Reef Check California: North Central Coast Baseline Surveys of Shallow Rocky Reef Ecosystems

Final Report

North Central Coast MPA Baseline Monitoring

2010-2013

Jan Freiwald, Megan Wehrenberg

Reef Check California

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Jan Freiwald, Megan Wehrenberg

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

Tel: 1-310-230-2371
california@reefcheck.org
www.reefcheck.org

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Executive Summary

Marine protected areas (MPAs) were implemented along California's North Central coast (NCCSR) in 2010 as a result of the Marine Life Protection Act (MLPA) legislation and in 2011 a collaborative comprehensive baseline monitoring program began to characterize the marine ecosystems of the region and investigate initial responses of these systems to MPA implementation should they occur. Reef Check California (RCCA), a program of the Reef Check Foundation, with the goal to improve marine management in California by providing critically needed data on California's near-shore rocky reef ecosystems through the use of volunteer citizen scientists, became part of the NCCSR baseline monitoring team. RCCAs objectives for NCCSR baseline monitoring were to use highly trained and certified citizen scientists to conduct baseline characterization of the shallow rocky reef and kelp forest ecosystem in the region, MPAs and reference areas and to build capacity for future long-term MPA monitoring in the region by conducting community trainings, education and providing support for local citizen scientist survey teams.

In 2010 and 2011 RCCA surveyed four of its five existing monitoring sites in the region each year and added two additional sites to its monitoring network in 2011. Since then RCCA has continued to monitor these seven sites in 2012 and 2013 and plans to do so in the years to come. During volunteer trainings in the study region in 2010/11 103 citizen scientists were trained or recertified. Additional divers were recruited from the program's volunteers in other regions of the state, particularly from central California and the scientific diving program at Humboldt State University. A total of 35 sites were surveyed in collaboration with PISCO, and abalone and urchin size frequency surveys were completed at all of these sites. This number far exceeded the proposed number of abalone/urchin surveys in the initial objectives and will provide a much more detailed picture of the populations of these species inside and outside of MPAs at the time of implementation. This success highlights the benefit and synergistic effects of collaborative efforts in the baseline monitoring of difficult and expensive-to-access subtidal habitats. All data collected by RCCA has been released to the public and can be viewed and downloaded at: http://ned.reefcheck.org. The data collected as part of the NCCSR baseline monitoring program (RCCA data and data collected in collaboration with PISCO) as well as detailed metadata can also be found at: http://oceanspaces.org/data.

RCCA's involvement in the NCCSR baseline monitoring demonstrates the effectiveness of using citizen scientists for data collection even in logistically challenging environments such as the rocky reefs and kelp forest along the North Central coast. Of special importance is the inclusion of regionally specific information, knowhow and understanding that locally experienced divers bring to the monitoring effort. An important benefit of involving the pubic (i.e. volunteers) in scientific data collection and the monitoring of California's MPAs, is that RCCA's training, education and monitoring provide an avenue for the public to be directly involved in the MPA management process from initial design and implementation to long-term monitoring and ecosystem condition assessment. RCCA's training and continued engagement of community members in scientific surveys provides an immersion-learning environment in which participants can gain knowledge of the ecosystems off their coast and engage in a meaningful effort to conserve and manage their marine resources. This training and engagement creates an informed, engaged, educated and politically active community of stakeholders that understand the value and importance of MPAs and MPA monitoring, and in turn go on to communicate that understanding to their communities and networks. RCCA thus trains, engages and educates the public and turns them into ocean stewards. The diversity of our volunteers, from commercial and recreational fishermen, to recreational divers, ocean enthusiasts, and professionals from wide range of fields, further compounds the importance of the educational component of our program by allowing us to reach and impact demographically diverse constituencies.

