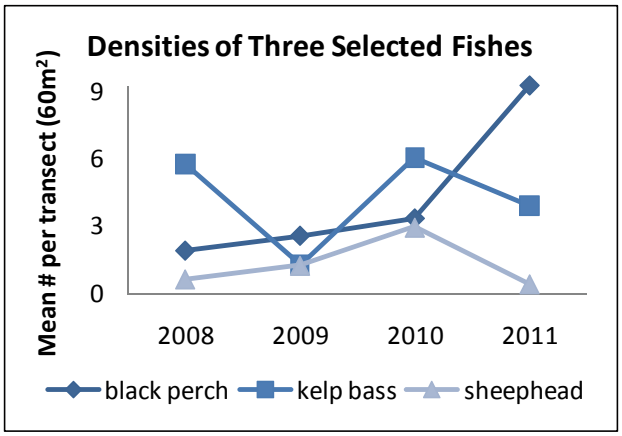


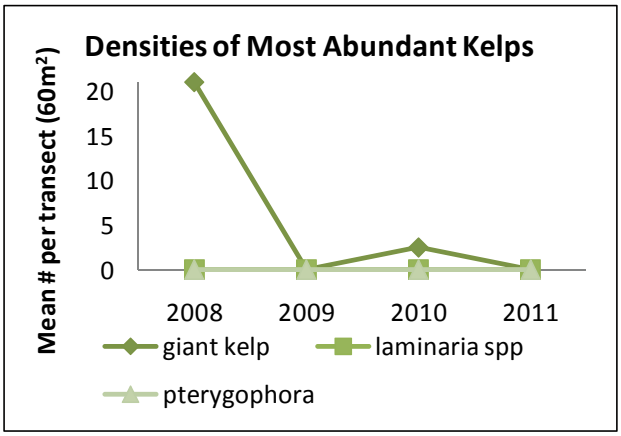
Indicator Species Observed: 29 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 1 of 5 seaweeds surveyed

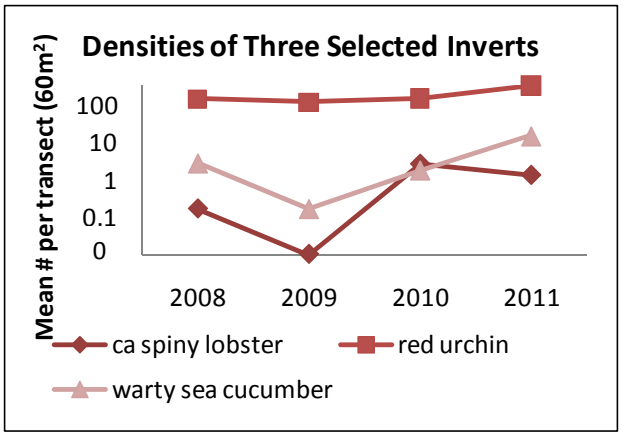
Invasive Algae: *Sargassum muticum*











Reef Check California 2006-2011

Leo Carrillo North

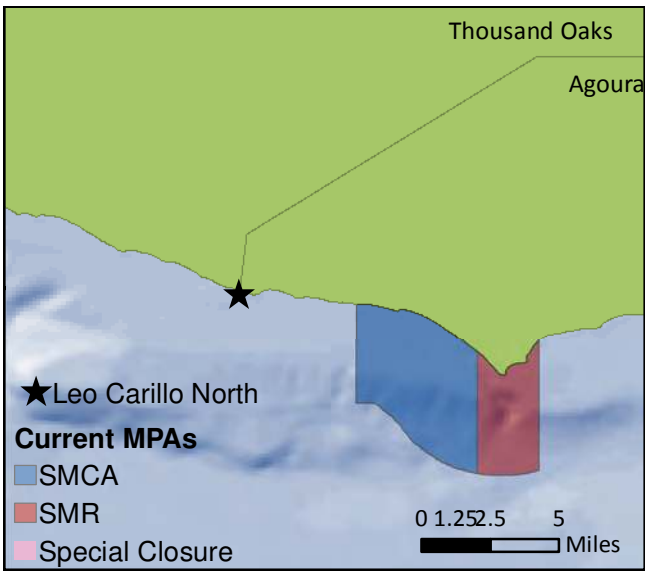
County: Los Angeles

Marine Protected Area: None

Restrictions: None

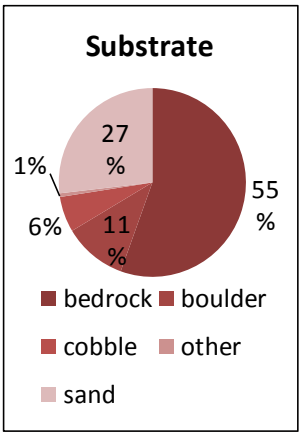
Survey history: 11/5/2006 3/31/2007 10/12/2007 9/6/2008 9/12/2009 9/11/2010

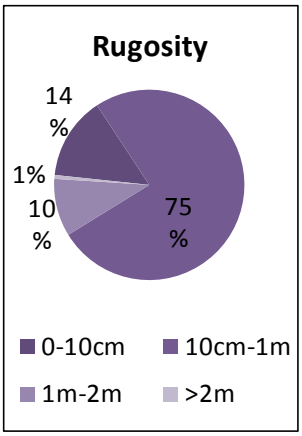
Survey Depths (ft): 13 - 35

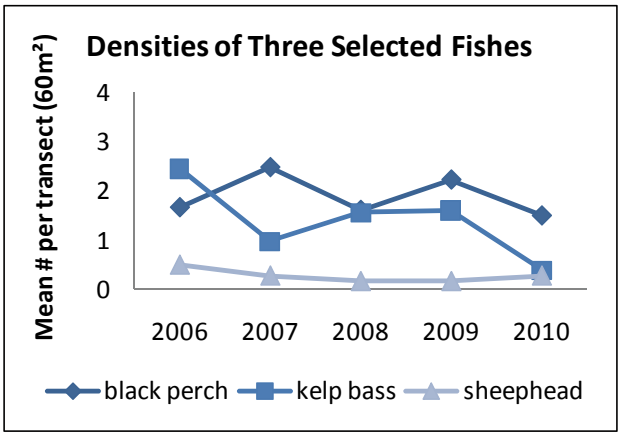


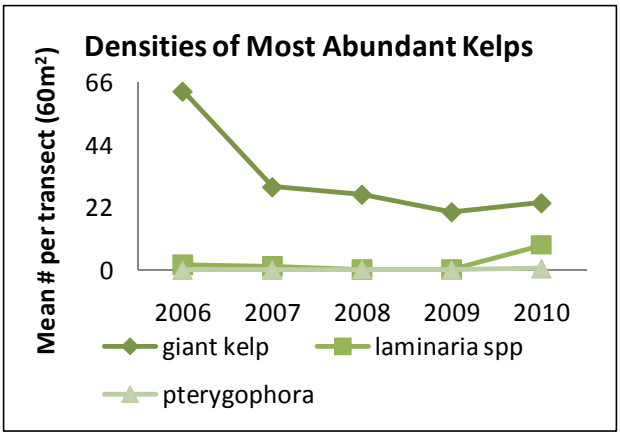
Indicator Species Observed: 25 of 35 fishes surveyed, 18 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

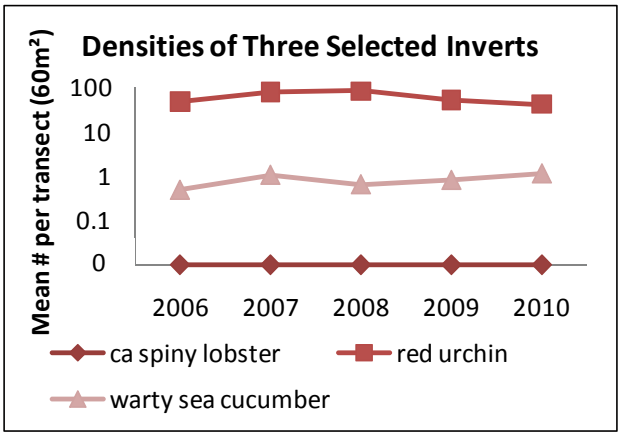
Invasive Algae: *Sargassum muticum*





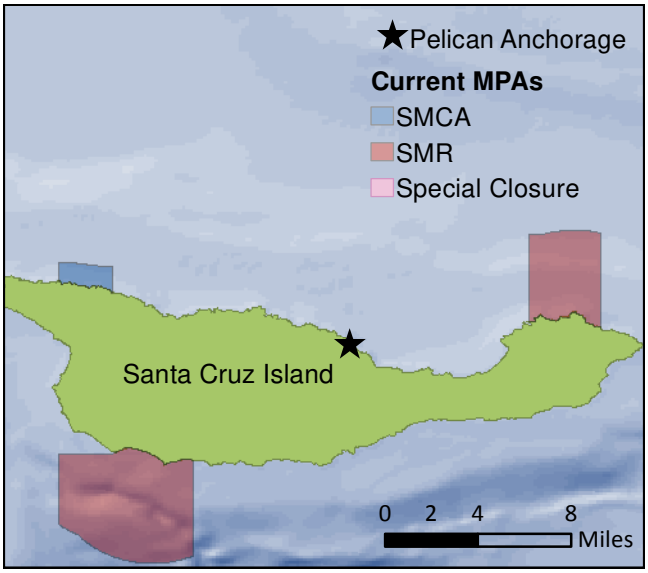






Reef Check California 2006-2011

Pelican Anchorage



County: Santa Barbara

Marine Protected Area: None

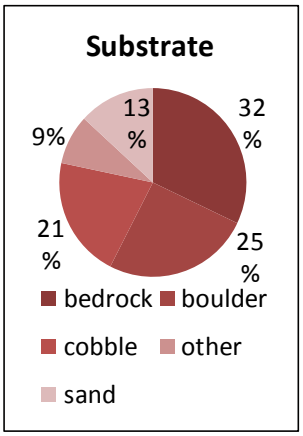
Restrictions: None

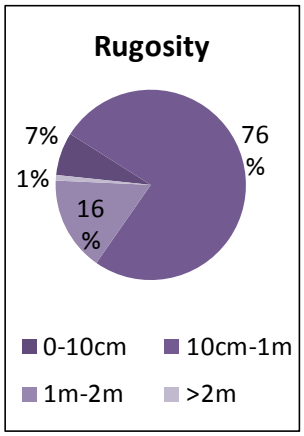
Survey history: 4/30/2006 4/15/2007 7/16/2008 9/26/2009 5/22/2010 11/19/2010 5/22/2011 11/1/2011

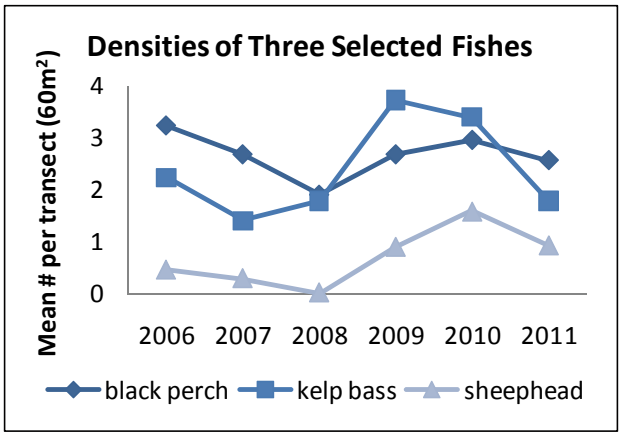
Survey Depths (ft): 10 - 50

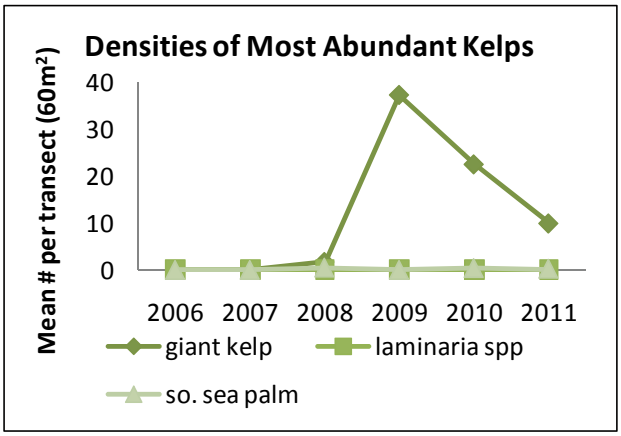
Indicator Species Observed: 32 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

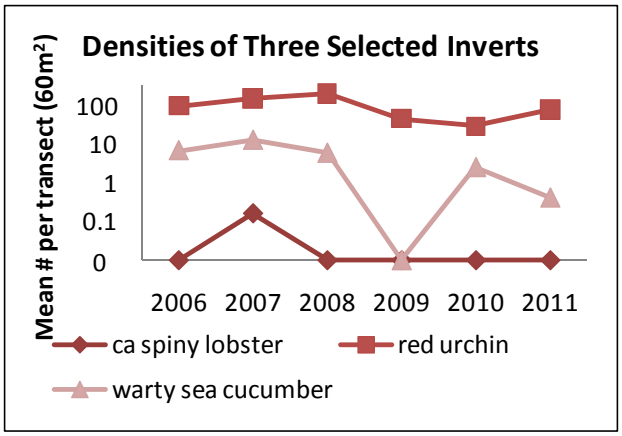
Invasive Algae: *Sargassum muticum*











Reef Check California 2006-2011

Big Rock

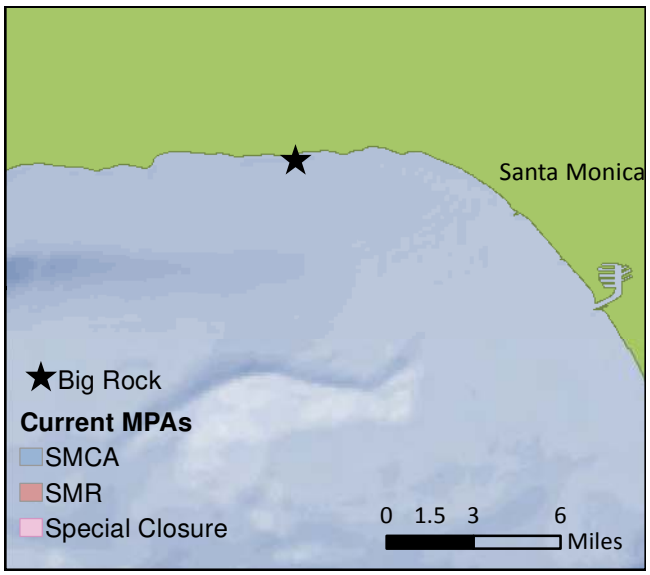
County: Los Angeles

Marine Protected Area: None

Restrictions: None

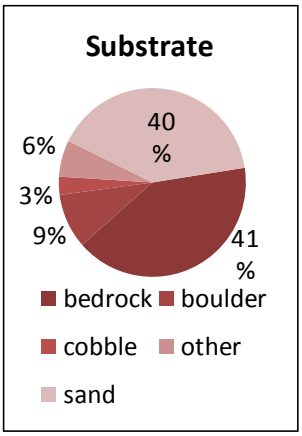
Survey history: 10/7/2007 10/10/2009 10/9/2010

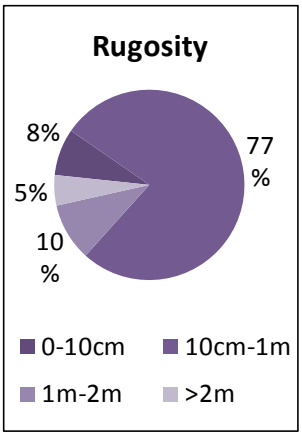
Survey Depths (ft): 18 - 35

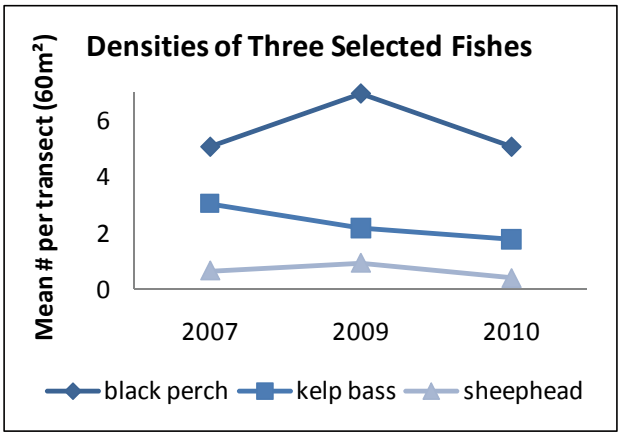


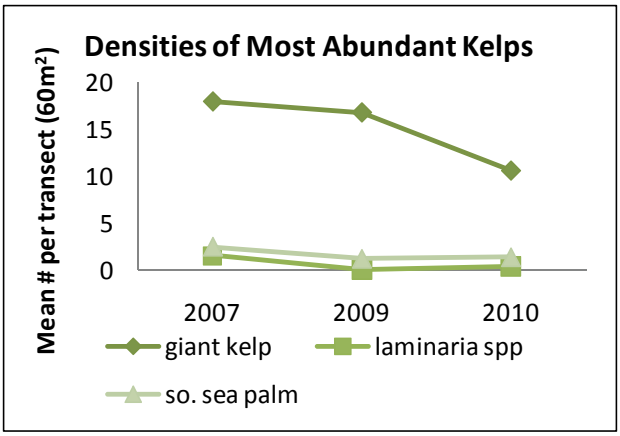
Indicator Species Observed: 22 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

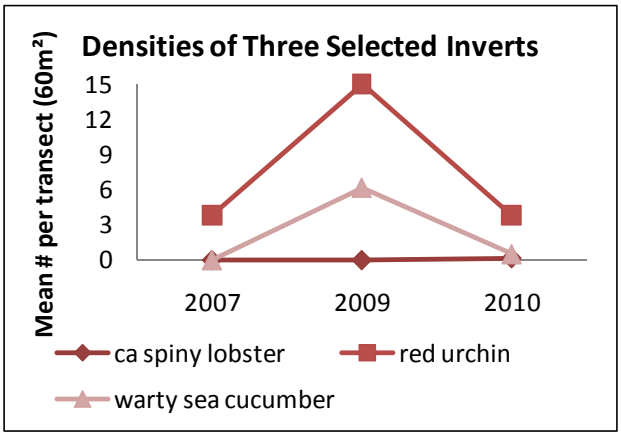
Invasive Algae: None





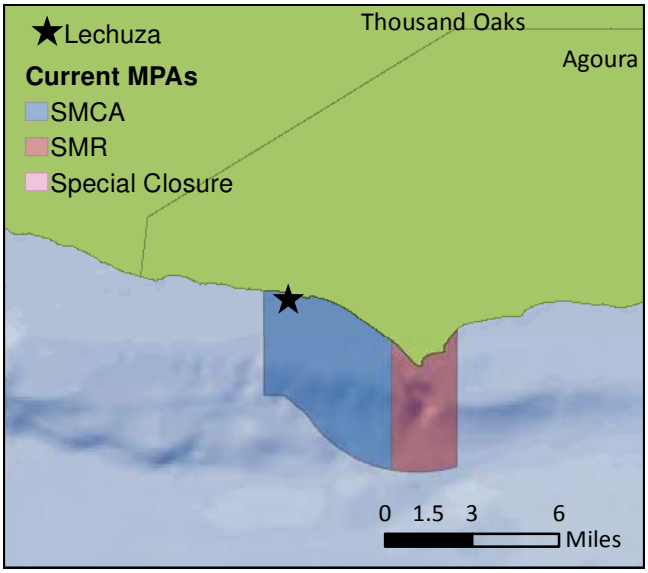






Reef Check California 2006-2011

Lechuza



County: Los Angeles

Marine Protected Area: Point Dume SMCA (since 1/1/12)

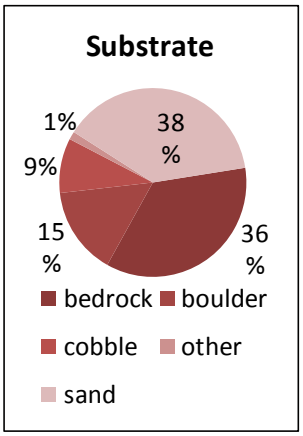
Restrictions: Take of marine resources prohibited except, pelagic finfish (rec and some com), and beach nourishment take

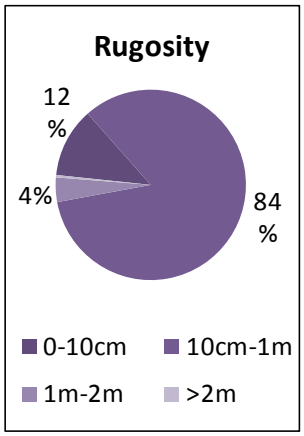
Survey history: 10/12/2007 9/6/2008 9/12/2009 9/11/2010

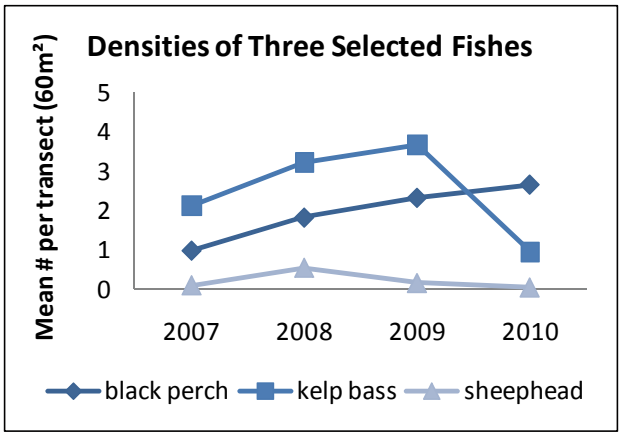
Survey Depths (ft): 15 - 36

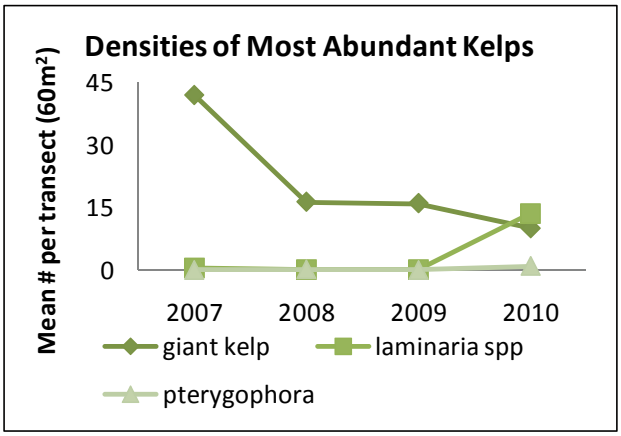
Indicator Species Observed: 23 of 35 fishes surveyed, 19 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

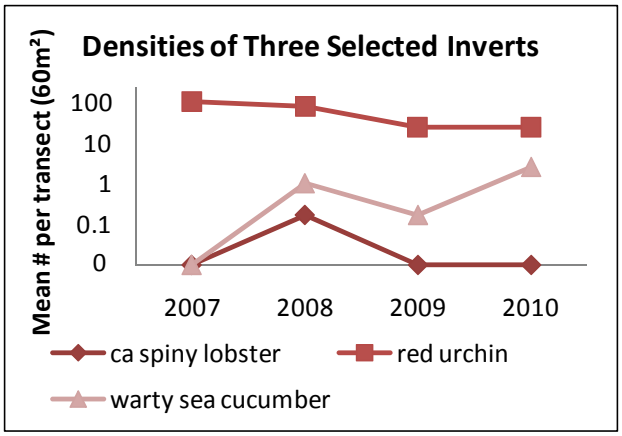
Invasive Algae: None





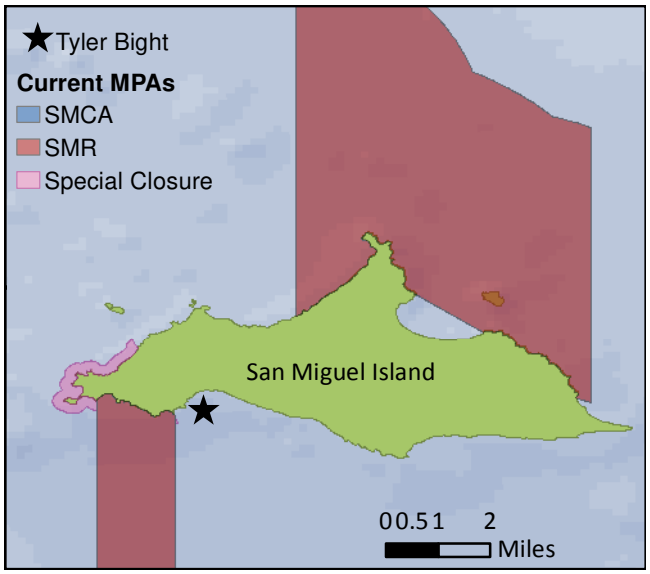






Reef Check California 2006-2011

Tyler Bight



County: Santa Barbara

Marine Protected Area: None

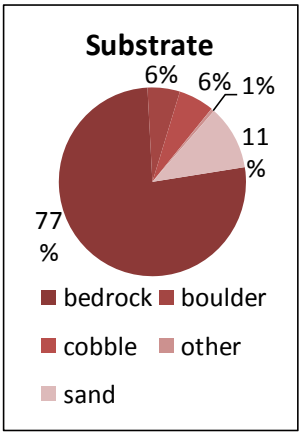
Restrictions: None

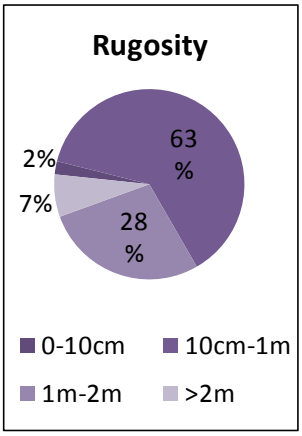
Survey history: 9/11/2007

Survey Depths (ft): 19 - 39

Indicator Species Observed: 16 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

Invasive Algae: *Sargassum muticum*





One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

Reef Check California 2006-2011

Judith Reserve

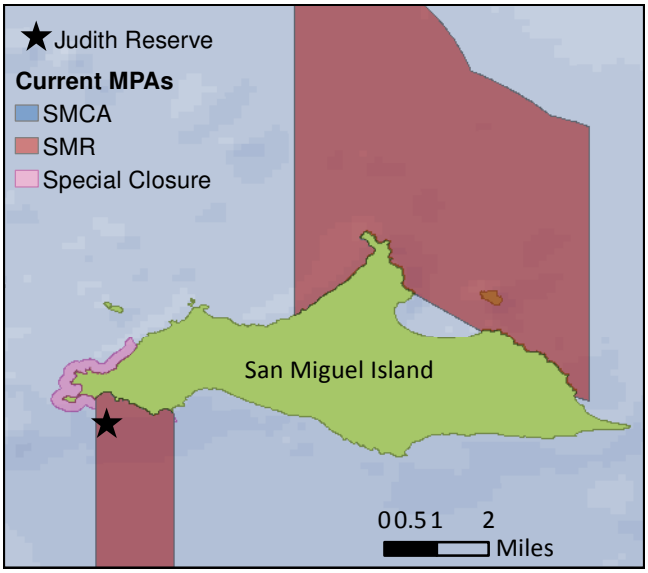
County: Santa Barbara

Marine Protected Area: Judith Rock SMR (since 2003)

Restrictions: Take of all living marine resources is prohibited.

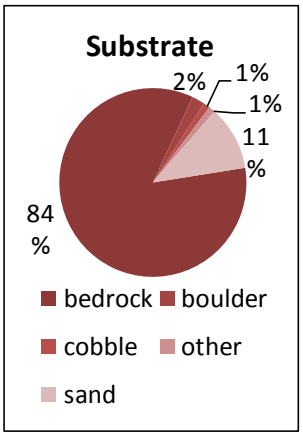
Survey history: 9/13/2007

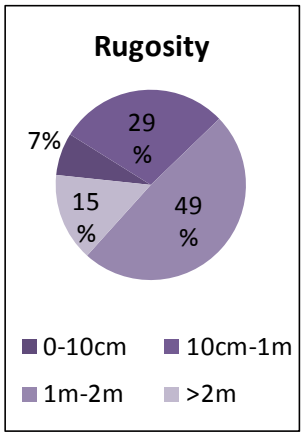
Survey Depths (ft): 25 - 43



Indicator Species Observed: 17 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

Invasive Algae: None





One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

Reef Check California 2006-2011

Landing Cove

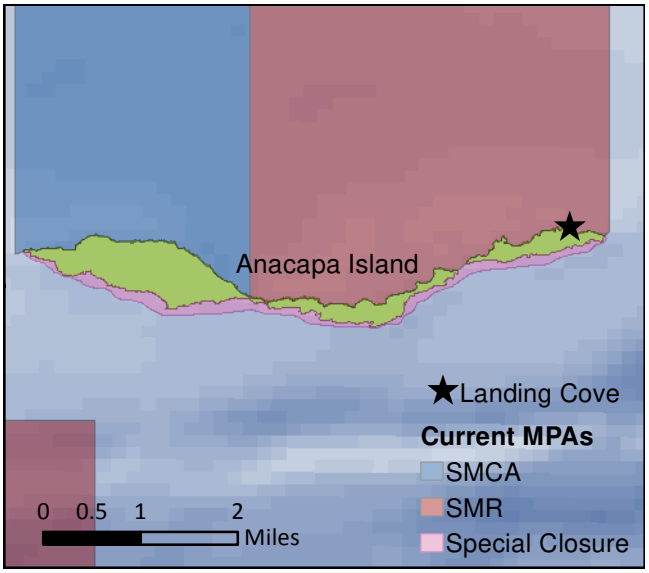
County: Ventura

Marine Protected Area: Anacapa Island SMR (since 2003)

Restrictions: Take of all living marine resources is prohibited.

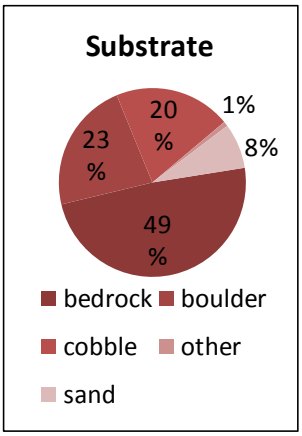
Survey history: 10/18/2009 4/18/2010

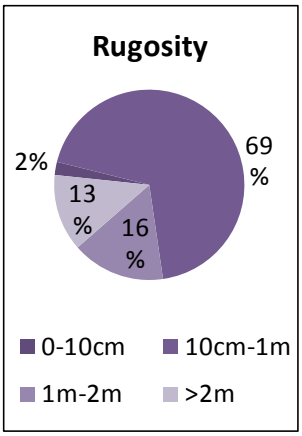
Survey Depths (ft): 13 - 49

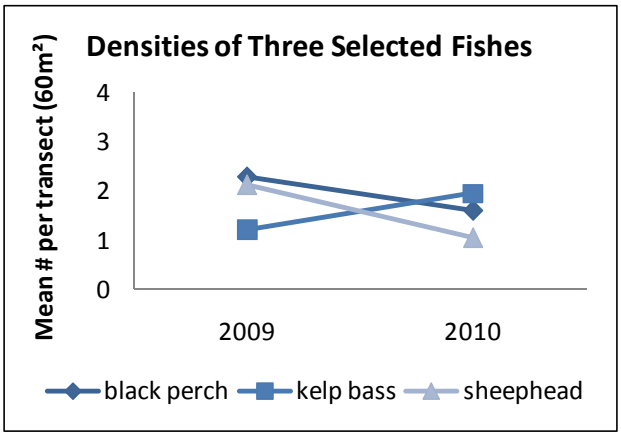


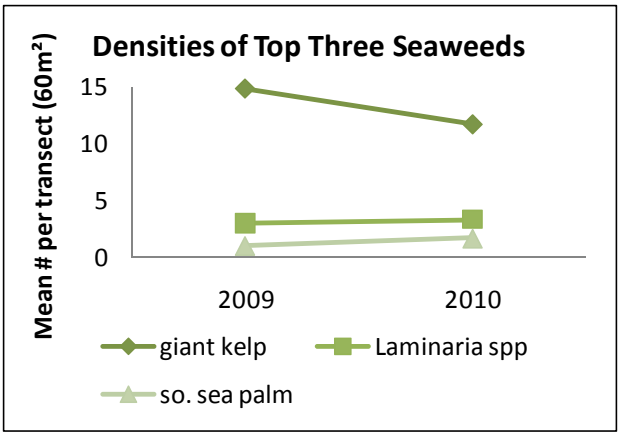
Indicator Species Observed: 26 of 35 fishes surveyed, 12 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

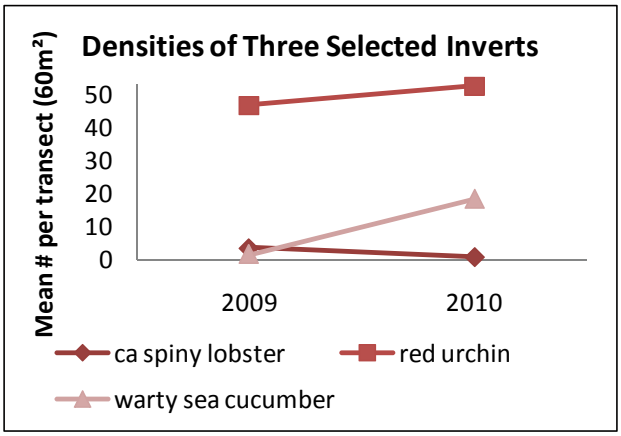
Invasive Algae: None











Reef Check California 2006-2011

Cathedral Cove

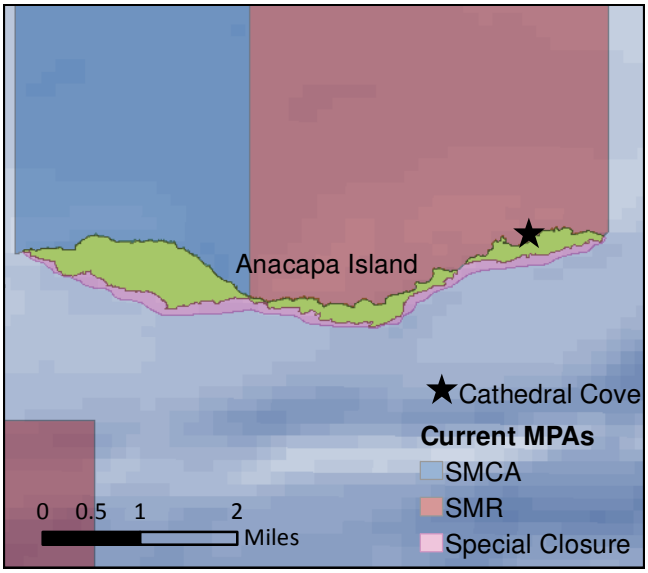
County: Ventura

Marine Protected Area: Anacapa Island SMR (since 2003)

Restrictions: Take of all living marine resources is prohibited.

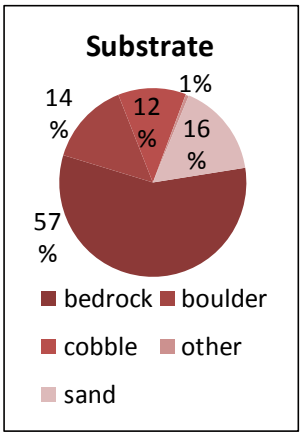
Survey history: 6/23/2006 10/23/2008 9/24/2009 11/18/2010 11/16/2011

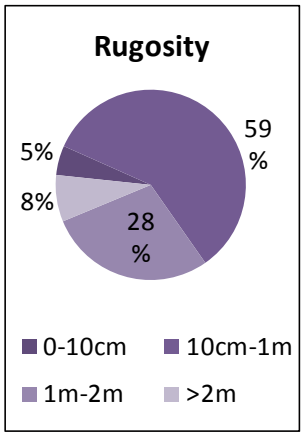
Survey Depths (ft): 10 - 39

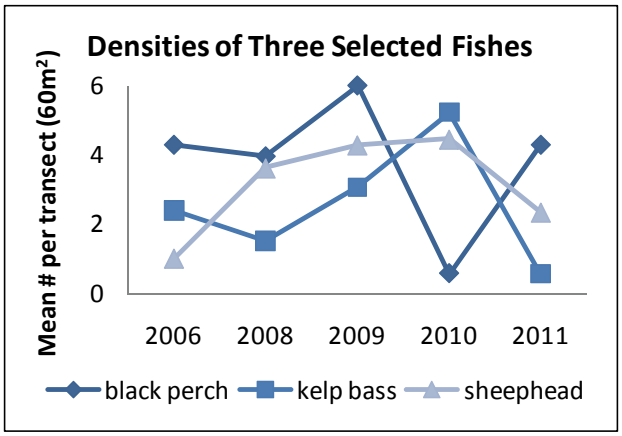


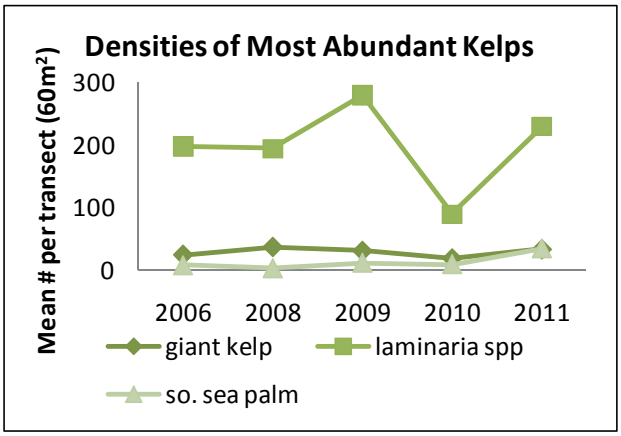
Indicator Species Observed: 24 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

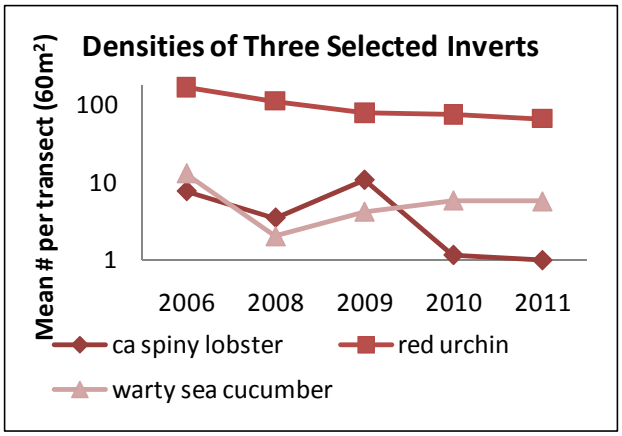
Invasive Algae: *Sargassum muticum, S. filicinum*





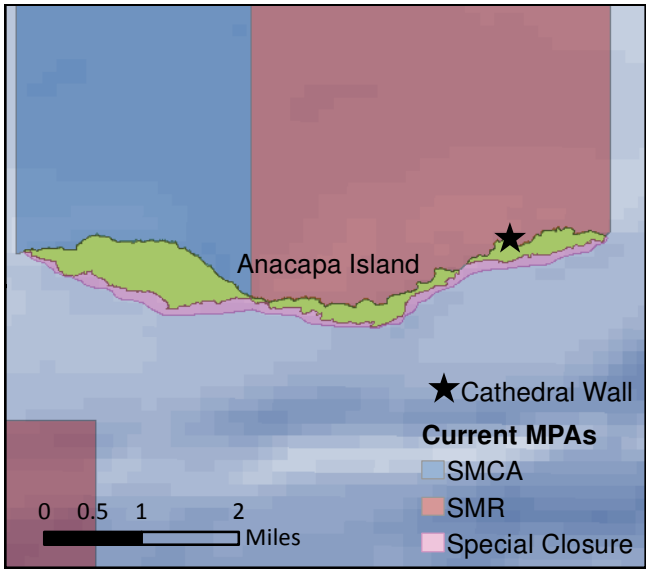






Reef Check California 2006-2011

Cathedral Wall



County: Ventura

Marine Protected Area: Anacapa Island SMR (since 2003)

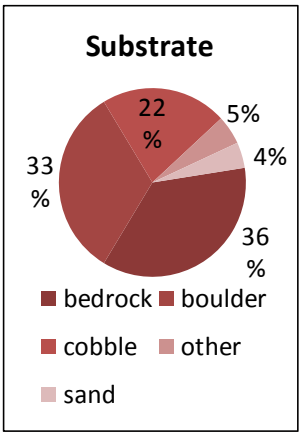
Restrictions: Take of all living marine resources is prohibited.

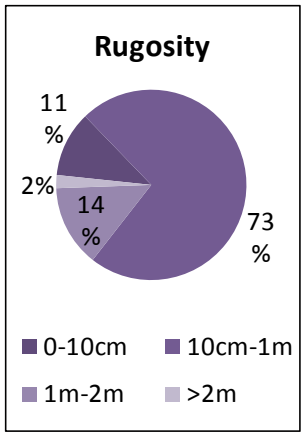
Survey history: 10/17/2009 11/3/2011

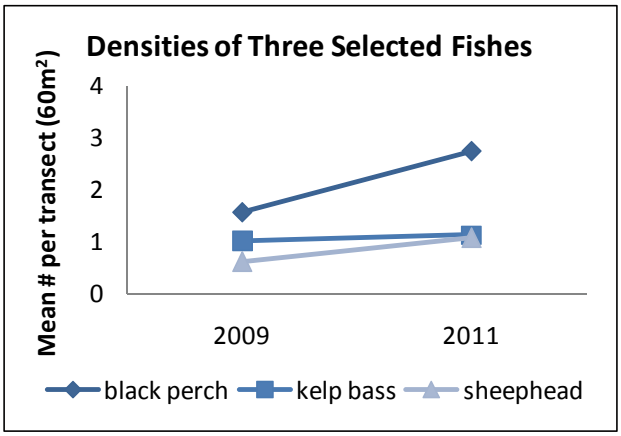
Survey Depths (ft): 6 - 32

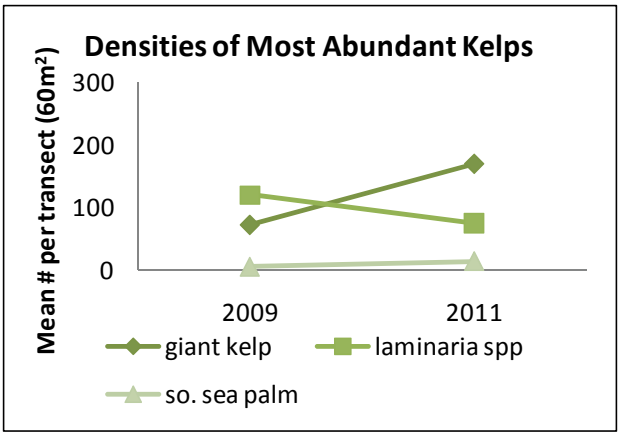
Indicator Species Observed: 18 of 35 fishes surveyed, 11 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

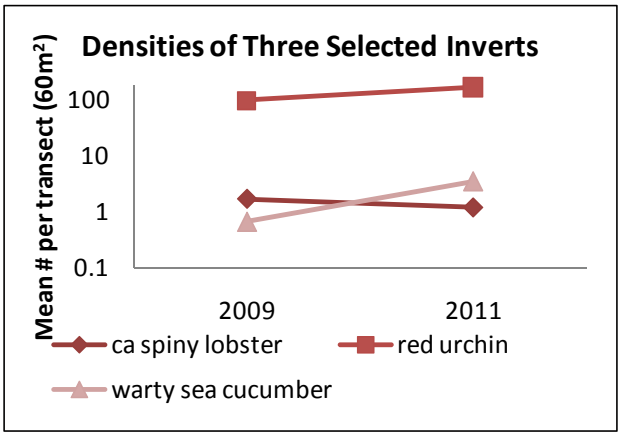
Invasive Algae: None





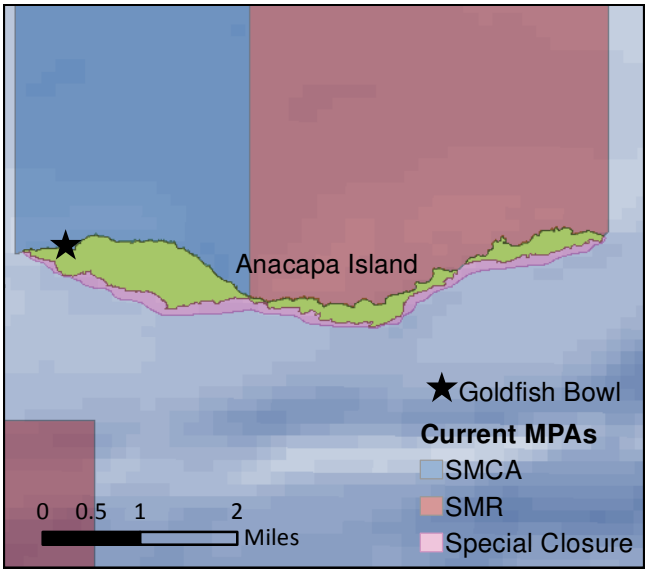






Reef Check California 2006-2011

Goldfish Bowl



County: Ventura

Marine Protected Area: Anacapa Island SMCA (since 2003)

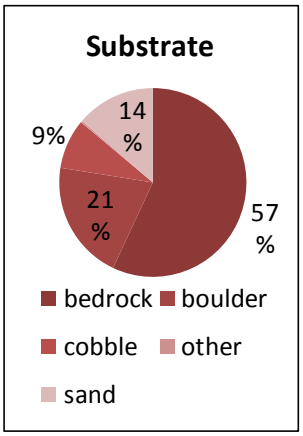
Restrictions: Take of all marine resources prohibited EXCEPT lobster and rec pelagic finfish

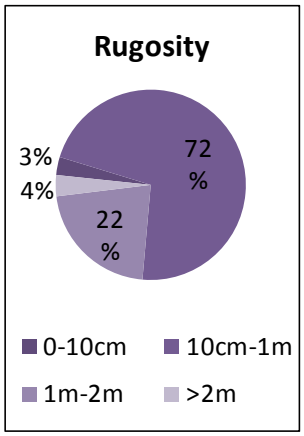
Survey history: 10/17/2009 11/18/2010 8/18/2011

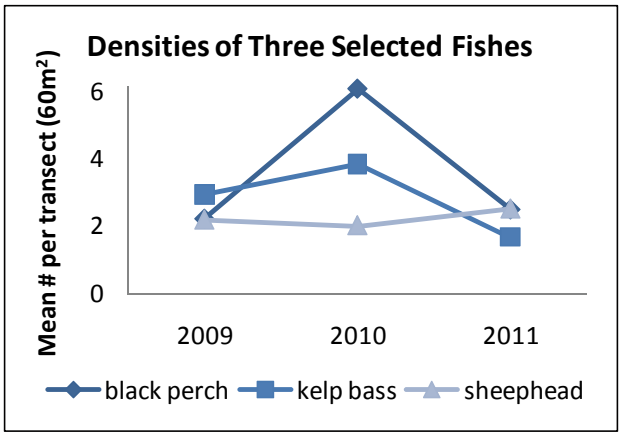
Survey Depths (ft): 10 - 40

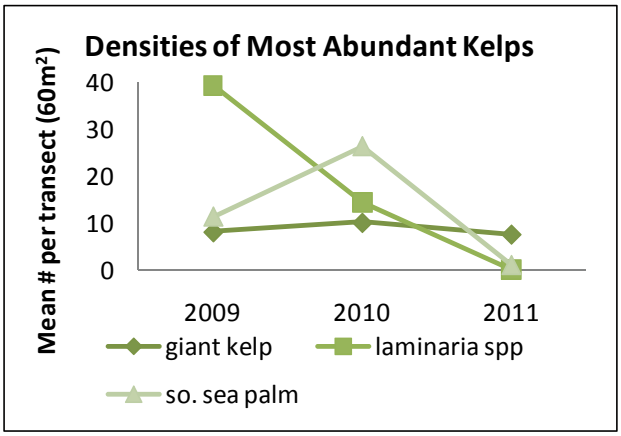
Indicator Species Observed: 25 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

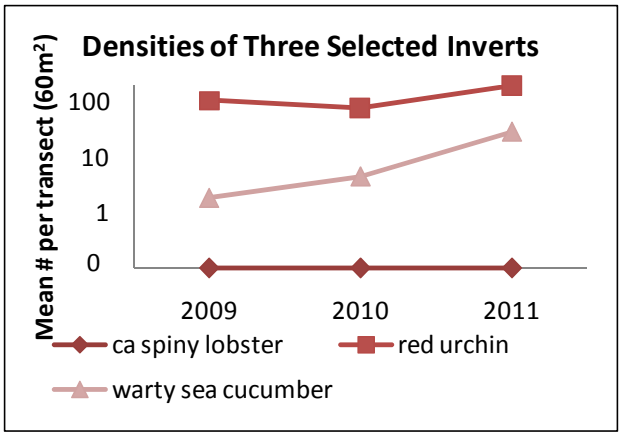
Invasive Algae: *Sargassum muticum*











Reef Check California 2006-2011

Lighthouse

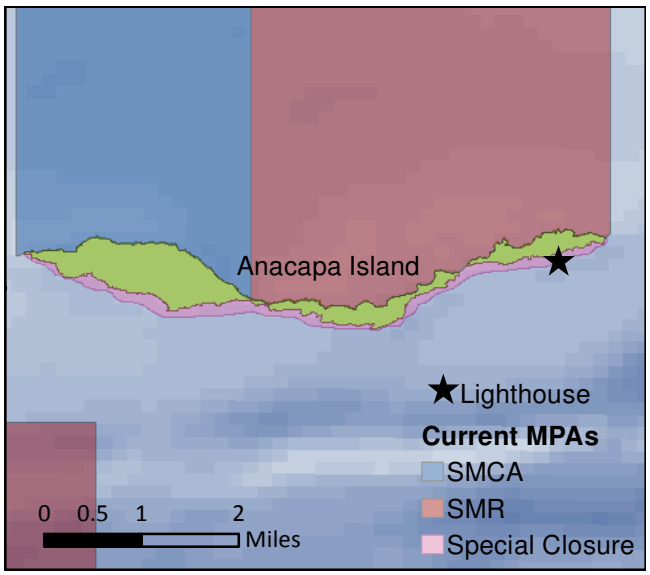
County: Ventura

Marine Protected Area: None

Restrictions: None

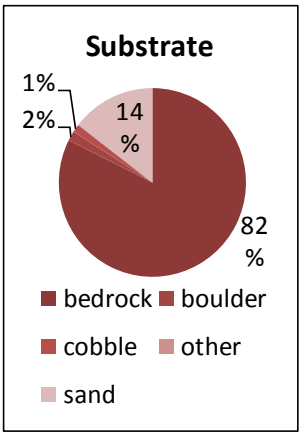
Survey history: 11/5/2008 10/8/2009 11/16/2011