Multivariate community characterizations of the study region identified three distinct kelp forest communities in the study region. Communities in the shallow and protected coves along the Sonoma coast are different from communities around Point Arena, Mendocino, and deeper reefs at Point Arena are more similar to each other than a shallow reef in the Lions Cove SMCA (Figure 1). Physical aspects of reef substrate, the depths of the sites and the height of the relief mostly drive these differences. Many species are a factor in the differences between the communities but sea urchin, black or blue rockfish and striped perch densities contribute strongest to the differences between communities.

Bull kelp and Pterygophora are the most common canopy forming and understory kelps, respectively and several species of fishes and invertebrates are commonly found at all RCCA monitoring sites throughout the NCCSR (summaries of species' densities are reported for each site, for an example see Table 1):

Most frequent fish species in NCCSR:

- Kelp greenling
- Blue rockfish
- Black rockfish
- Black and yellow rockfish
- Gopher rockfish

Most frequent invertebrate species in NCCSR:

- Purple urchins
- Red urchins
- Bat stars
- Red abalone

In 2011, a die-off of red abalone and other invertebrates was reported along the Sonoma coast. The abalone data collected in collaboration between PISCO and RCCA documented this decline and RCCA's long-term dataset, especially from Gerstle Cove, puts this decline into historical context (Figure 2). A similarly strong decline was recorded in 2007 at Gerstle Cove. In contrast to 2007, the population decline in 2011 was geographically more widespread. Red abalone populations at RCCA's other long-term sites do not show increasing or decreasing population trends since they were first surveyed in 2007. Red abalone sizes inside and outside of the new MPAs did not show a significant change in mean size over the two years of baseline monitoring and sizes inside and out of MPAs were not significantly different across the study region. Red urchins, on the other hand, showed a 1.5 cm decline in mean size between 2010 and 2011 and a population decline from 2007 to 2012 in Reef Check long-term data.

Most of RCCA's long-term monitoring sites in the NCCSR are located outside of the new MPAs. This is due to the historic placement of sites at heavily impacted and easy to access coves along the coast. Nevertheless, these sites contribute to a characterization of the region as a whole and describe distinct kelp forest communities within the region. Intensive sampling of red abalone sizes inside and out of MPAs did not show significant differences in sizes. This is consistent with expectations for a slow growing species such as abalone two years after the establishment of MPAs.

The distinct communities identified by RCCA surveys suggests that long-term monitoring has to insure that sites inside and out of MPAs in all respective communities are monitored because ecological processes and management actions might act differently in different communities. Further, monitoring has to cover the entire depth range of the habitats of interest. RCCA's baseline data identified common species and provides a quantitative characterization of their densities in the respective kelp forest communities that will serve as a reference point for future measures of MPA performance. At the same time the program has expanded in the region, trained additional citizen scientists and built the capacity for continued long-term monitoring beyond the initial baseline monitoring program along the North Central coast.