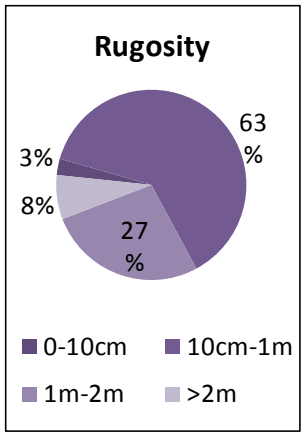
Survey Depths (ft): 7 - 33

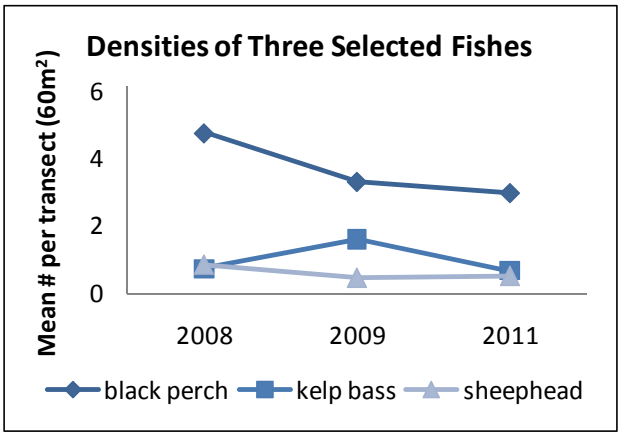


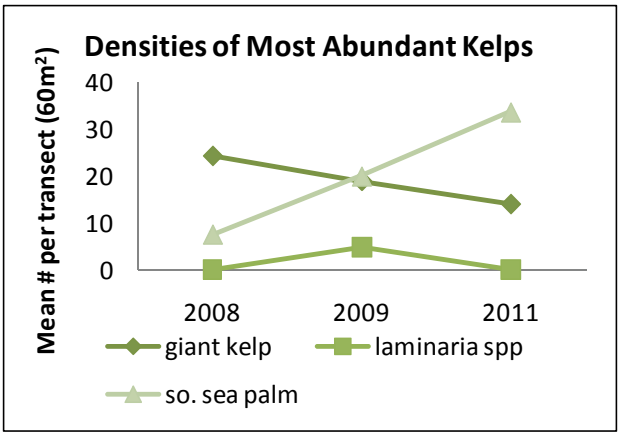
Indicator Species Observed: 24 of 35 fishes surveyed, 14 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

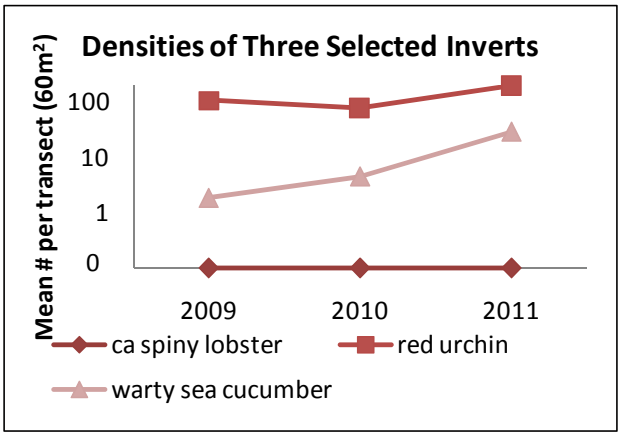
Invasive Algae: None





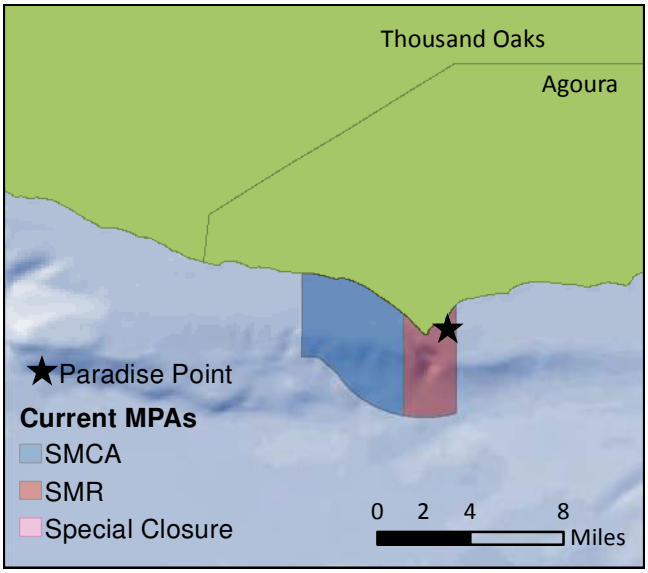






Reef Check California 2006-2011

Paradise Point



County: Los Angeles

Marine Protected Area: Point Dume SMR (since 1/1/12)

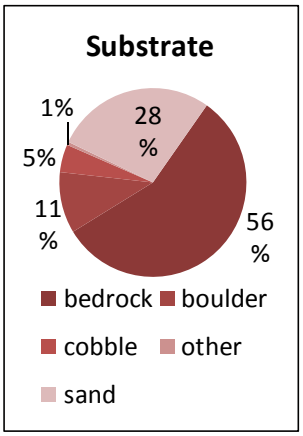
Restrictions: Take of all living marine resources is prohibited.

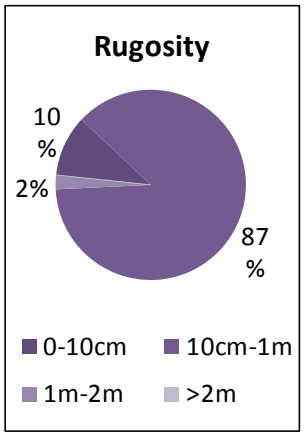
Survey history: 9/6/2008 9/12/2009 9/11/2010

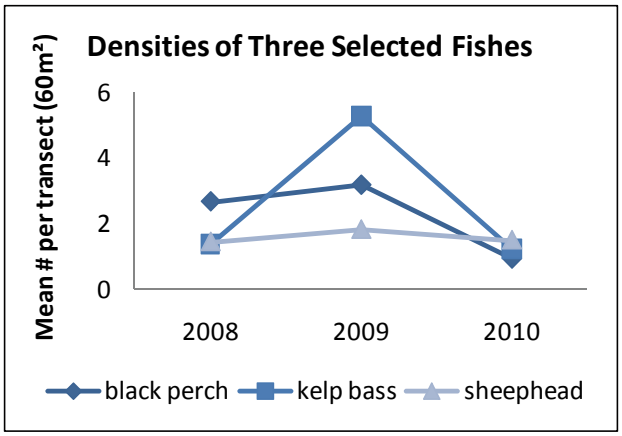
Survey Depths (ft): 18 - 34

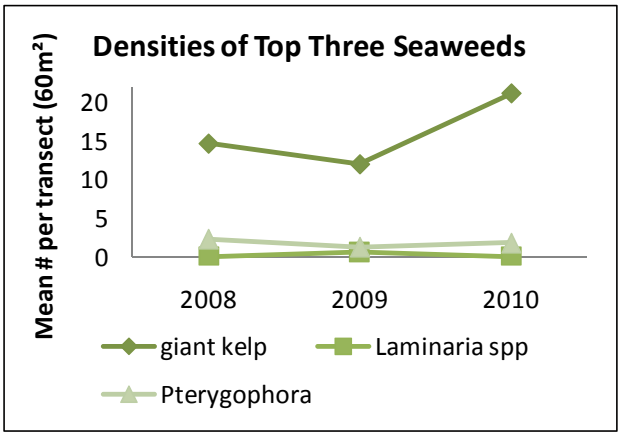
Indicator Species Observed: 23 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

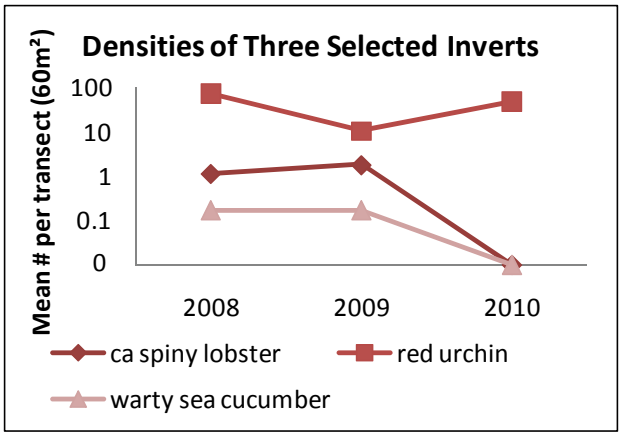
Invasive Algae: None











Reef Check California 2006-2011

Yellowbanks

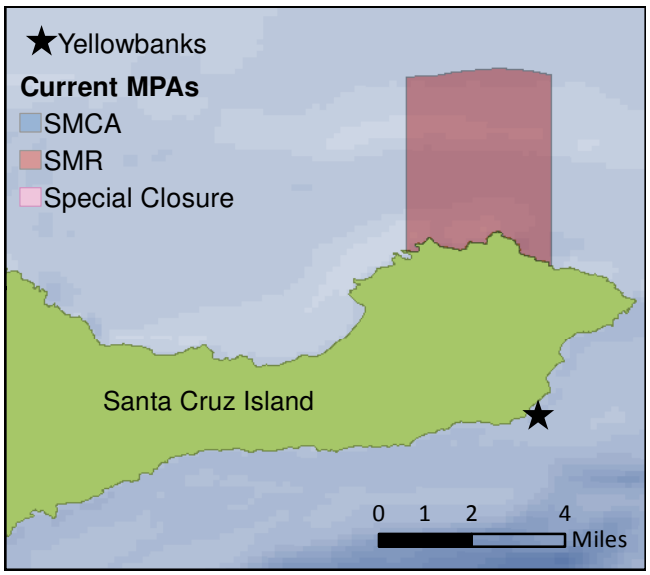
County: Santa Barbara

Marine Protected Area: None

Restrictions: None

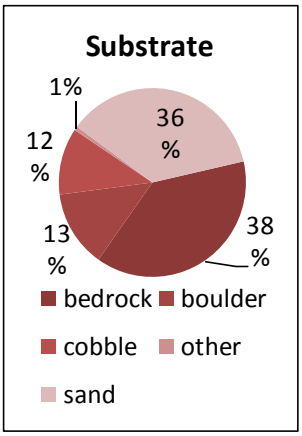
Survey history: 11/4/2008 4/19/2009 10/29/2009 11/17/2010 9/8/2011

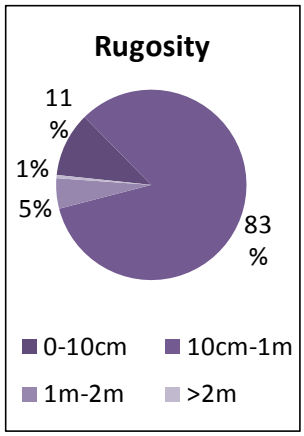
Survey Depths (ft): 16 - 29

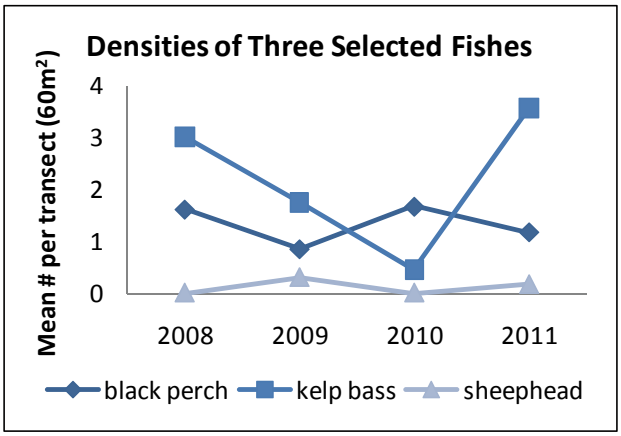


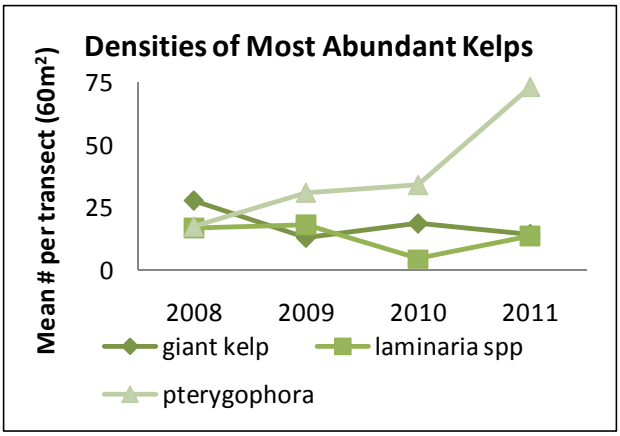
Indicator Species Observed: 17 of 35 fishes surveyed, 14 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

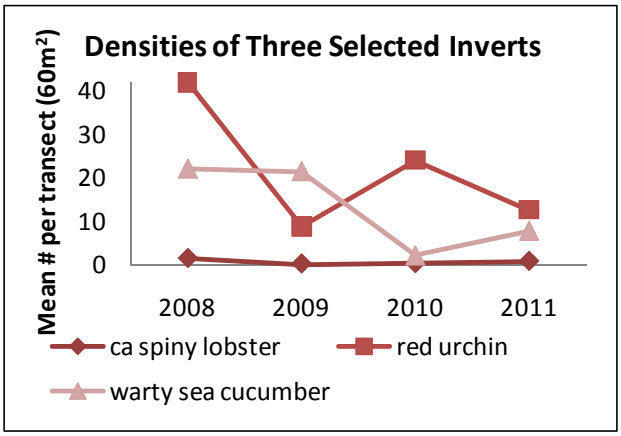
Invasive Algae: *Sargassum filicinum*











Reef Check California 2006-2011

Sandstone Point

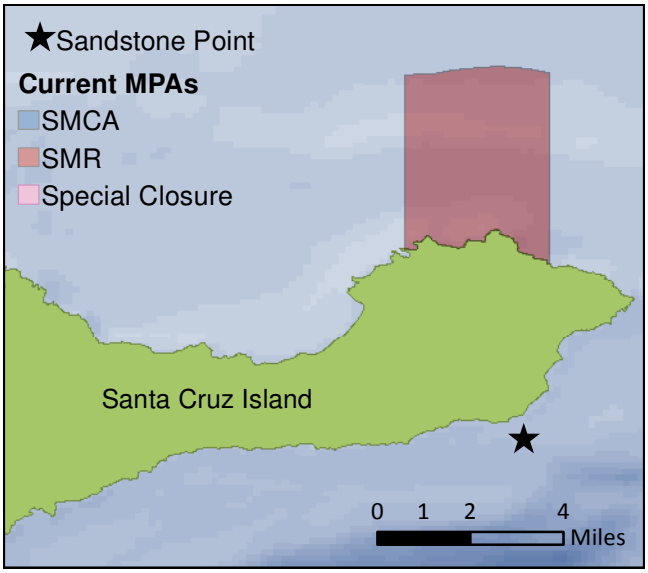
County: Santa Barbara

Marine Protected Area: None

Restrictions: None

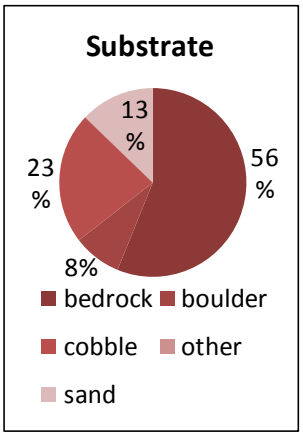
Survey history: 5/30/2008 9/8/2011

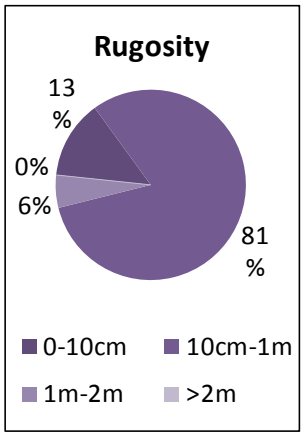
Survey Depths (ft): 28 - 41

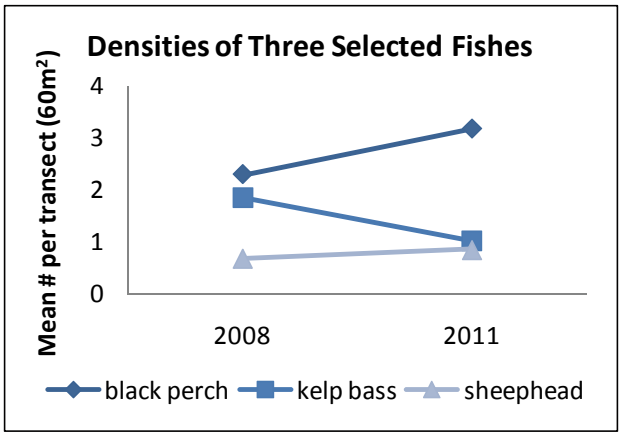


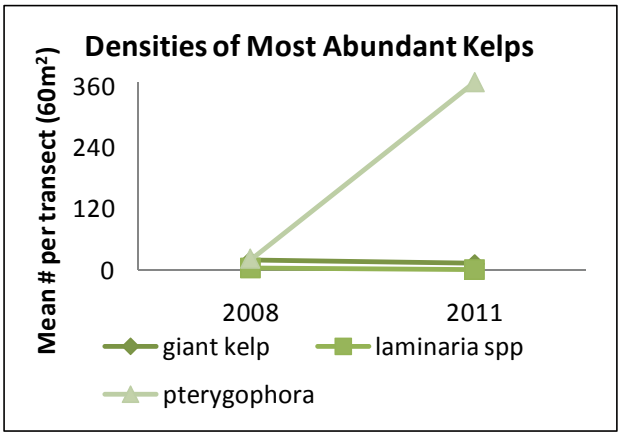
Indicator Species Observed: 17 of 35 fishes surveyed, 12 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

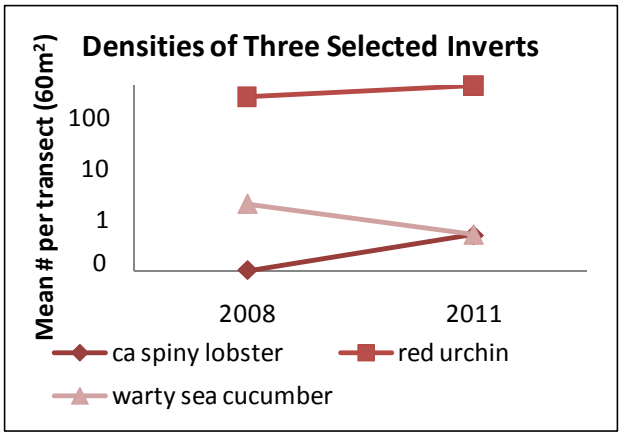
Invasive Algae: None











Reef Check California 2006-2011

Elk Ridge

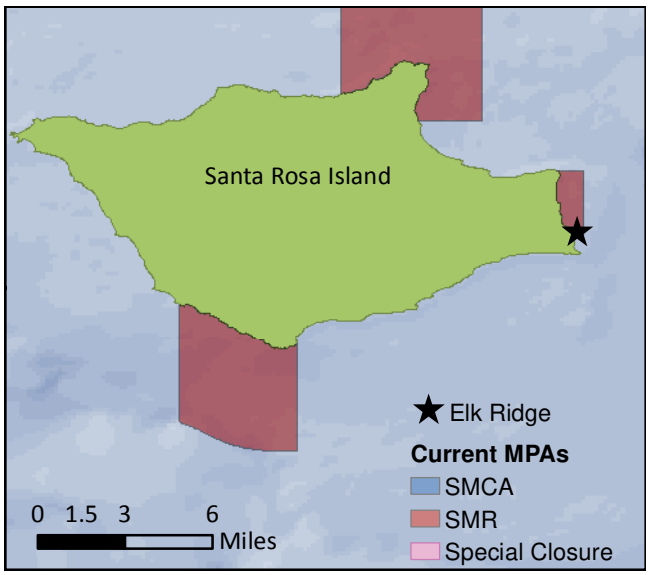
County: Santa Barbara

Marine Protected Area: Skunk Point SMR (since 2003)

Restrictions: Take of all living marine resources is prohibited.

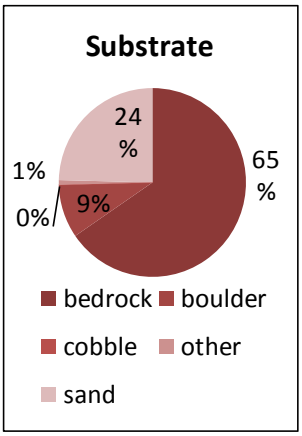
Survey history: 8/11/2007 7/15/2008

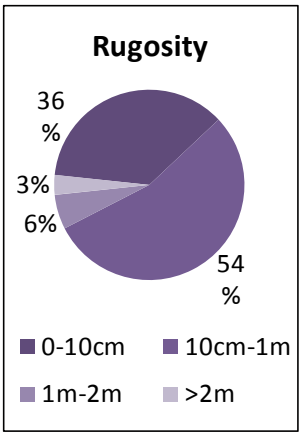
Survey Depths (ft): 11 - 34

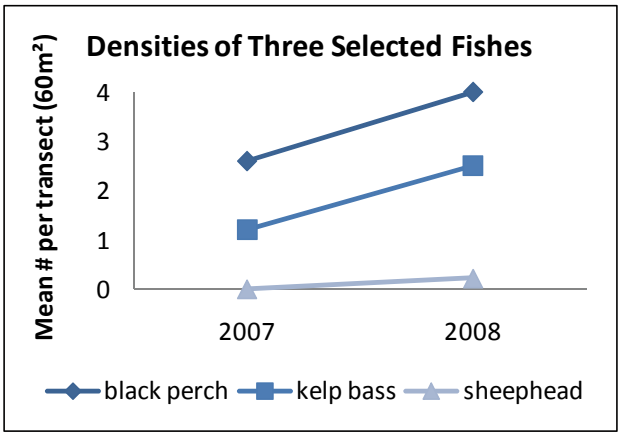


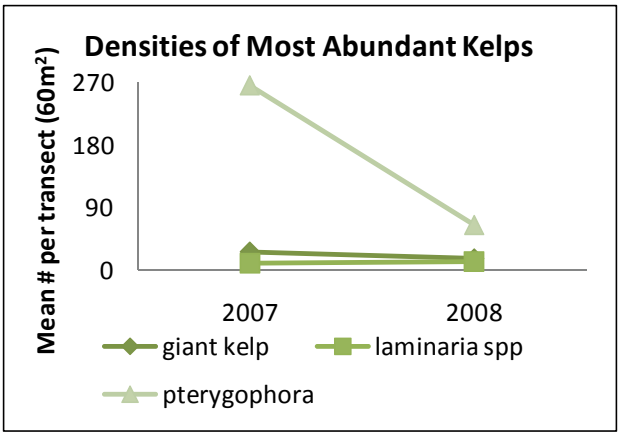
Indicator Species Observed: 16 of 35 fishes surveyed, 13 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

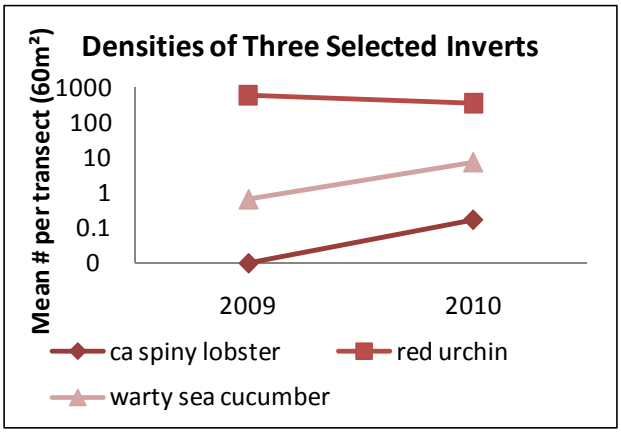
Invasive Algae: *Sargassum muticum*











Reef Check California 2006-2011

East Point

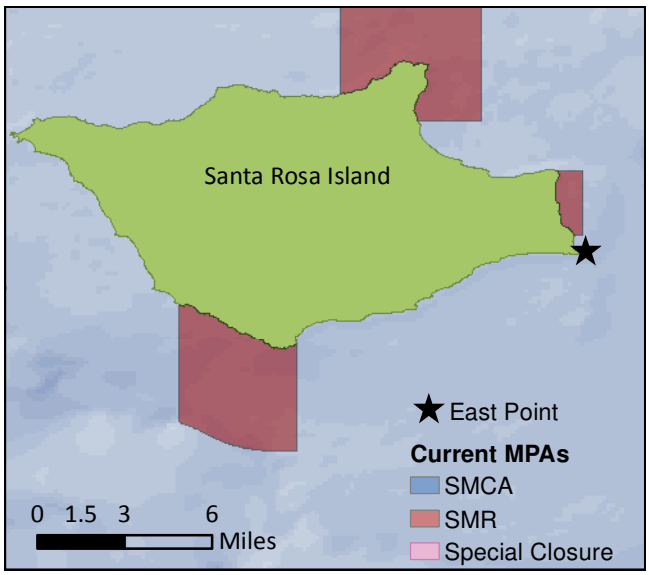
County: Santa Barbara

Marine Protected Area: None

Restrictions: None

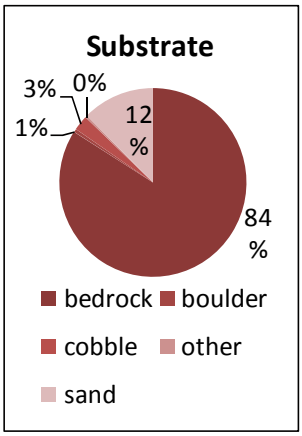
Survey history: 8/11/2007 7/15/2008 5/17/2009

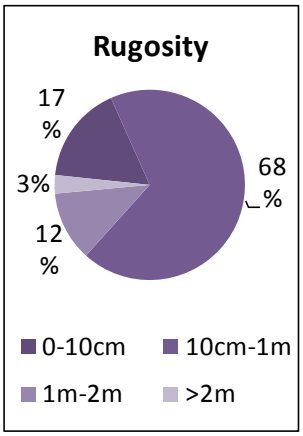
Survey Depths (ft): 7 - 41

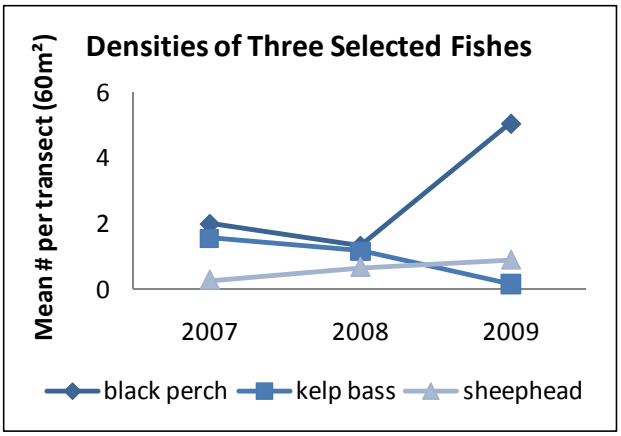


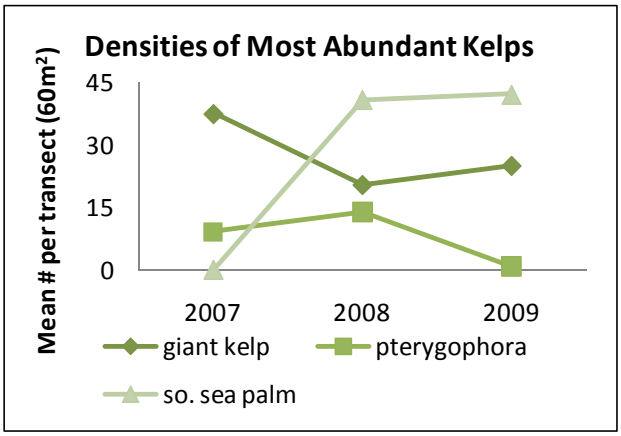
Indicator Species Observed: 28 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

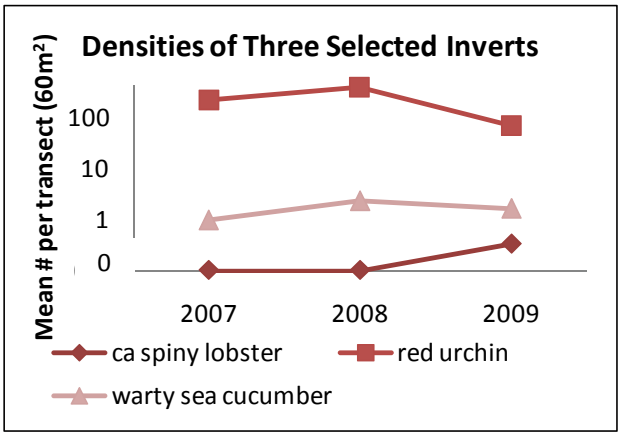
Invasive Algae: None





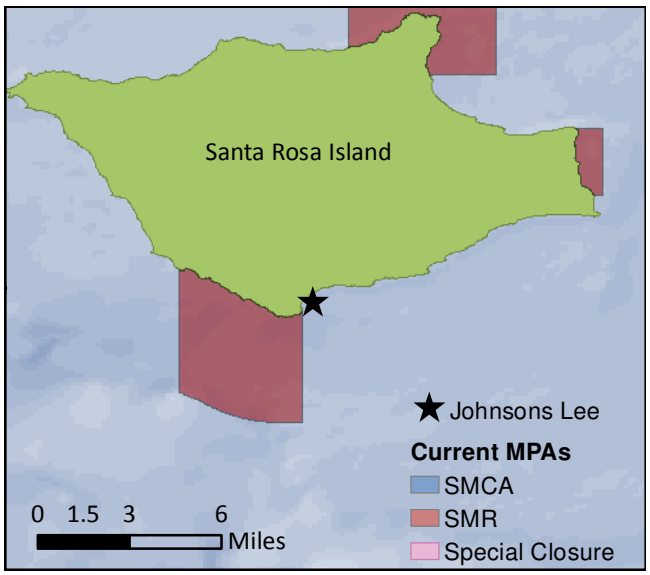






Reef Check California 2006-2011

Johnson's Lee



County: Santa Barbara

Marine Protected Area: None

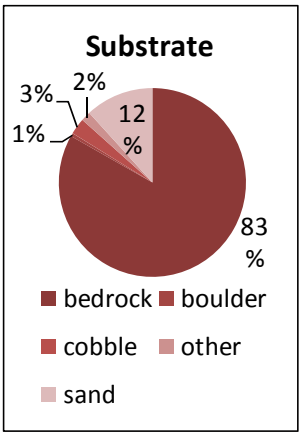
Restrictions: None

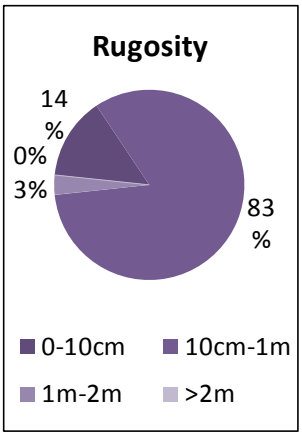
Survey history: 10/7/2009

Survey Depths (ft): 21 - 34

Indicator Species Observed: 17 of 35 fishes surveyed, 11 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

Invasive Algae: None





One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

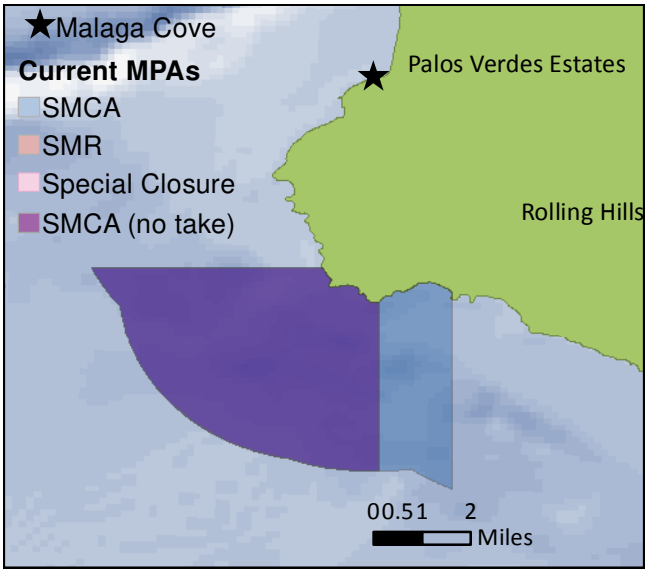
Reef Check California 2006-2011

Malaga Cove

County: Los Angeles

Marine Protected Area: None

Restrictions: None

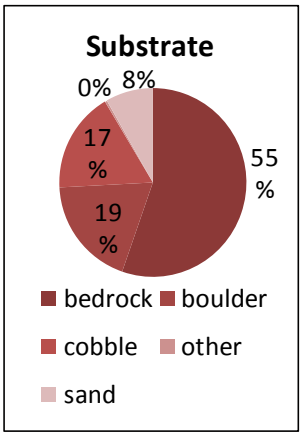


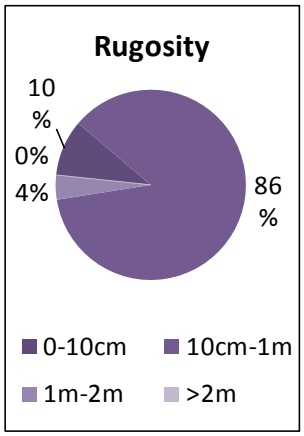
Survey history: 8/6/2006 5/26/2007 11/3/2007 4/27/2008 8/15/2009 11/13/2010 4/23/2011

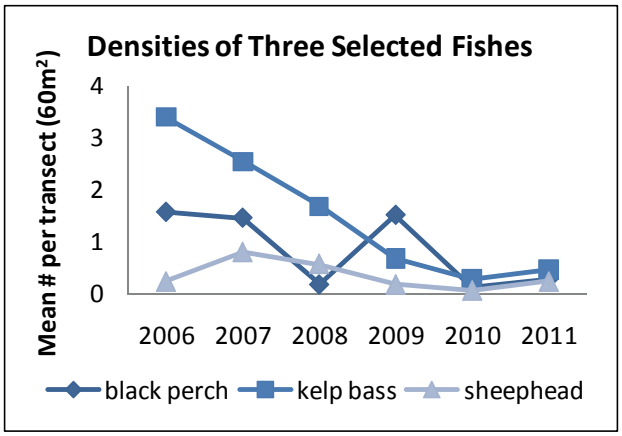
Survey Depths (ft): 5 - 28

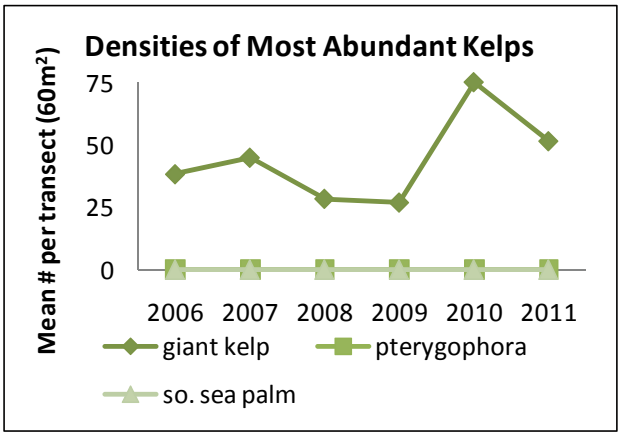
Indicator Species Observed: 21 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 1 of 5 seaweeds surveyed

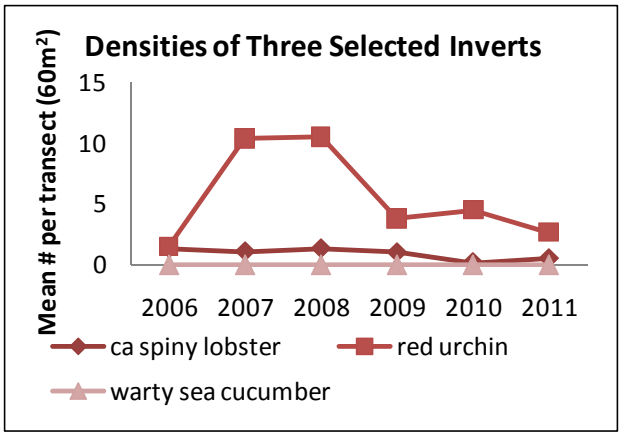
Invasive Algae: *Sargassum muticum*





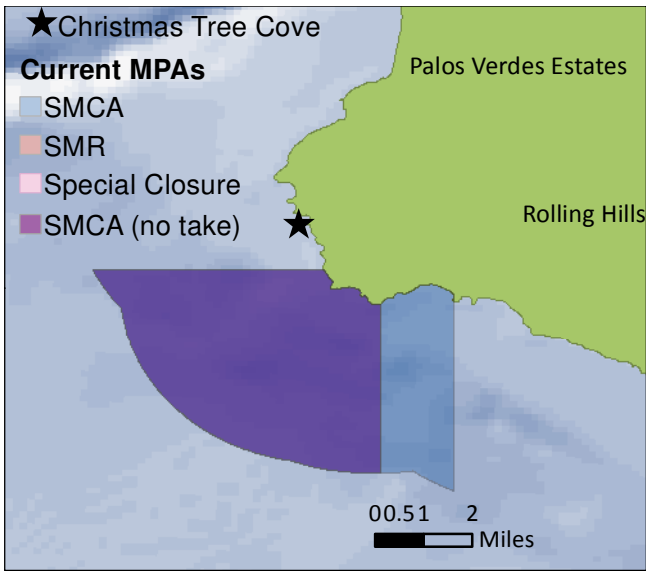






Reef Check California 2006-2011

Christmas Tree Cove



County: Los Angeles

Marine Protected Area: None

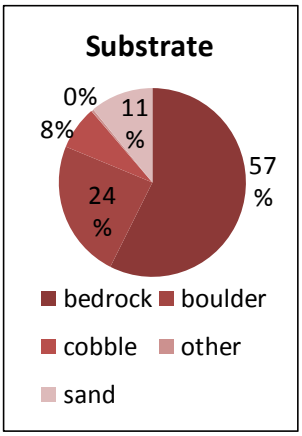
Restrictions: None

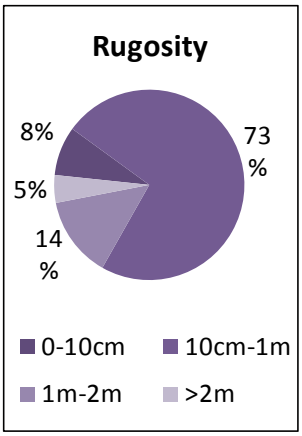
Survey history: 11/18/2007 7/26/2008 6/6/2009 7/10/2010 7/9/2011

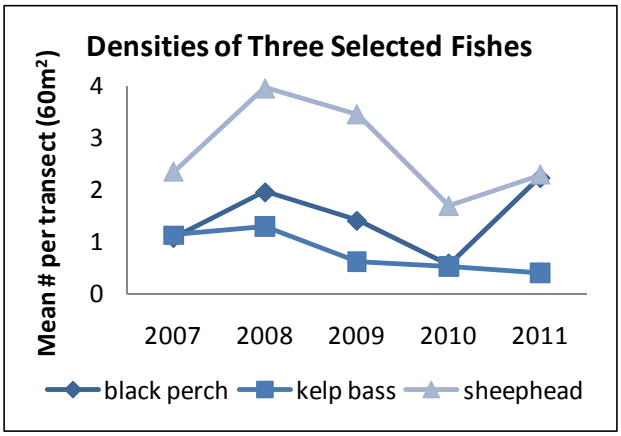
Survey Depths (ft): 14 - 60

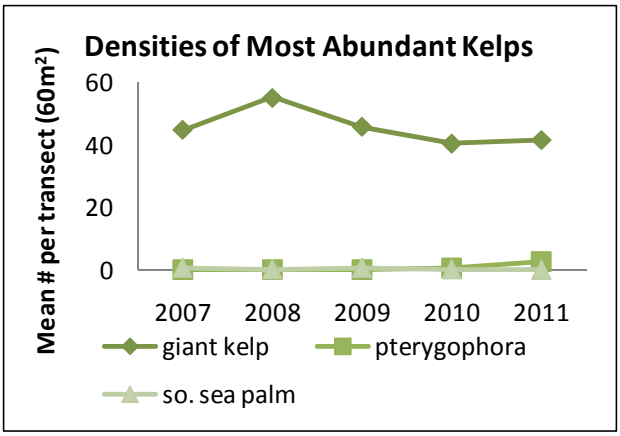
Indicator Species Observed: 26 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

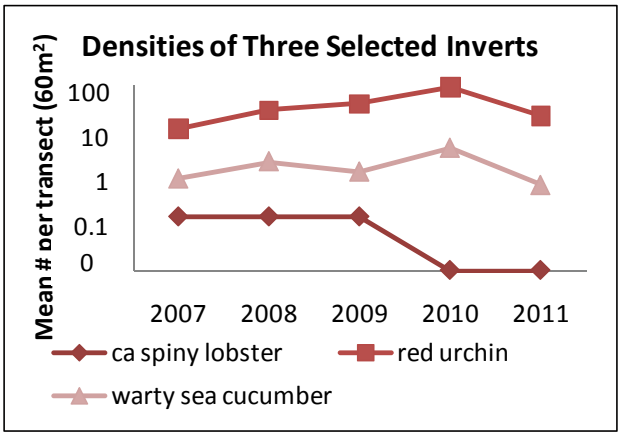
Invasive Algae: *Sargassum muticum, S. filicinum*





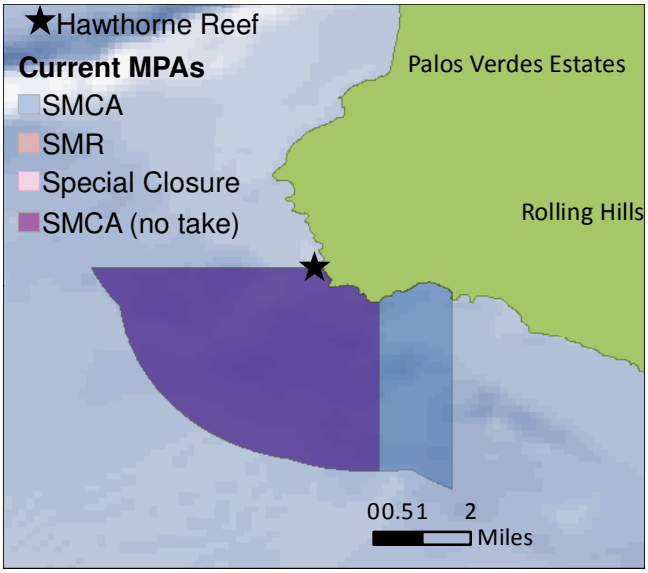






Reef Check California 2006-2011

Hawthorne Reef



County: Los Angeles

Marine Protected Area: Point Vicente SMCA (since 1/1/12)

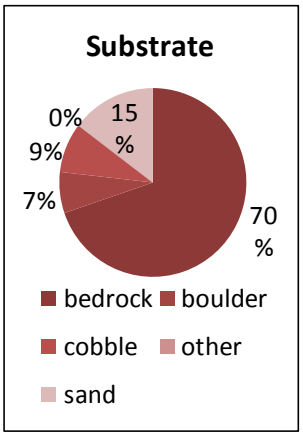
Restrictions: Take of marine resources prohibited except when associated with remediation

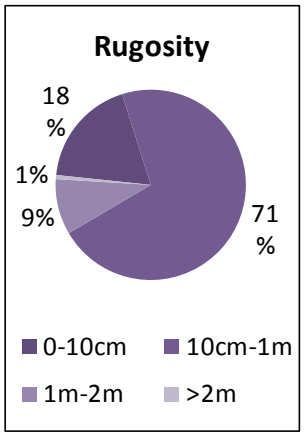
Survey history: 9/15/2007 6/14/2008 6/7/2009 7/10/2010 7/9/2011

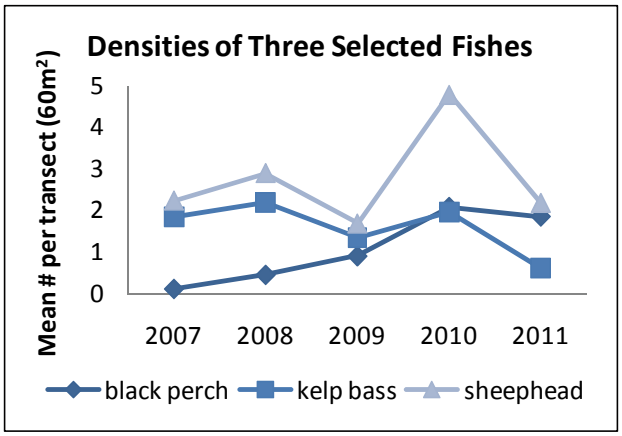
Survey Depths (ft): 8 - 52

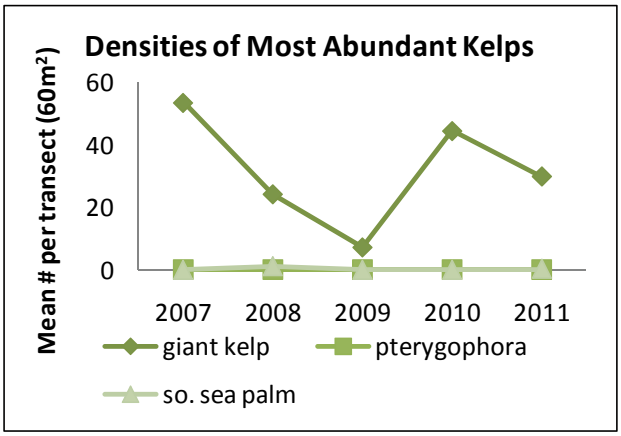
Indicator Species Observed: 28 of 35 fishes surveyed, 18 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

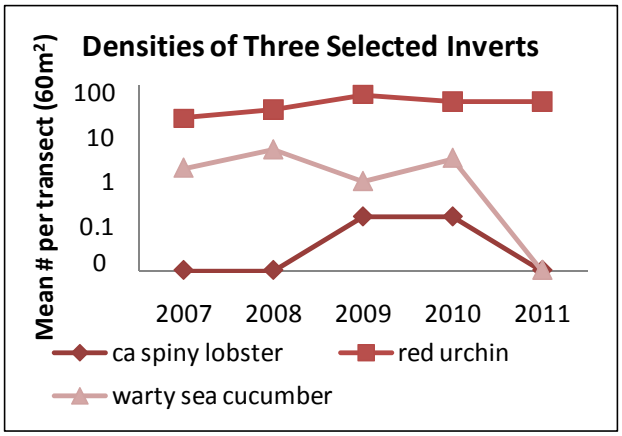
Invasive Algae: *Sargassum muticum, S. filicinum*





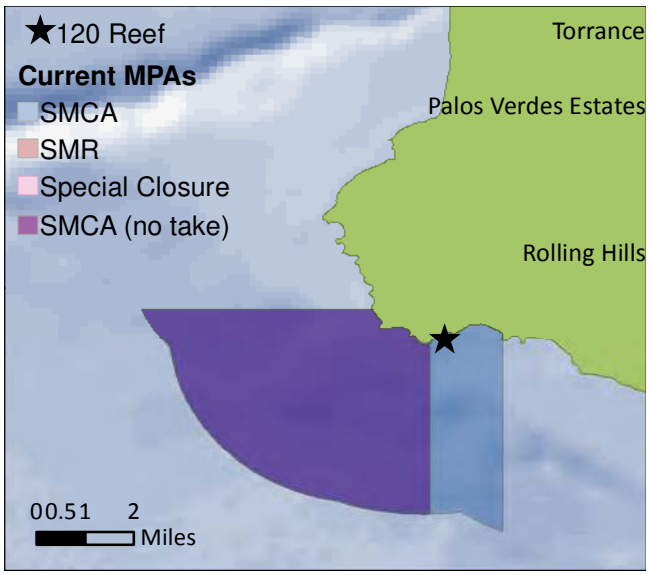






Reef Check California 2006-2011

120 Reef



County: Los Angeles

Marine Protected Area: Abalone Cove SMCA (since 1/1/12)

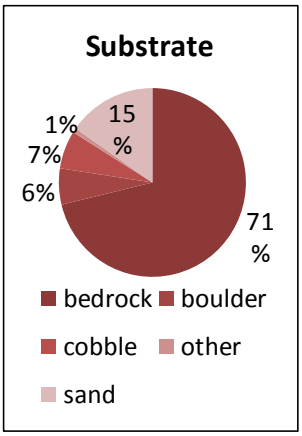
Restrictions: Take of marine resources prohibited except pelagic finfish (rec and some com), market squid (rec), and remediation

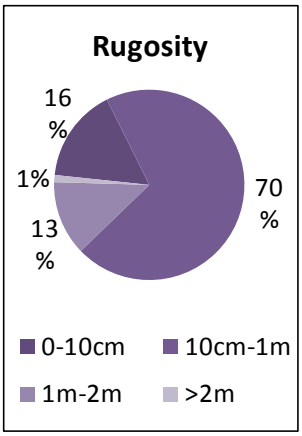
Survey history: 10/1/2006 8/19/2007 8/23/2008 6/7/2009 8/1/2010 9/17/2011

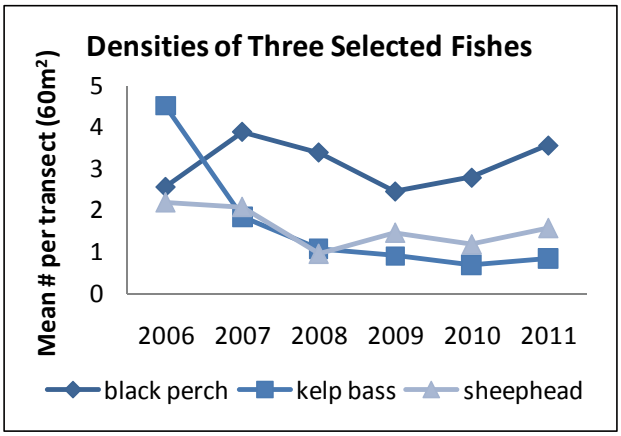
Survey Depths (ft): 13 - 44

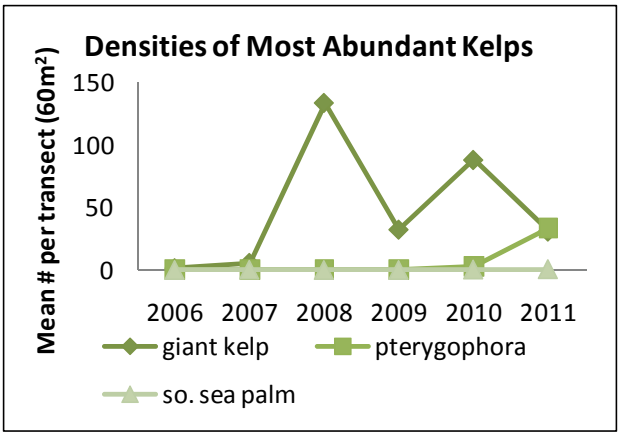
Indicator Species Observed: 25 of 35 fishes surveyed, 18 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

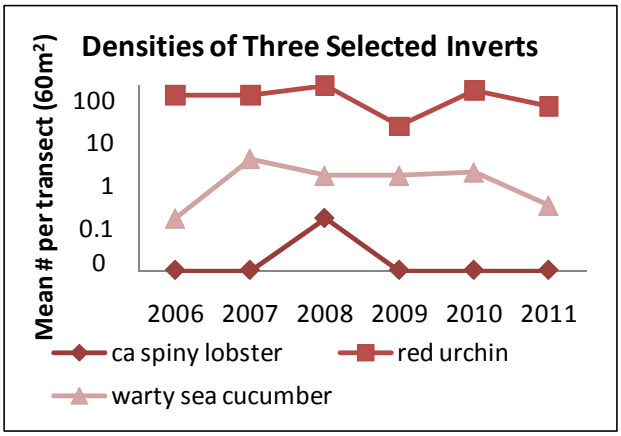
Invasive Algae: *Sargassum muticum, S. filicinum*





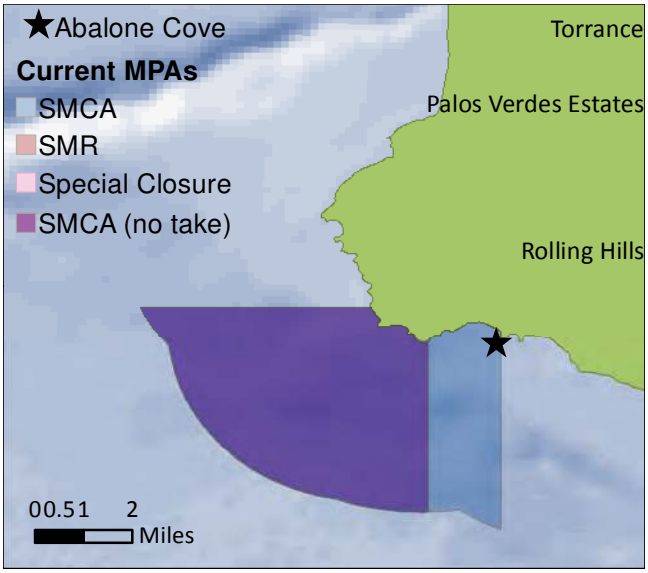






Reef Check California 2006-2011

Abalone Cove



County: Los Angeles

Marine Protected Area: Abalone Cove SMCA (2012; Abalone Cove SMP since 1977)

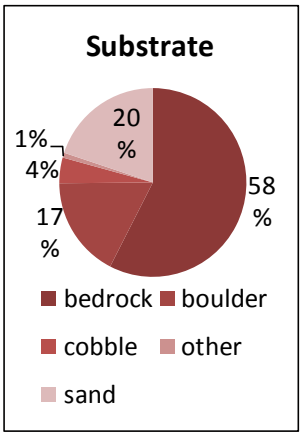
Restrictions: Take of marine resources prohibited except pelagic finfish (rec and some com), market squid (rec), and remediation

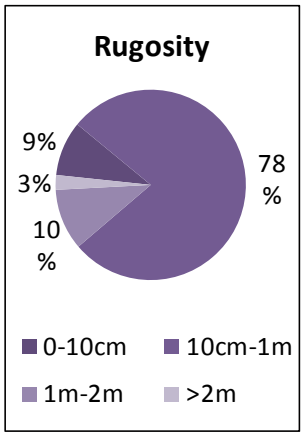
Survey history: 9/29/2007 8/9/2008 6/7/2009 7/10/2010

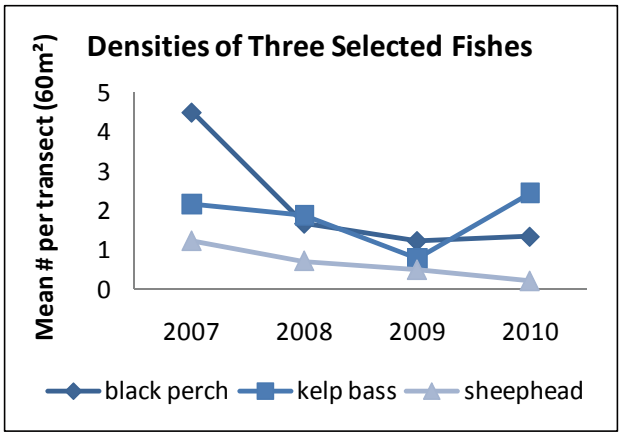
Survey Depths (ft): 9 - 48

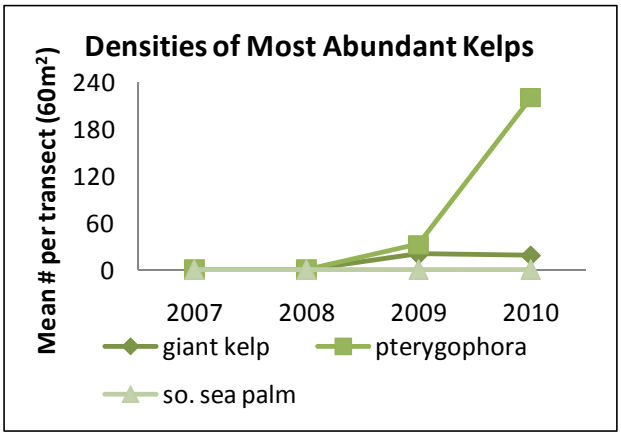
Indicator Species Observed: 23 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

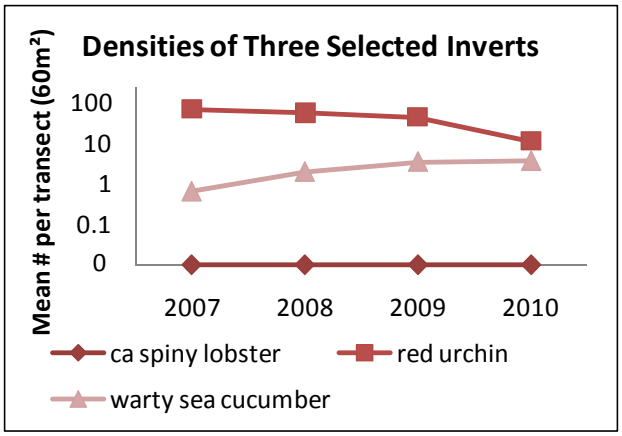
Invasive Algae: *Sargassum filicinum*











Reef Check California 2006-2011

Pier 400

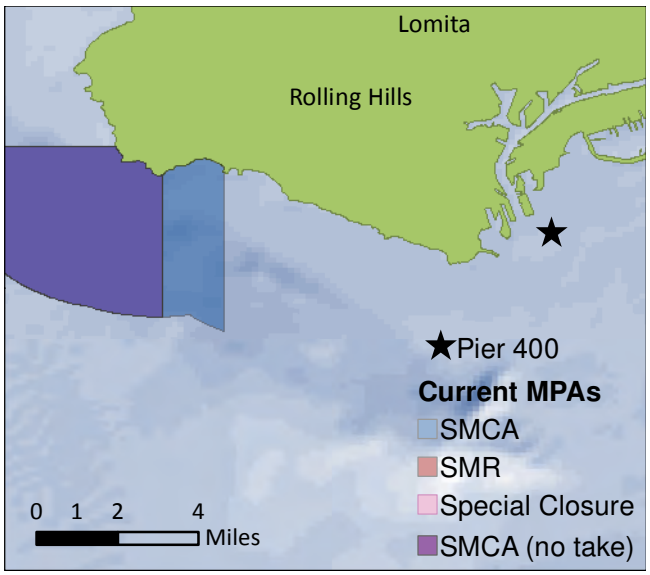
County: Los Angeles

Marine Protected Area: None

Restrictions: None

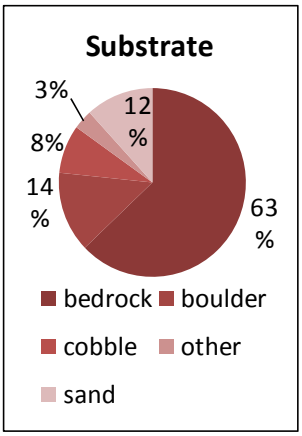
Survey history: 11/12/2009

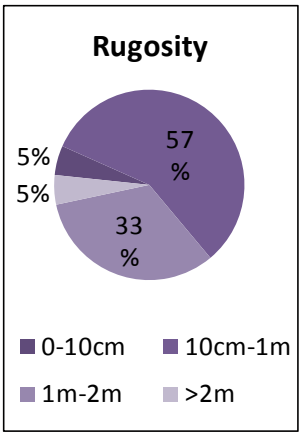
Survey Depths (ft): 6 - 35



Indicator Species Observed: 16 of 35 fishes surveyed, 11 of 30 invertebrates surveyed, 1 of 5 seaweeds surveyed

Invasive Algae: *Sargassum muticum, S. filicinum*





One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

Reef Check California 2006-2011

White Point

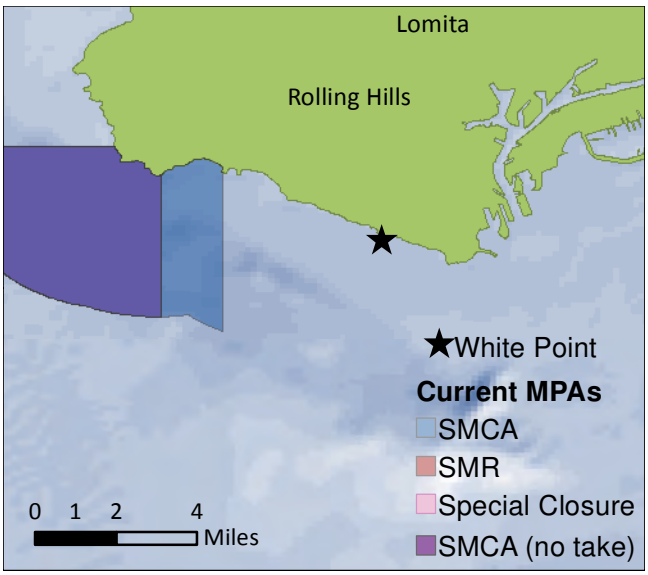
County: Los Angeles

Marine Protected Area: None

Restrictions: None

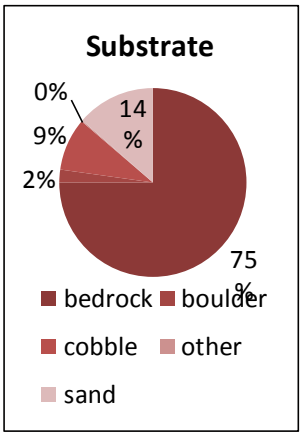
Survey history: 9/27/2008 9/27/2009 9/19/2010 7/9/2011

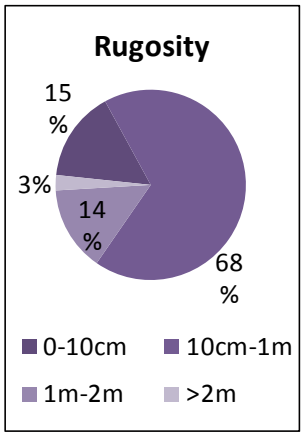
Survey Depths (ft): 12 - 40

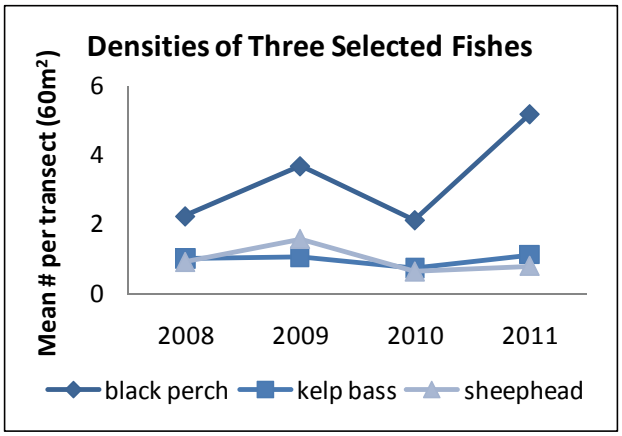


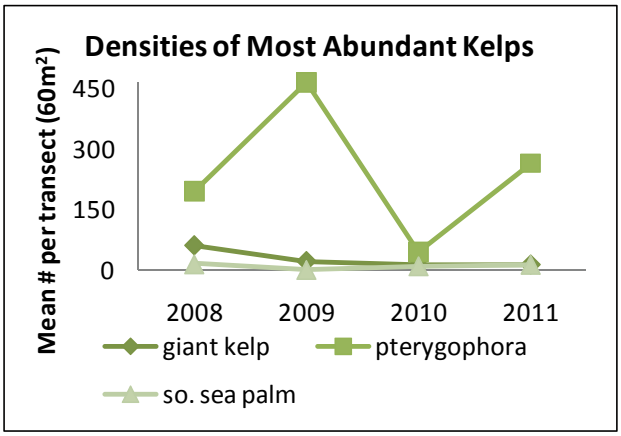
Indicator Species Observed: 22 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

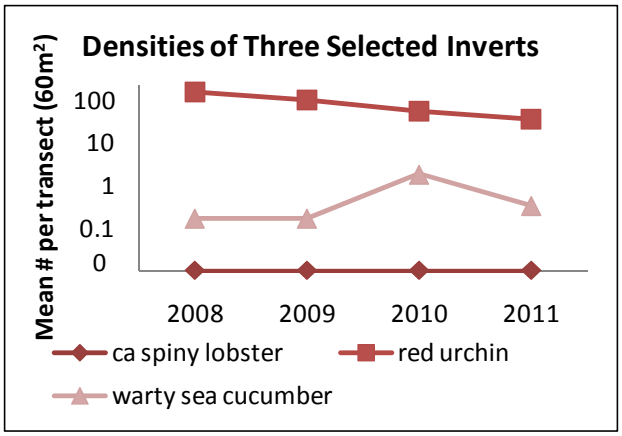
Invasive Algae: *Sargassum muticum*





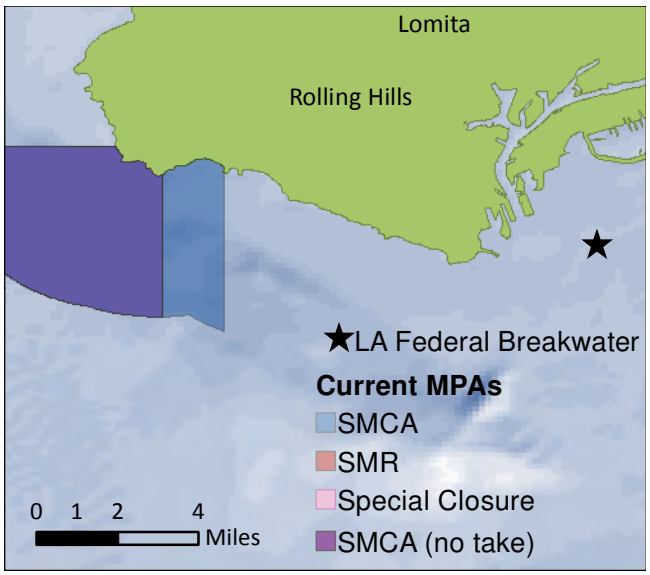






Reef Check California 2006-2011

LA Federal Breakwater



County: Los Angeles

Marine Protected Area: None

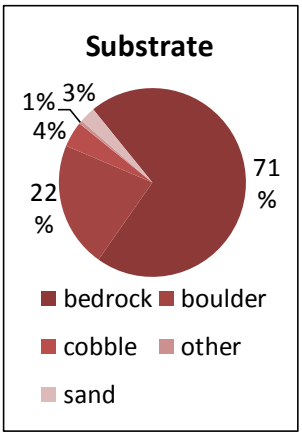
Restrictions: None

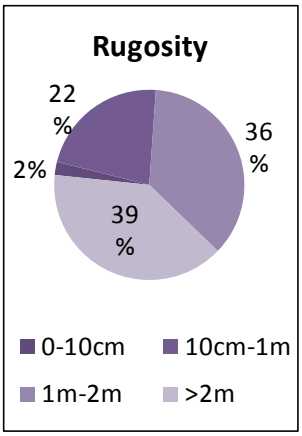
Survey history: 12/16/2009

Survey Depths (ft): 6 - 34

Indicator Species Observed: 17 of 35 fishes surveyed, 14 of 30 invertebrates surveyed, 1 of 5 seaweeds surveyed

Invasive Algae: *Sargassum muticum, S. filicinum*





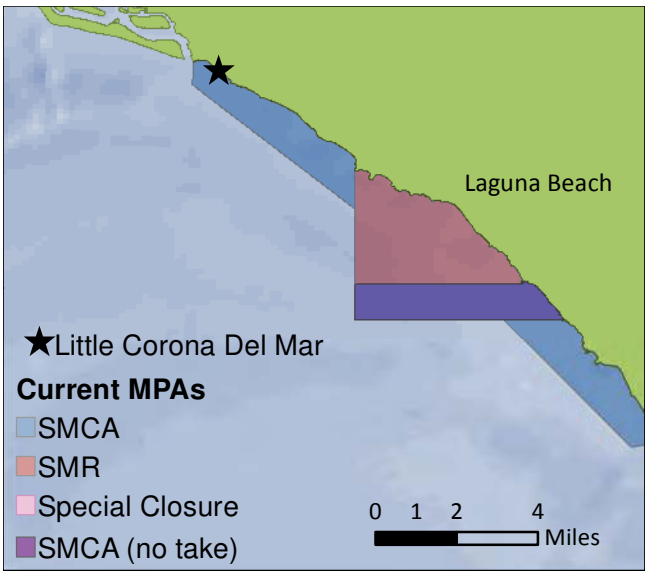
One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

Reef Check California 2006-2011

Little Corona Del Mar



County: Orange

Marine Protected Area: Crystal Cove SMCA (2012; Robert E. Badham SMCA since 1968)

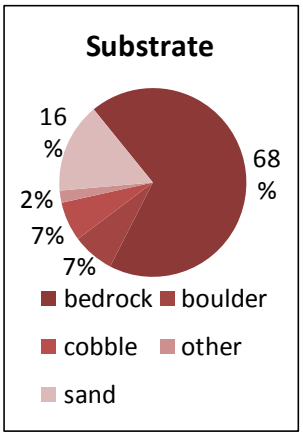
Restrictions: No take EXCEPT rec finfish, lobster, and urchin, some com pelagics, and beach nourishment

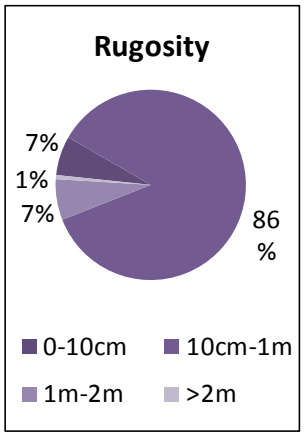
Survey history: 10/28/2007 6/27/2009 10/24/2009 6/19/2010 7/2/2011 11/22/2011

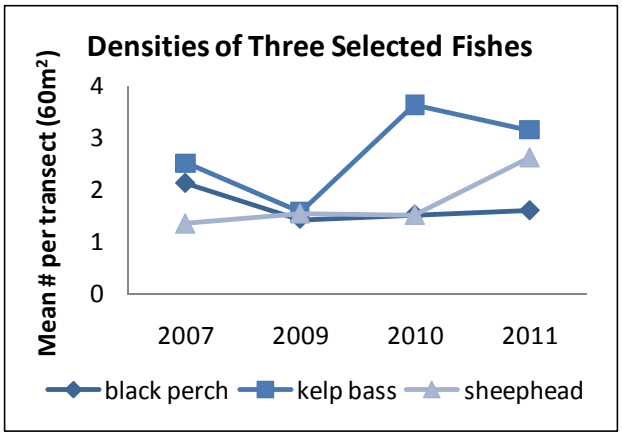
Survey Depths (ft): 10 - 40

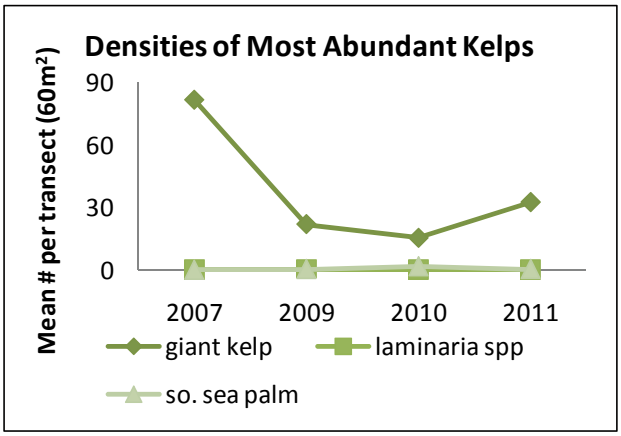
Indicator Species Observed: 21 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

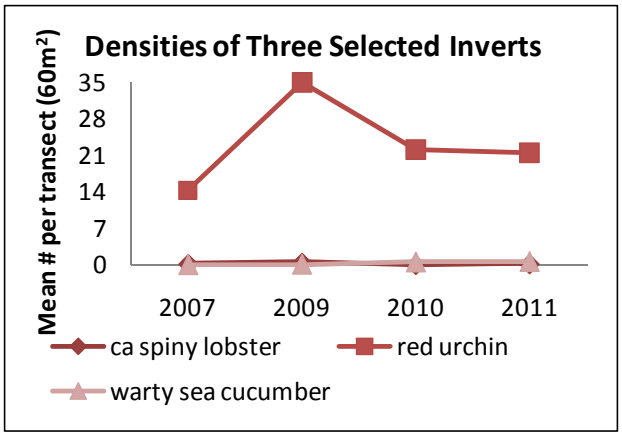
Invasive Algae: *Sargassum muticum*











Reef Check California 2006-2011

Crystal Cove

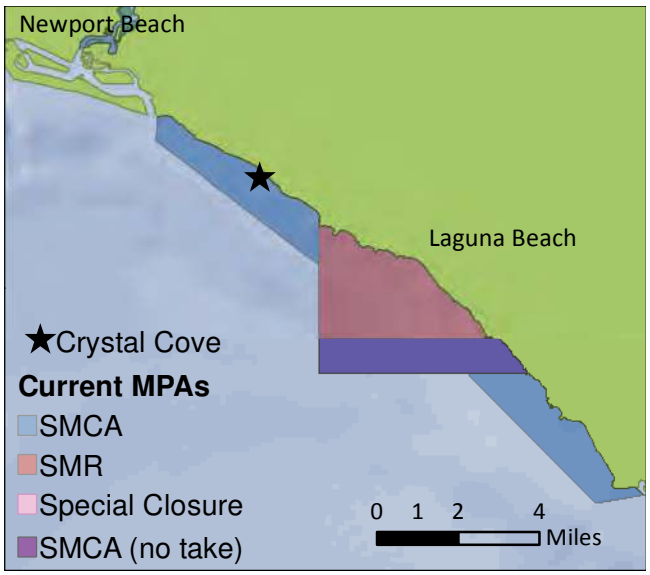
County: Orange

Marine Protected Area: Crystal Cove SMCA (since 1982)

Restrictions: No recreational take of aquatic plants or various inverts. No commercial take of kelp or various inverts.

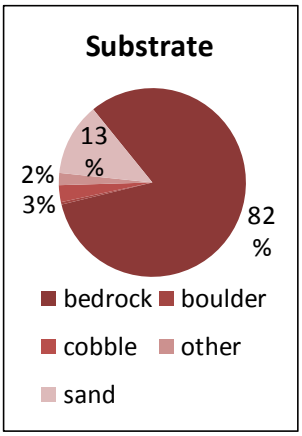
Survey history: 6/27/2008 12/2/2008 3/31/2009 10/19/2009 10/27/2011

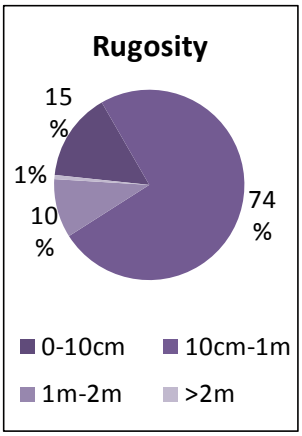
Survey Depths (ft): 16 - 39

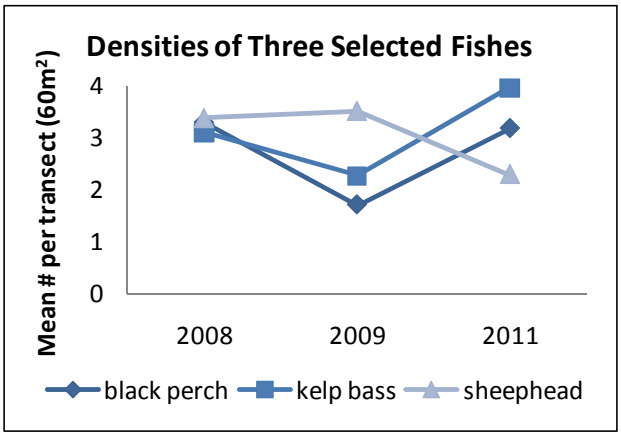


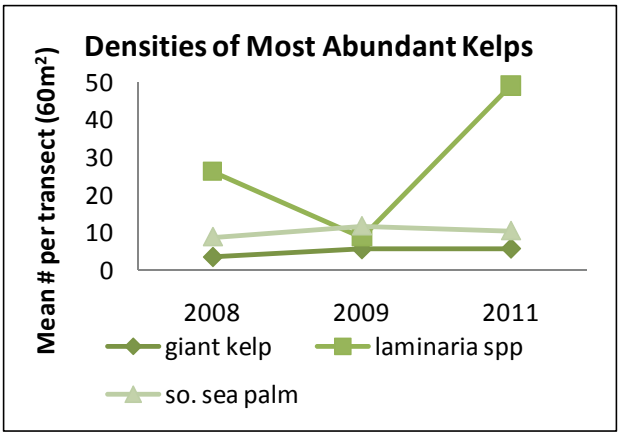
Indicator Species Observed: 20 of 35 fishes surveyed, 20 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

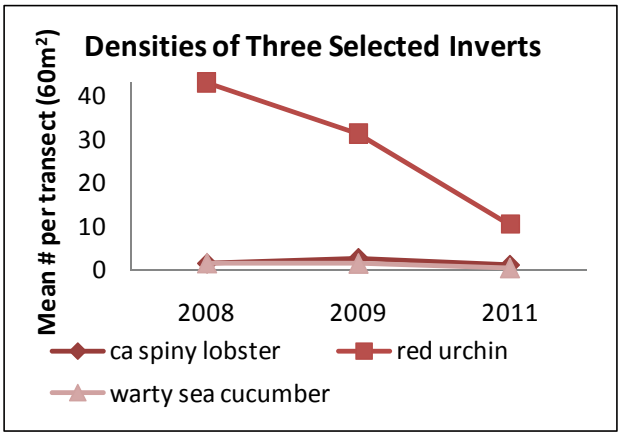
Invasive Algae: None











Reef Check California 2006-2011

Seal Rock North Crescent

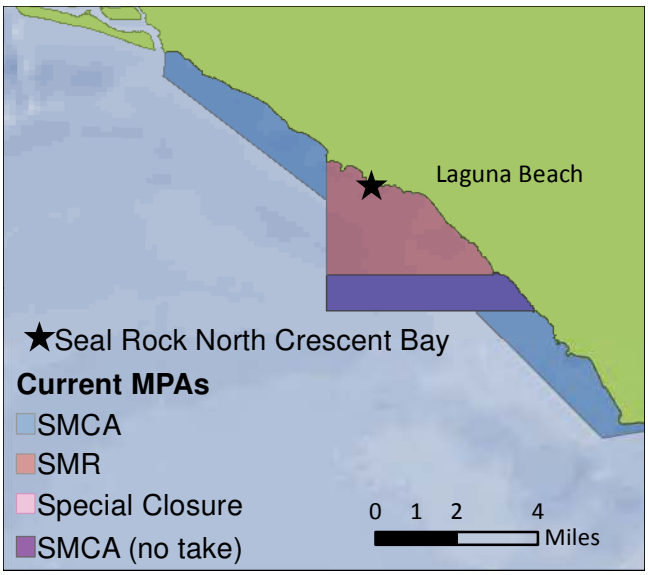
County: Orange

Marine Protected Area: Laguna Beach SMR (2012: SMCA since 1968)

Restrictions: Take of marine resources prohibited

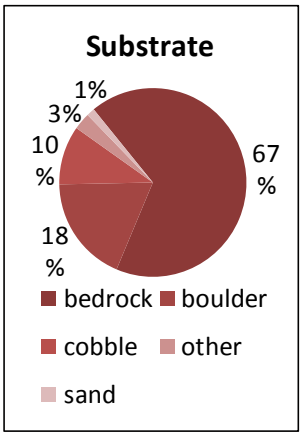
Survey history: 7/14/2007 7/12/2008 8/8/2009 8/15/2010 9/24/2011

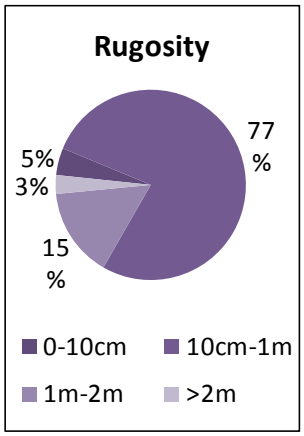
Survey Depths (ft): 6 - 45

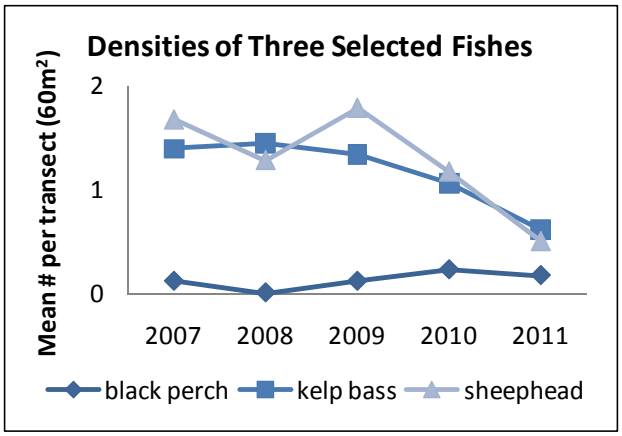


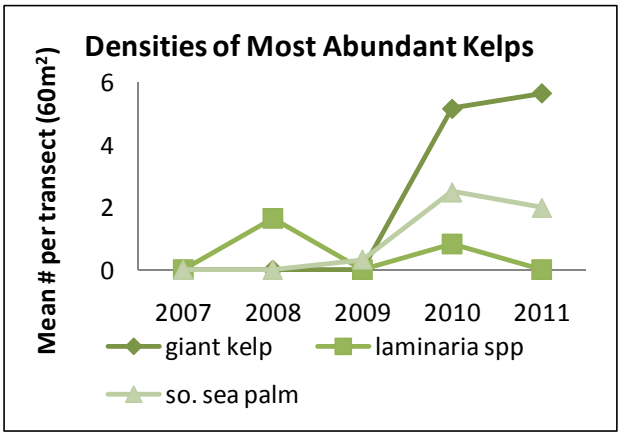
Indicator Species Observed: 25 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

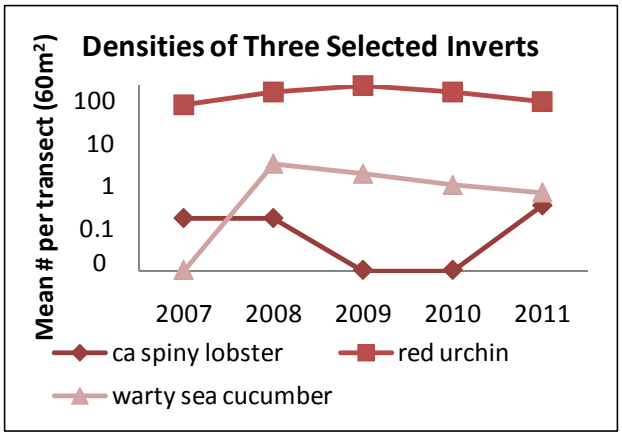
Invasive Algae: None











Reef Check California 2006-2011

Shaw's Cove

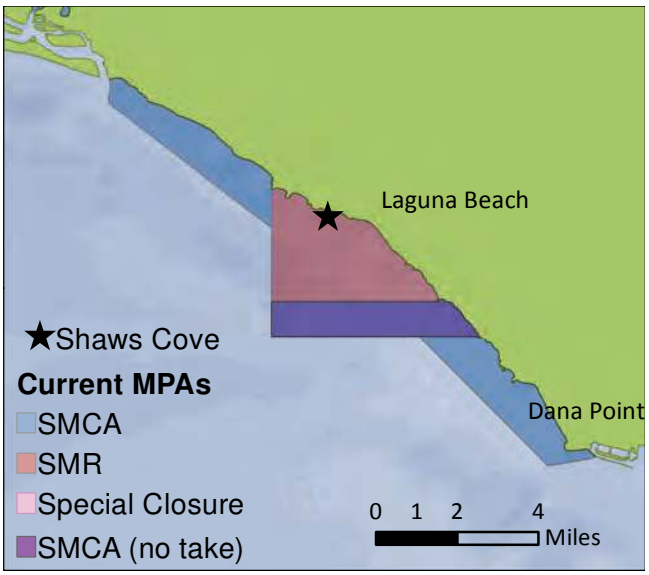
County: Orange

Marine Protected Area: Laguna Beach SMR (2012: SMCA since 1968)

Restrictions: Take of marine resources prohibited

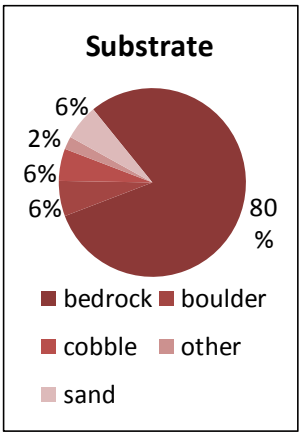
Survey history: 9/3/2010 4/28/2011 10/15/2011

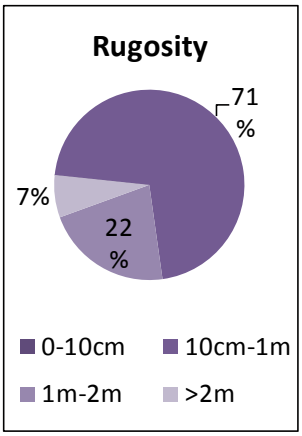
Survey Depths (ft): 8 - 44

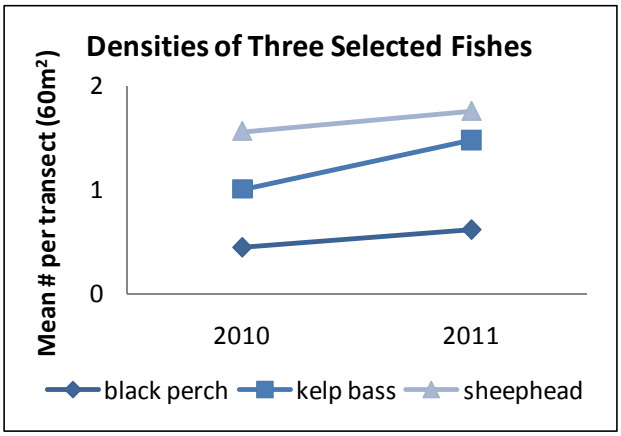


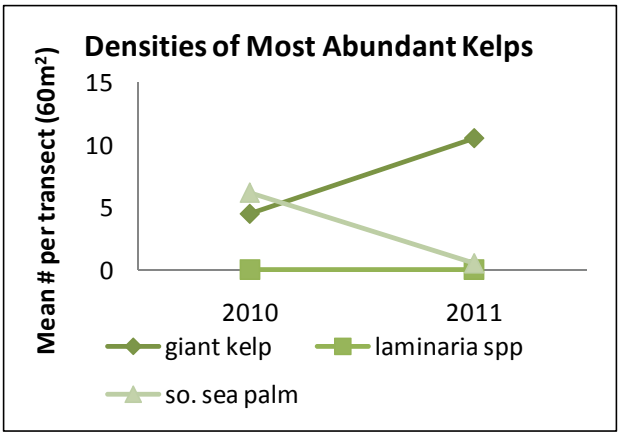
Indicator Species Observed: 17 of 35 fishes surveyed, 12 of 30 invertebrates surveyed, 2 of 5 seaweeds surveyed

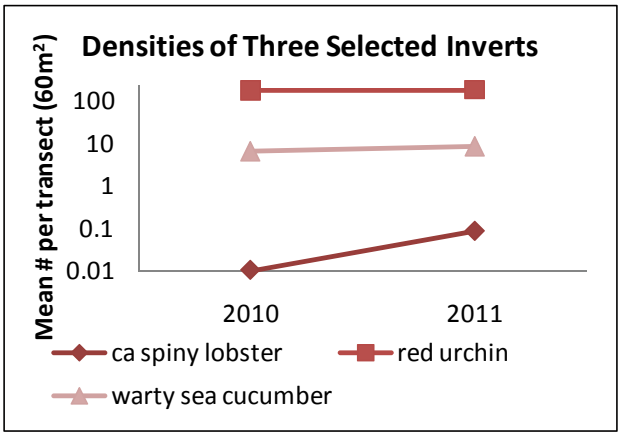
Invasive Algae: *Sargassum muticum, S. filicinum*











Reef Check California 2006-2011

Divers' Cove

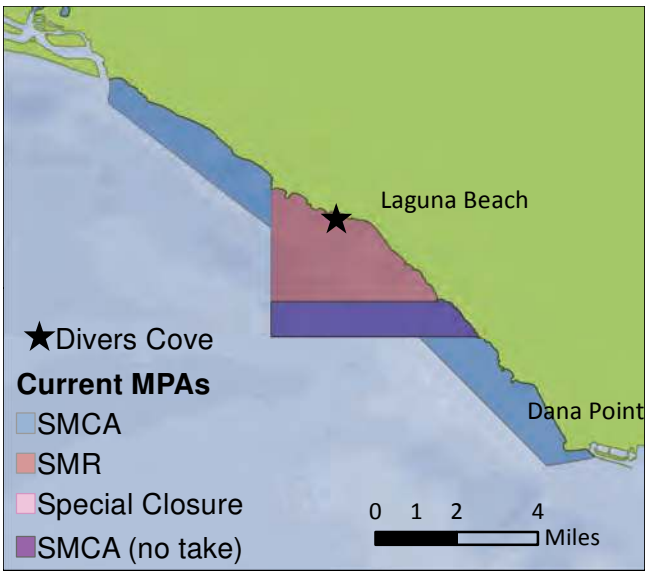
County: Orange

Marine Protected Area: Laguna Beach SMR (2012: SMCA since 1968)

Restrictions: Take of all living marine resources prohibited

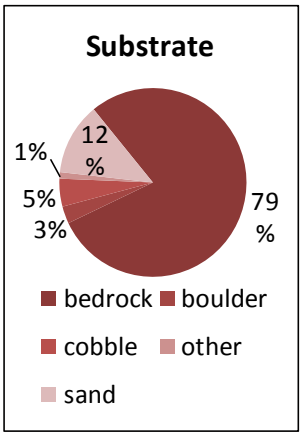
Survey history: 8/23/2008 10/3/2009 12/4/2010 7/23/2011

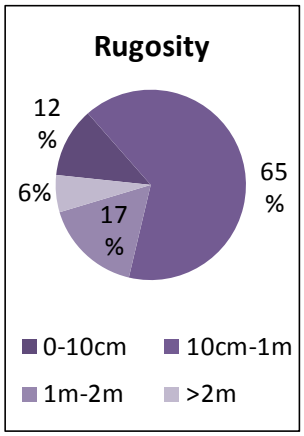
Survey Depths (ft): 5 - 37

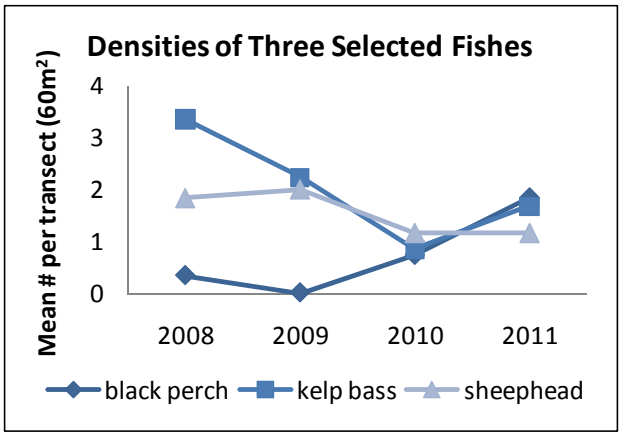


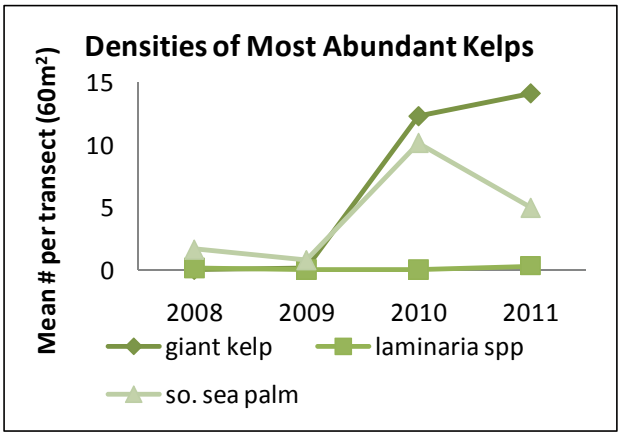
Indicator Species Observed: 19 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

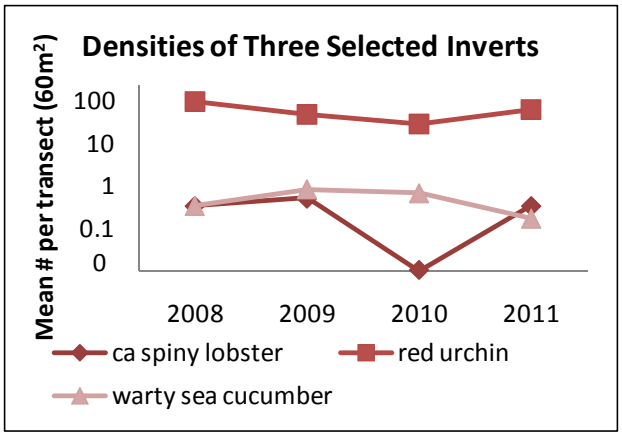
Invasive Algae: *Sargassum muticum, S. filicinum*











Reef Check California 2006-2011

Heisler Park

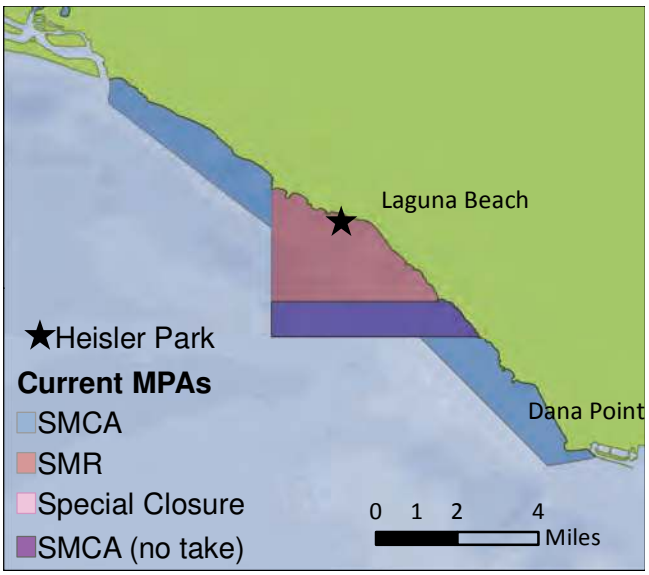
County: Orange

Marine Protected Area: Laguna Beach SMR (2012: Heisler Park SMCA since 1973)

Restrictions: Take of all living marine resources is prohibited.

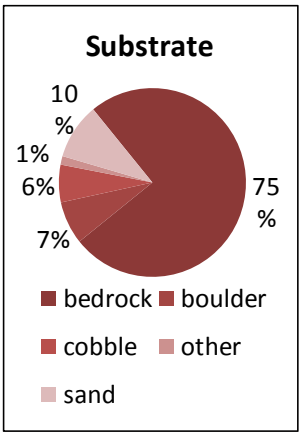
Survey history: 6/5/2008 12/11/2008 5/12/2009 11/18/2011

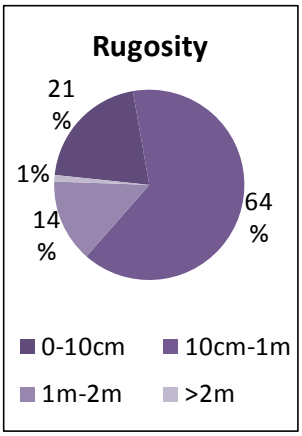
Survey Depths (ft): 20 - 42

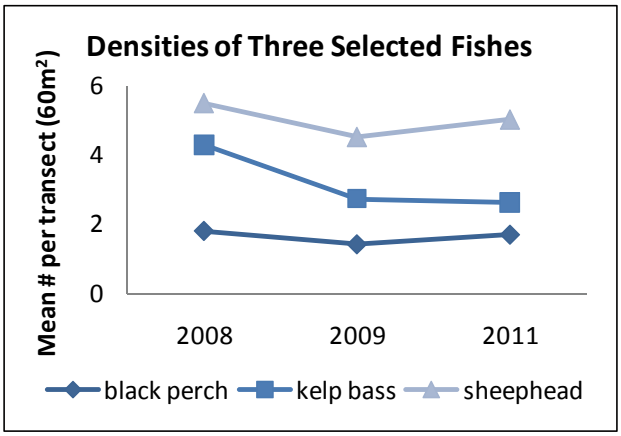


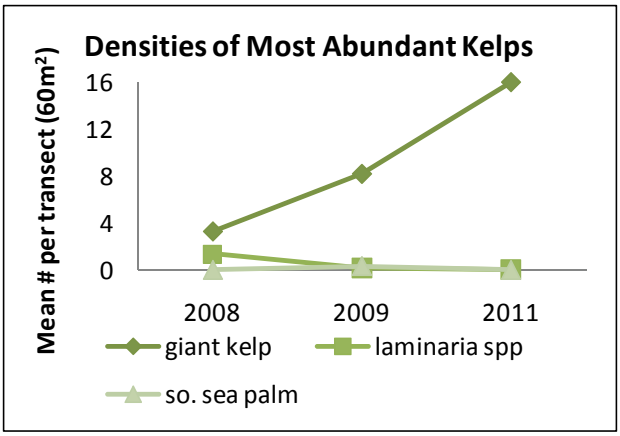
Indicator Species Observed: 21 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

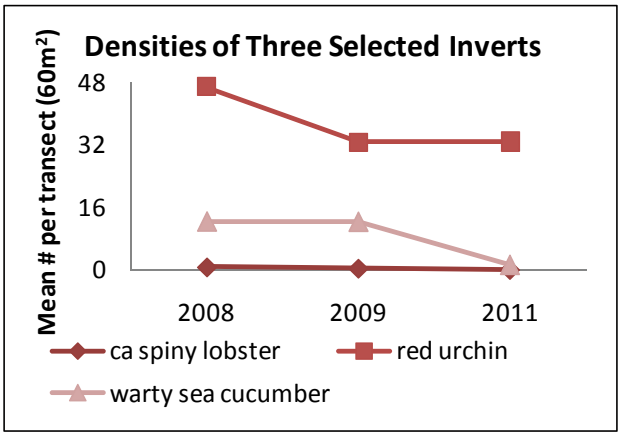
Invasive Algae: *Sargassum muticum*











Reef Check California 2006-2011

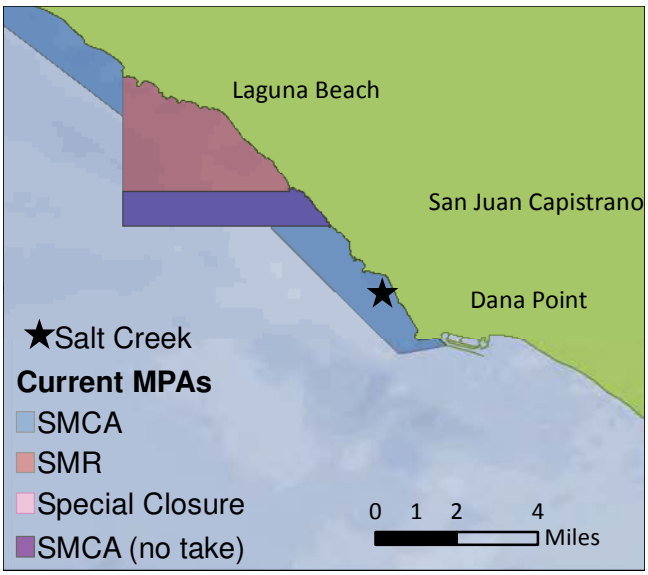
Salt Creek

County: Orange

Marine Protected Area: Dana Point SMCA (2012; Niguel SMCA since 1971)

Restrictions: No take EXCEPT finfish, lobster, and urchin (rec and com)

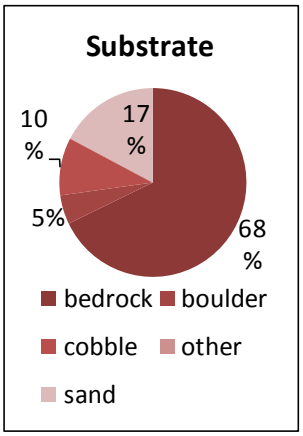
Survey history: 1/8/2009

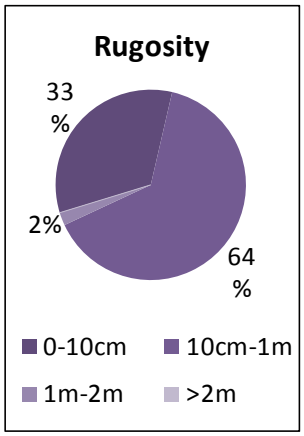


Survey Depths (ft): 16 - 31

Indicator Species Observed: 15 of 35 fishes surveyed, 13 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

Invasive Algae: None





One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

Reef Check California 2006-2011

Ship Rock

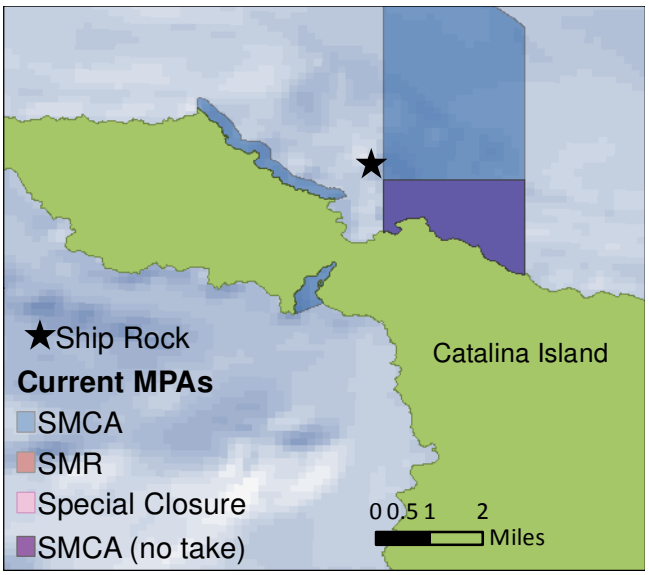
County: Los Angeles

Marine Protected Area: None

Restrictions: None

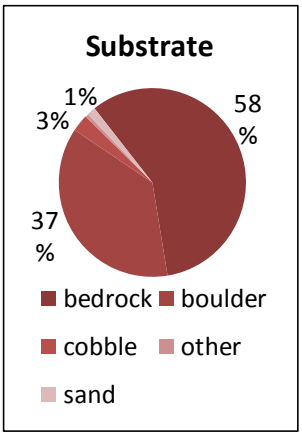
Survey history: 11/20/2007 11/25/2008 11/24/2009

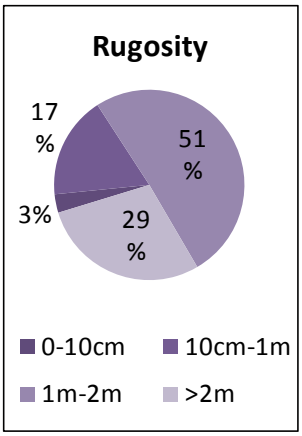
Survey Depths (ft): 16 - 68

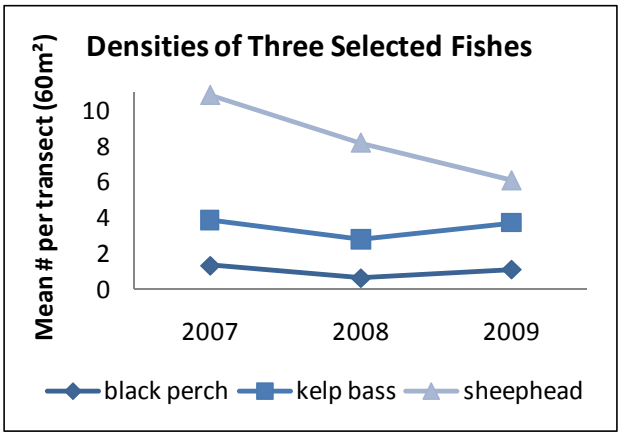


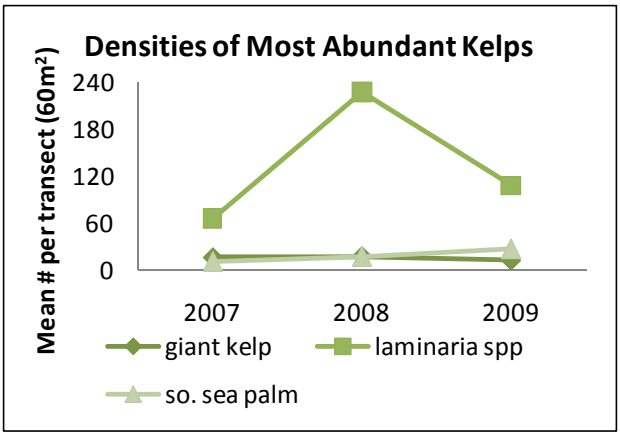
Indicator Species Observed: 28 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

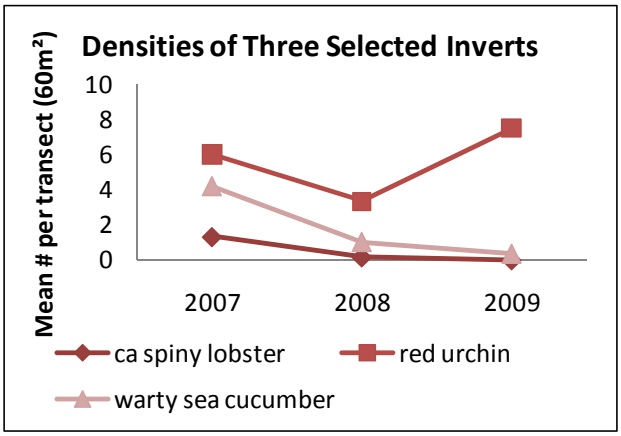
Invasive Algae: *Sargassum muticum, S. filicinum, Undaria pinnatifida*











Reef Check California 2006-2011

Lion's Head

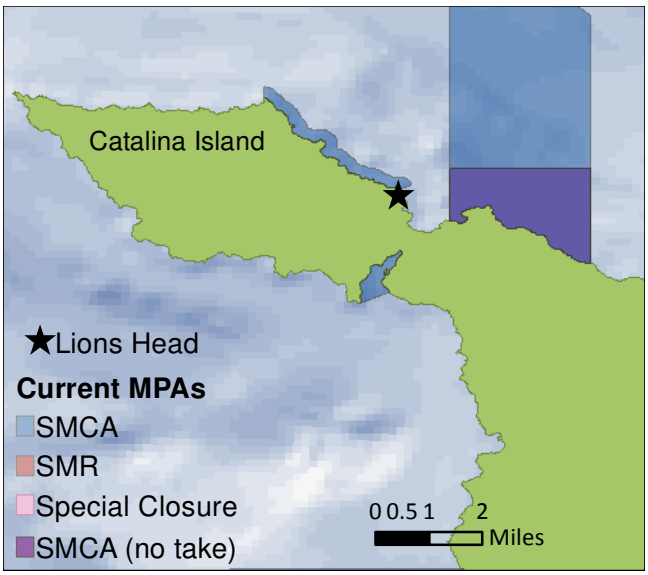
County: Los Angeles

Marine Protected Area: Arrow Point to Lion Head Point SMCA (since 1/1/2012)

Restrictions: Recreational take of invertebrates is prohibited. Take of all other living marine resources is allowed.

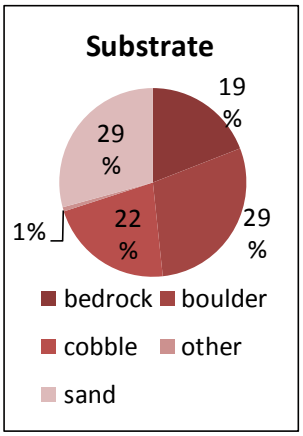
Survey history: 11/24/2008 11/23/2009 11/23/2010 11/22/2011

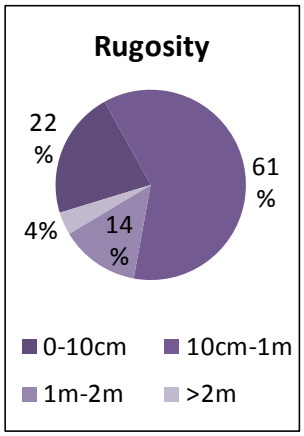
Survey Depths (ft): 11 - 57

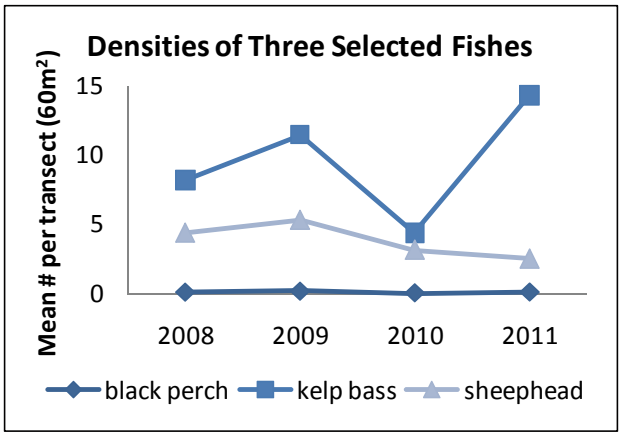


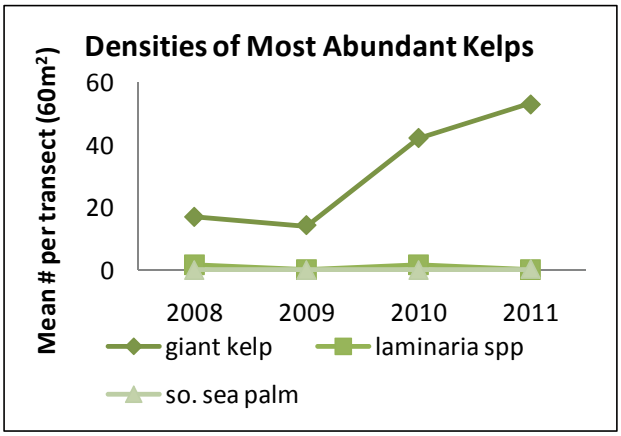
Indicator Species Observed: 24 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 2 of 5 seaweeds surveyed

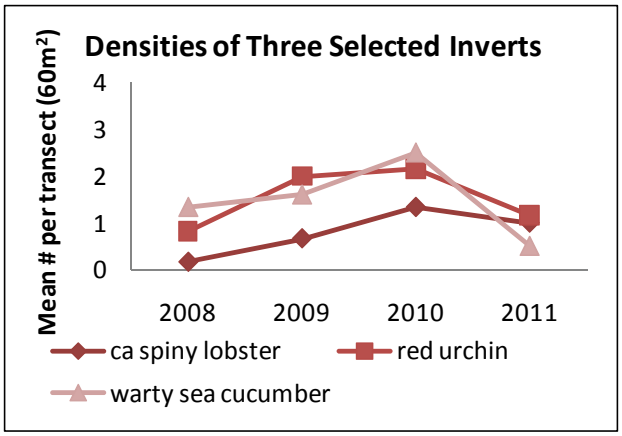
Invasive Algae: *Sargassum muticum, S. filicinum*











Reef Check California 2006-2011

Isthmus Reef

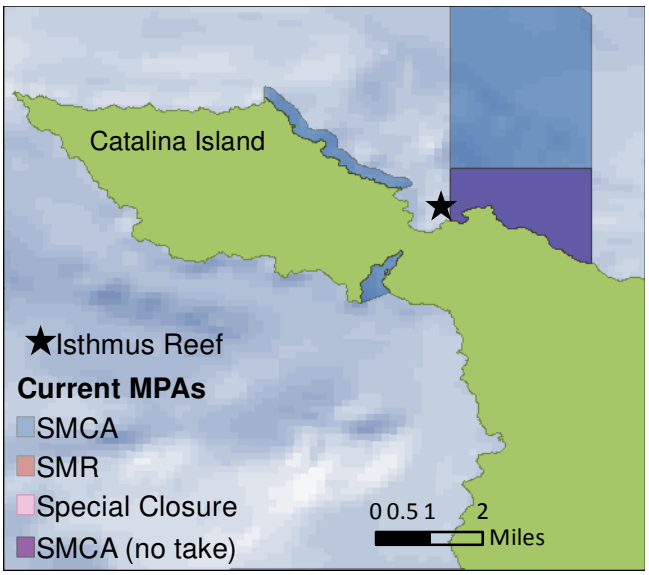
County: Los Angeles

Marine Protected Area: None

Restrictions: None

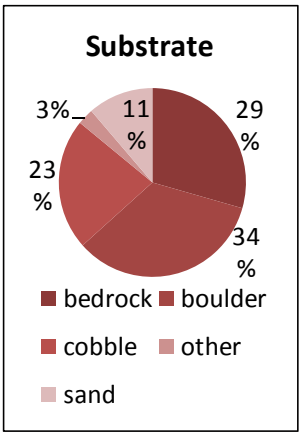
Survey history: 11/19/2007 11/24/2008 11/23/2009 11/23/2010 11/22/2011

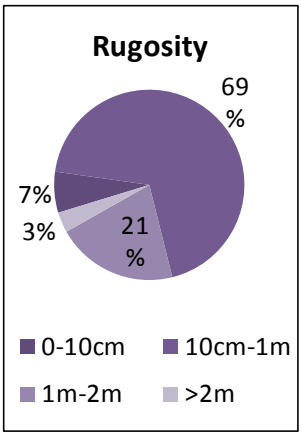
Survey Depths (ft): 13 - 65

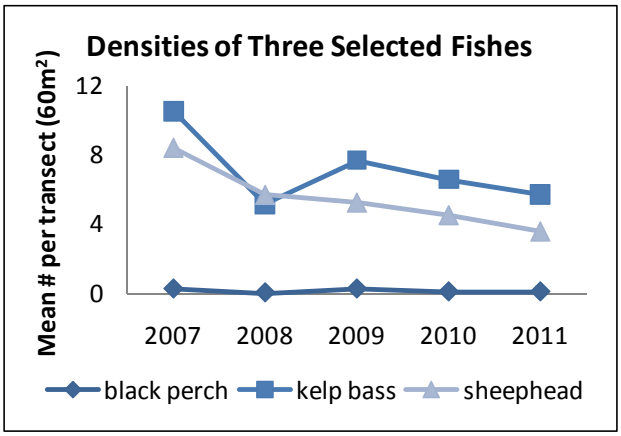


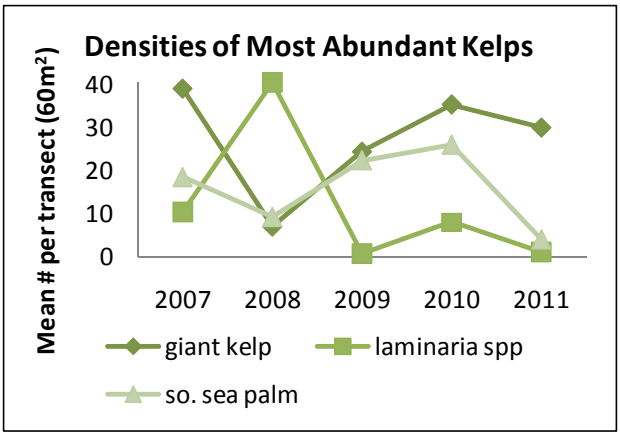
Indicator Species Observed: 24 of 35 fishes surveyed, 14 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

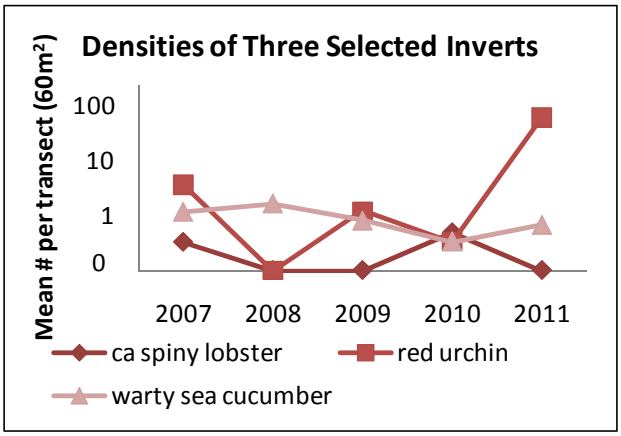
Invasive Algae: *Sargassum muticum, S. filicinum*











Reef Check California 2006-2011

WIES Intake Pipes

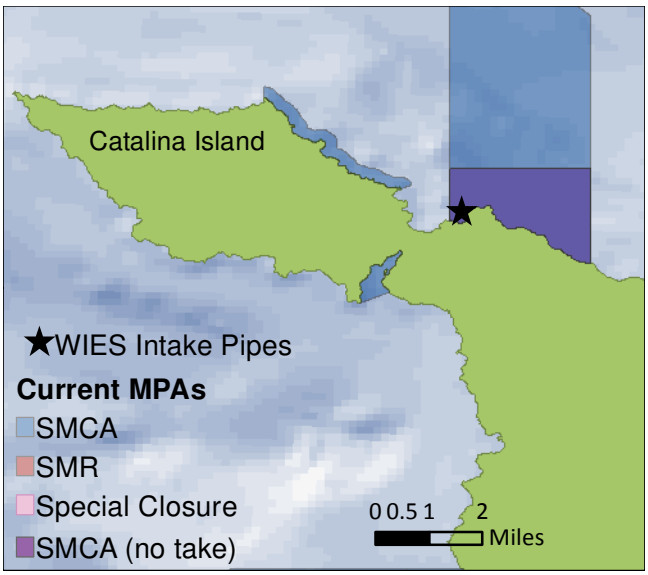
County: Los Angeles

Marine Protected Area: Blue Cavern SMCA (since 1/1/2012)

Restrictions: Take of all living marine resources is prohibited.

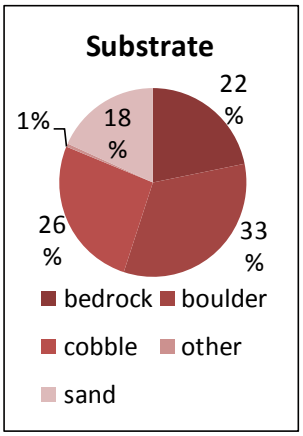
Survey history: 11/19/2007 11/24/2008 11/23/2009 11/20/2010 11/23/2011

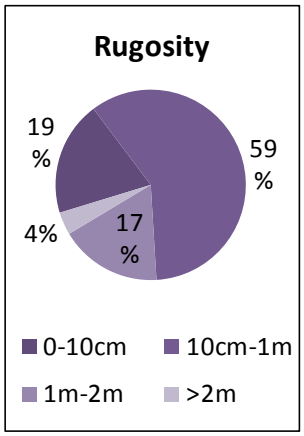
Survey Depths (ft): 11 - 60

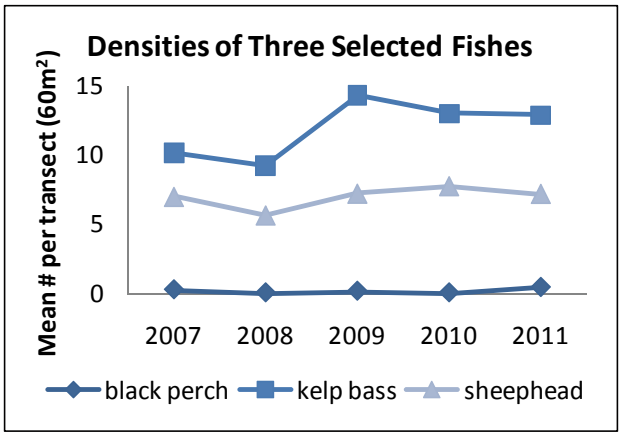


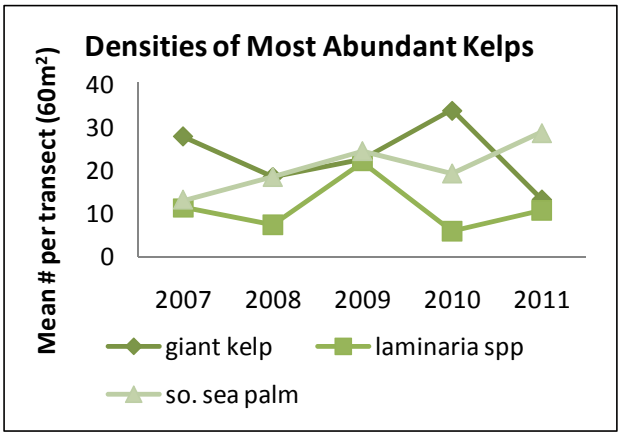
Indicator Species Observed: 26 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

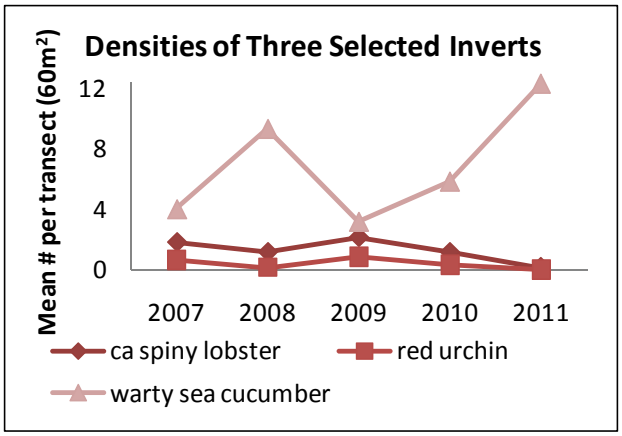
Invasive Algae: *Sargassum muticum, S. filicinum, Undaria pinnatifida*





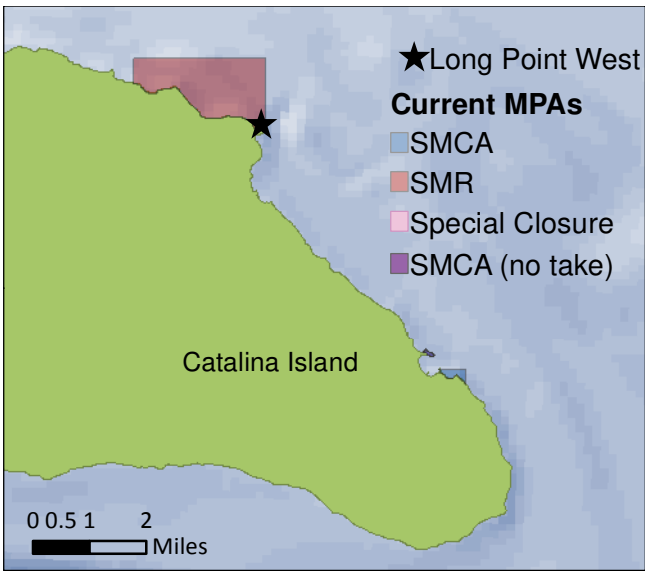






Reef Check California 2006-2011

Long Point West



County: Los Angeles

Marine Protected Area: Long Point SMR (since 1/1/12)

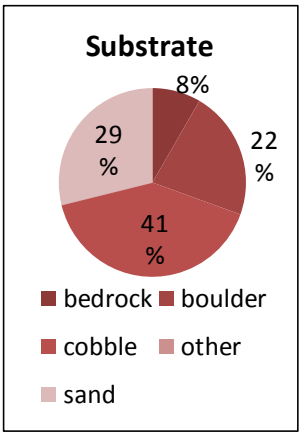
Restrictions: Take of all living marine resources prohibited

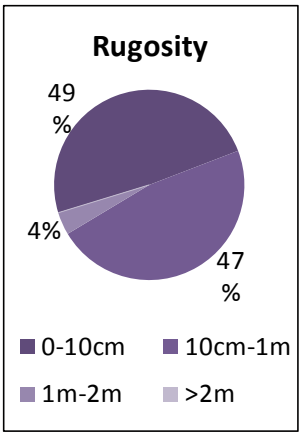
Survey history: 10/25/2010

Survey Depths (ft): 11 - 60

Indicator Species Observed: 19 of 35 fishes surveyed, 8 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

Invasive Algae: *Sargassum filicinum*





One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

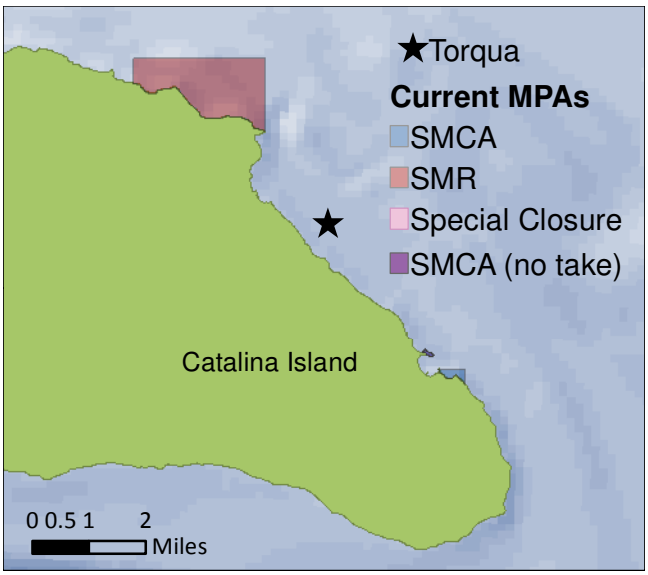
Reef Check California 2006-2011

Torqua

County: Los Angeles

Marine Protected Area: None

Restrictions: None

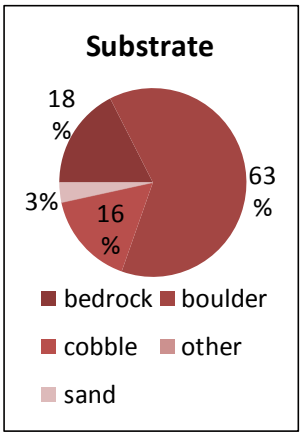


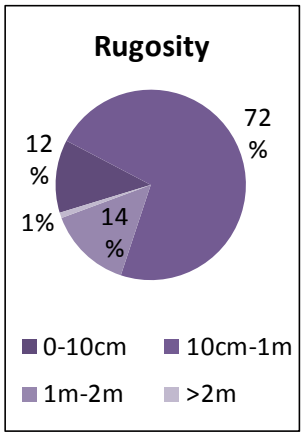
Survey history: 5/18/2008 11/3/2008 5/4/2009 10/19/2009 5/17/2010 9/27/2010 5/9/2011 9/26/2011

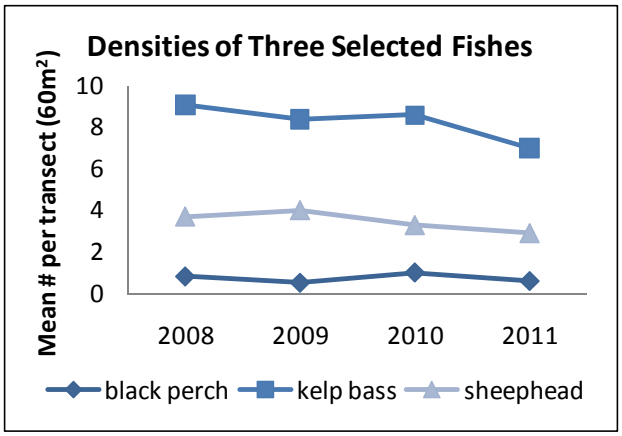
Survey Depths (ft): 12 - 55

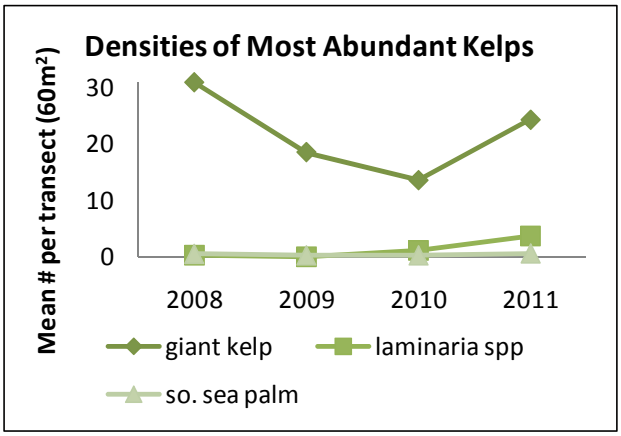
Indicator Species Observed: 24 of 35 fishes surveyed, 16 of 30 invertebrates surveyed, 3 of 5 seaweeds surveyed

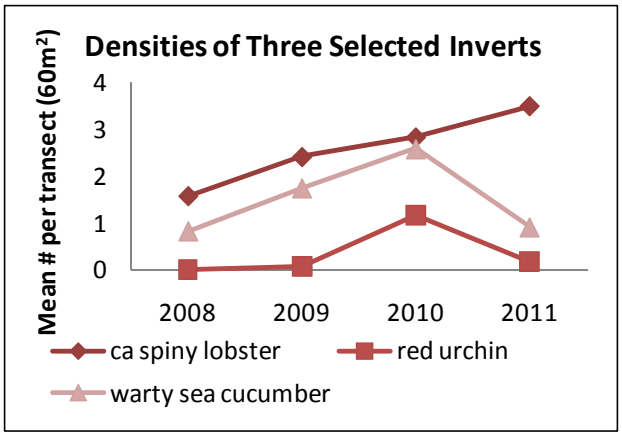
Invasive Algae: *Sargassum muticum, S. filicinum*











Reef Check California 2006-2011

Casino Point

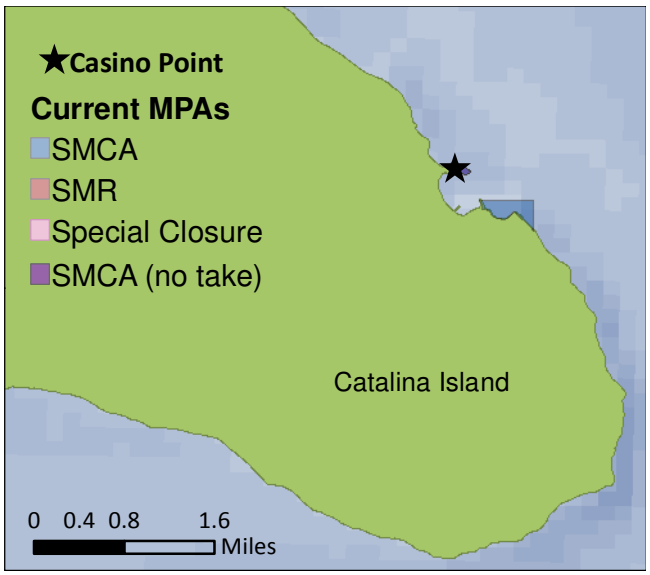
County: Los Angeles

Marine Protected Area: Casino Point SMCA (since 1/1/12)

Restrictions: Take of all living marine resources is prohibited.

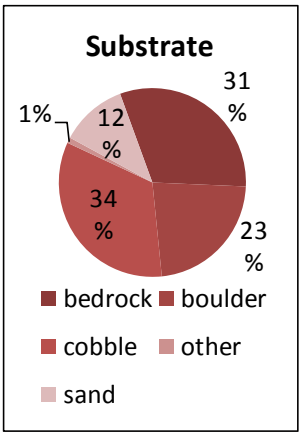
Survey history: 5/13/06 5/31/07 11/10/07 6/7/08 11/1/08 11/7/09 6/26/10 11/6/10 7/16/11 10/22/11

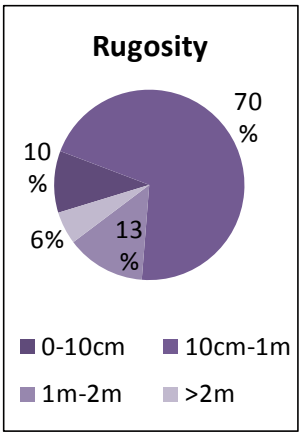
Survey Depths (ft): 16 - 70

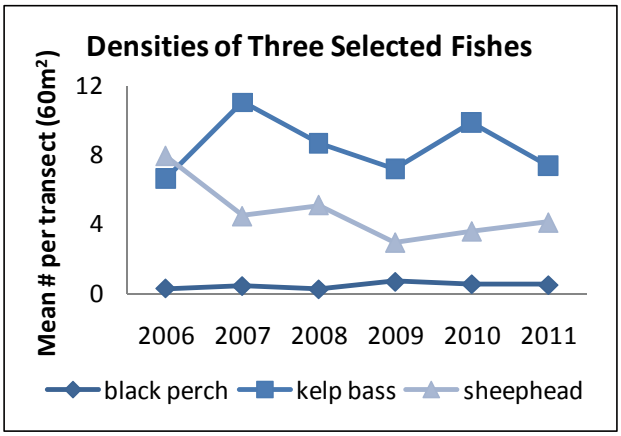


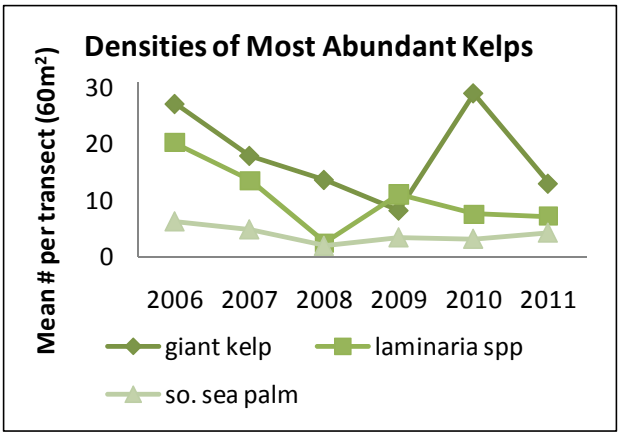
Indicator Species Observed: 26 of 35 fishes surveyed, 17 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

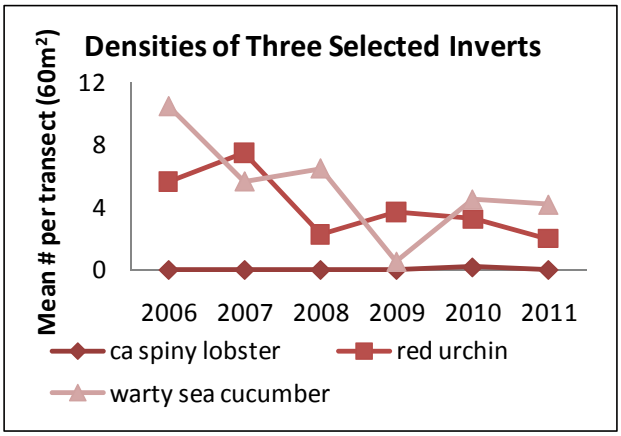
Invasive Algae: *Sargassum muticum, S. filicinum*











Reef Check California 2006-2011

La Jolla Cove

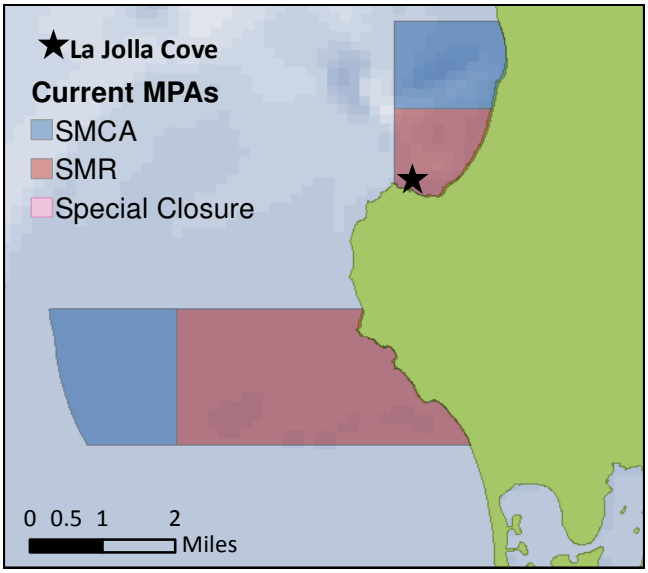
County: San Diego

Marine Protected Area: Matlahuayl SMR (2012; was La Jolla SMCA since 1971)

Restrictions: Take of all living marine resources prohibited

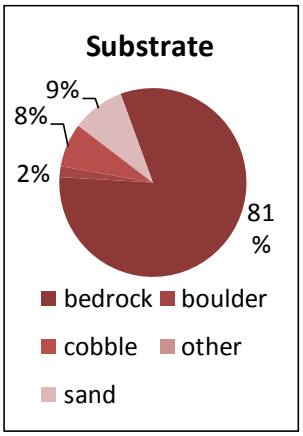
Survey history: 7/28/2007 5/17/2008 7/26/2008 5/30/2009 5/28/2010 7/30/2010 6/18/2011 8/21/2011

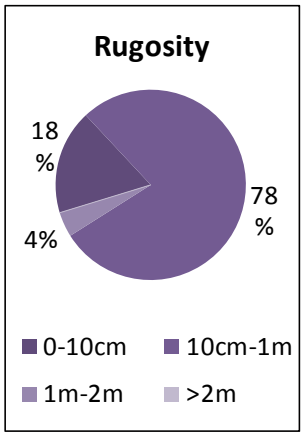
Survey Depths (ft): 22 - 43

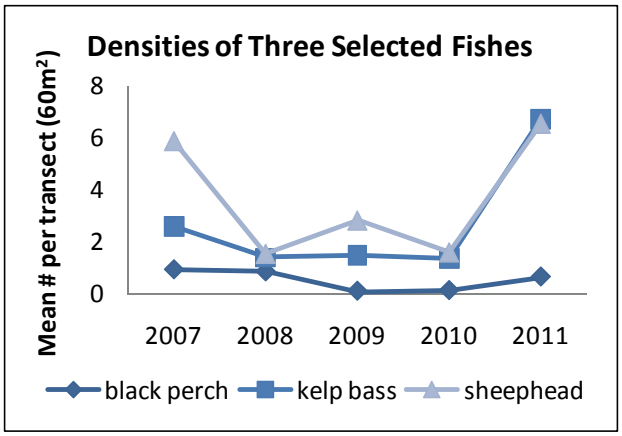


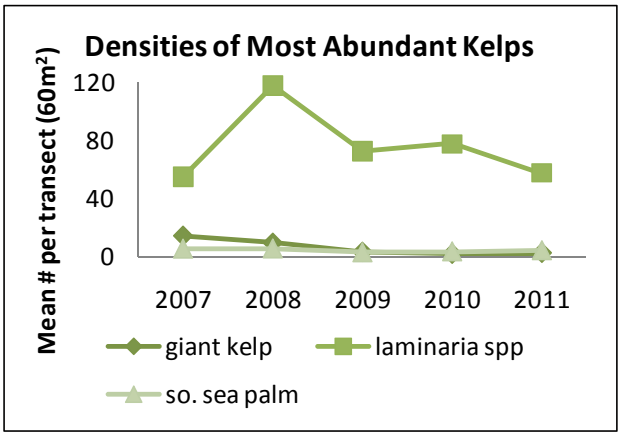
Indicator Species Observed: 18 of 35 fishes surveyed, 14 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

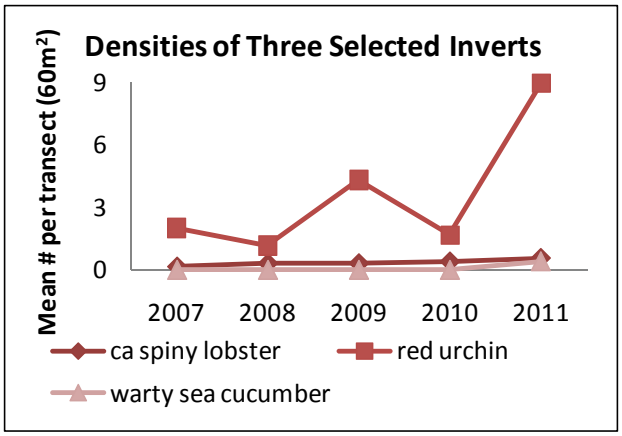
Invasive Algae: *Sargassum muticum, S. filicinum*





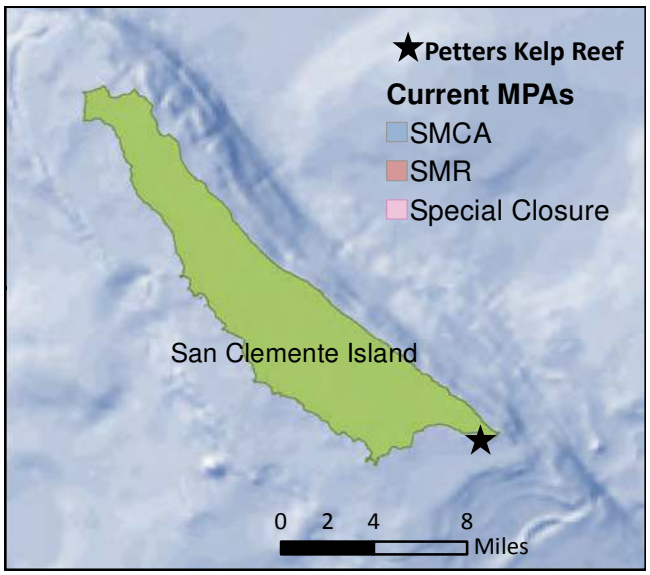






Reef Check California 2006-2011

Petter's Kelp Reef



County: San Diego

Marine Protected Area: None

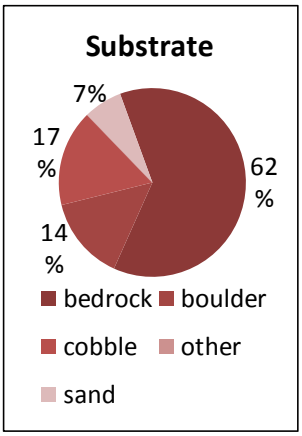
Restrictions: None

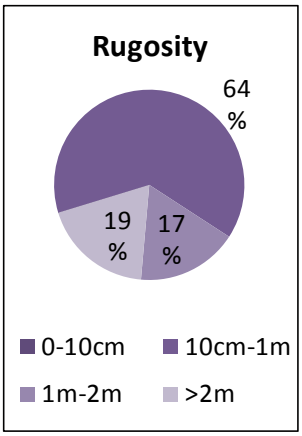
Survey history: 12/11/2010

Survey Depths (ft): 18 - 60

Indicator Species Observed: 15 of 35 fishes surveyed, 13 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

Invasive Algae: None





One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

One survey only, insufficient data for comparison

Reef Check California 2006-2011

North Hill Street

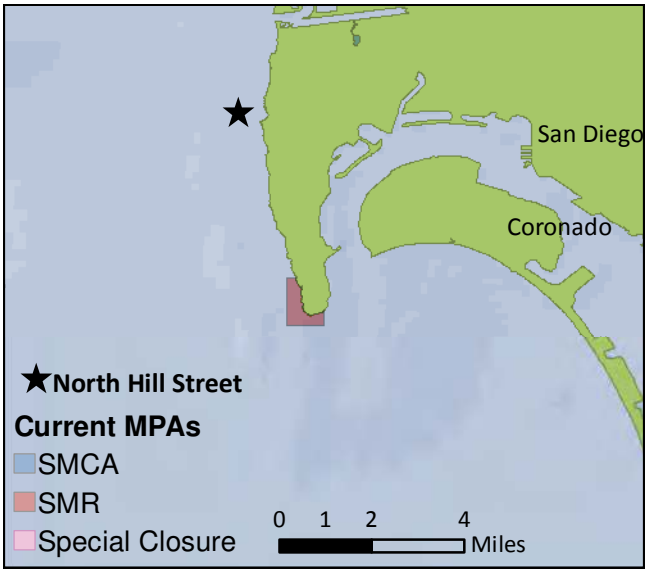
County: San Diego

Marine Protected Area: None

Restrictions: None

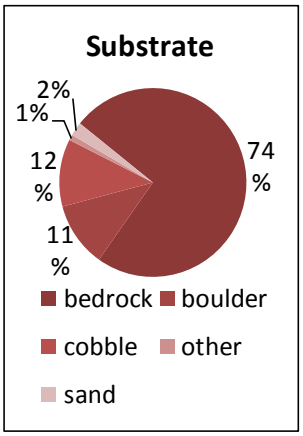
Survey history: 9/15/2007 9/13/2008 9/26/2009 9/25/2010 9/18/2011

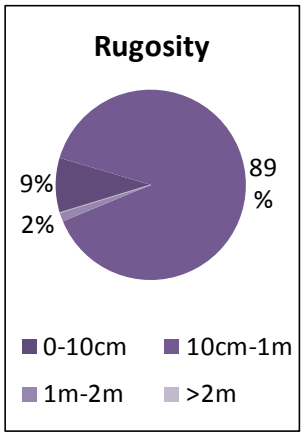
Survey Depths (ft): 29 - 49

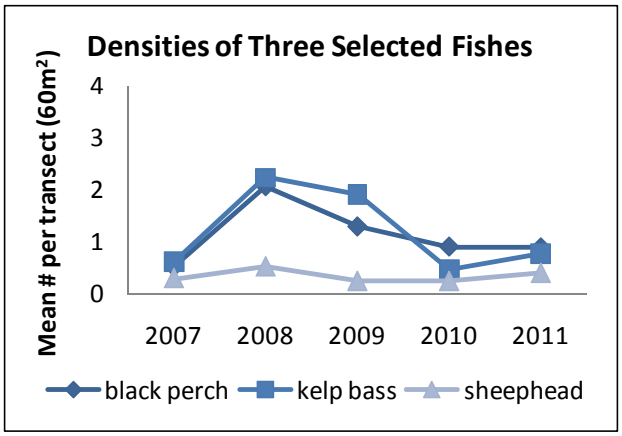


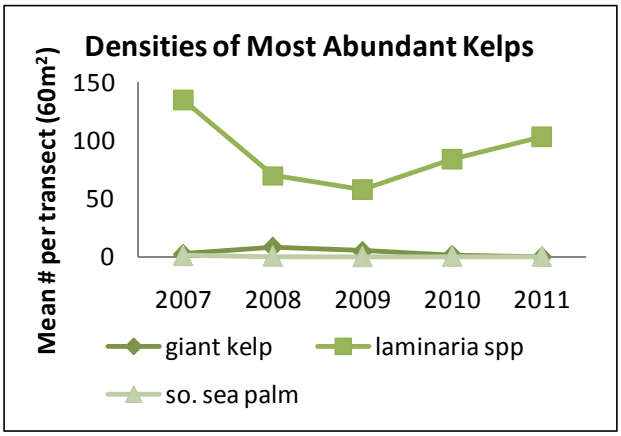
Indicator Species Observed: 24 of 35 fishes surveyed, 15 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

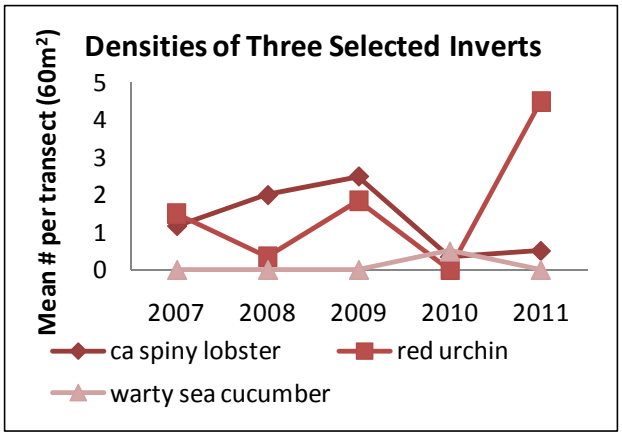
Invasive Algae: None











Reef Check California 2006-2011

Broomtail Reef

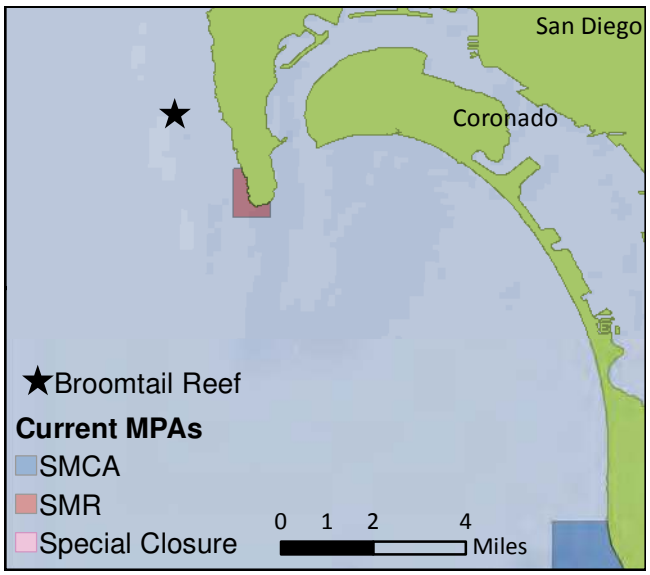
County: San Diego

Marine Protected Area: None

Restrictions: None

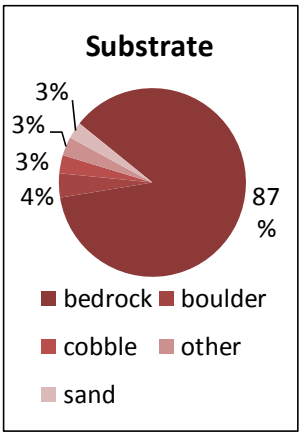
Survey history: 10/14/2007 6/14/2008 10/18/2008 6/28/2009 10/11/2009 10/17/2010 9/18/2011

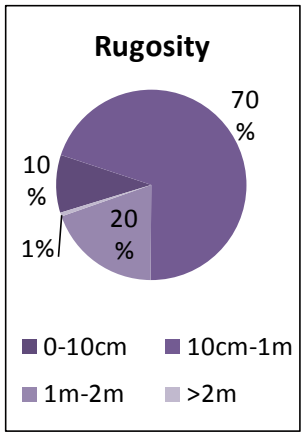
Survey Depths (ft): 27 - 48

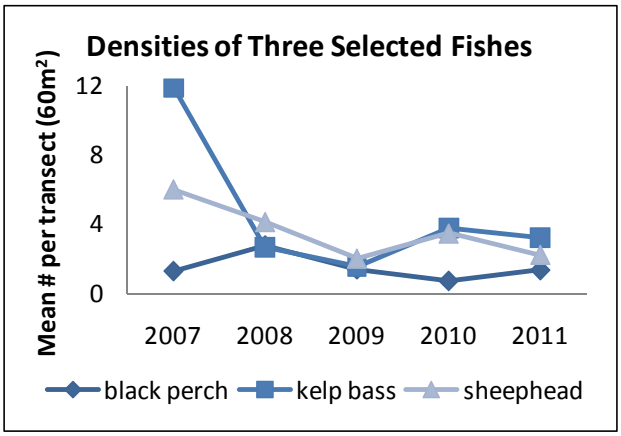


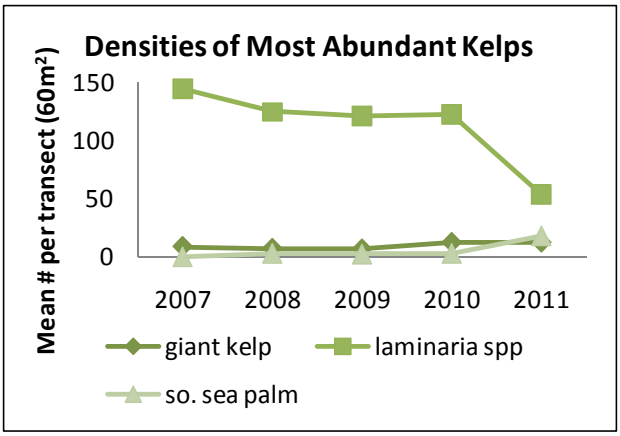
Indicator Species Observed: 26 of 35 fishes surveyed, 19 of 30 invertebrates surveyed, 4 of 5 seaweeds surveyed

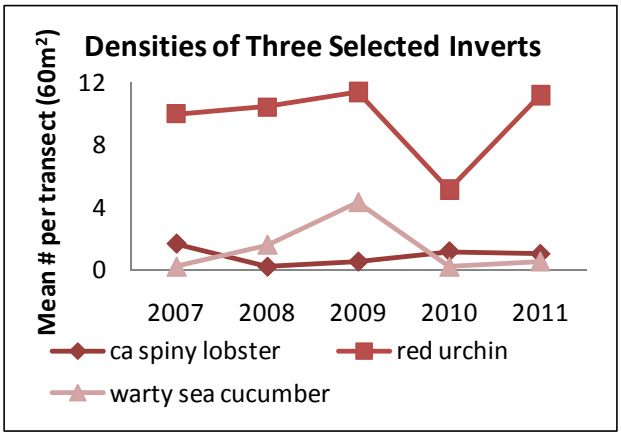
Invasive Algae: None











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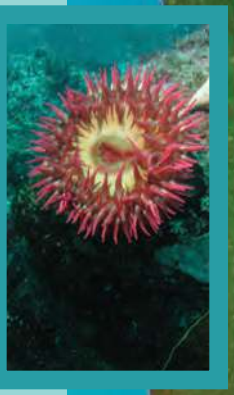

Reef Check Foundation
P.O. Box 1057
17575 Pacific Coast Highway
Pacific Palisades CA 90272-1057 USA
Tel: 1-310-230-2371
Email: rcinfo@reefcheck.org
http://reefcheck.org

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