Executive Summary Figures and Tables

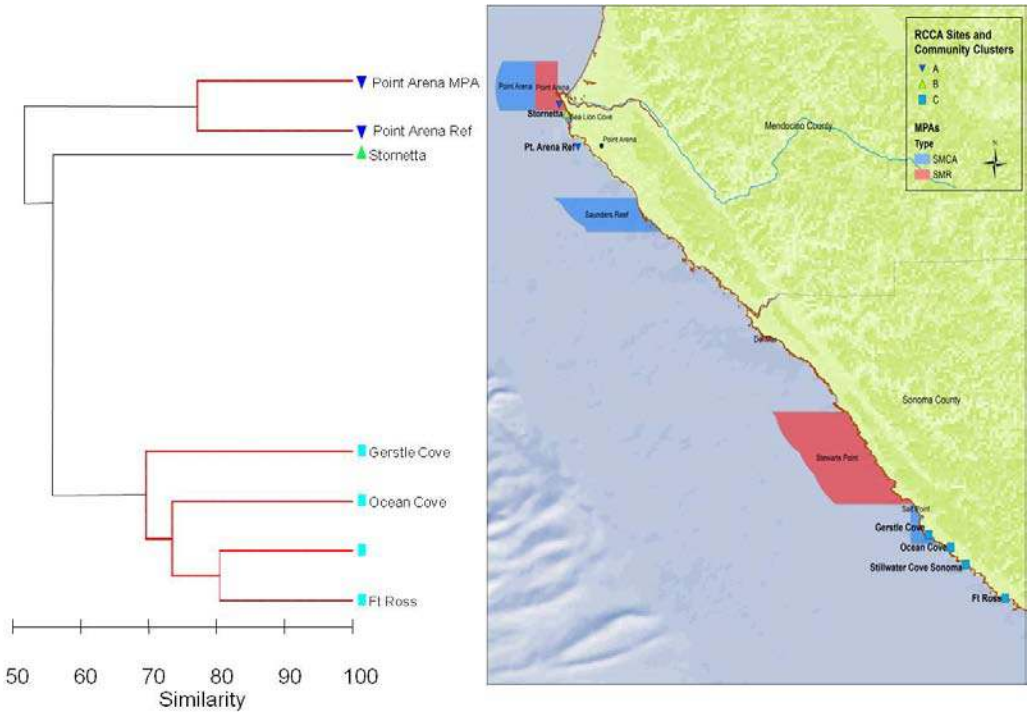

Figure 1. Community characterization of NCCSR. Three distinct kelp forest communities were identified during the baseline characterization.

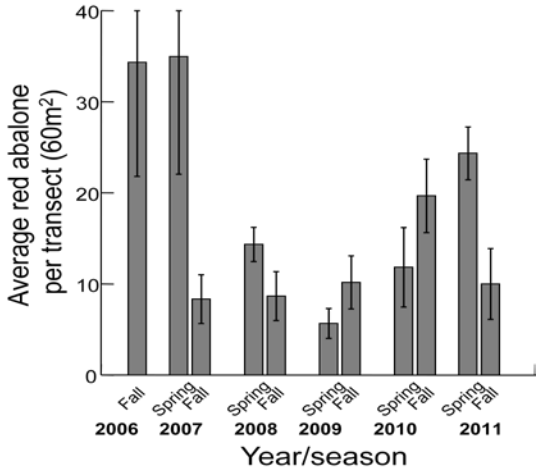

Figure 2. Red abalone densities at Gerstle Cove, Sonoma. Seasonal surveys show large population declines in 2007 and after the 'abalone die-off' in 2011.

Table 1. An example of RCCA density data: fish and invertebrate densities (60m^2) at Fort Ross site (2010-2011). For baseline characterization average densities of fishes, invertebrates and algae as well as physical habitat variables are reported for each site.

Common name	Scientific name	Mean Density	Std Error
Black and yellow rockfish	*Sebastes chrysomelas*	0.39	0.134
Black rockfish	*Sebastes melanops*	0.83	0.277
Blue rockfish	*Sebastes mystinus*	5.50	1.904
Brown rockfish	*Sebastes auriculatus*	0.03	0.028
China rockfish	*Sebastes nebulosus*	0.06	0.039
Copper rockfish	*Sebastes caurinus*	0.06	0.056
Gopher rockfish	*Sebastes carnatus*	1.11	0.248
Grass rockfish	*Sebastes rastrelliger*	0.00	0.000
Kelp rockfish	*Sebastes atrovirens*	0.11	0.087
Vermilion/canary rockfishes	*Sebastes miniatus*	0.03	0.028
Yellowtail/olive rockfishes	*Sebastes serranoides*	0.03	0.028
Young of the Year rockfishes	*Sebastes* spp.	1.28	0.535
Cabezon	*Scorpaenichthys marmoratus*	0.08	0.047
Kelp greenling	*Hexagrammos decagrammus*	1.53	0.205
Lingcod	*Ophiodon elongatus*	0.17	0.063
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.000
Black perch	*Embiotoca jacksoni*	0.19	0.096
Pile perch	*Rhacochilus vacca*	0.33	0.098
Rainbow perch	*Hypsurus caryi*	0.00	0.000
Rubberlip perch	*Rhacochilus toxotes*	0.08	0.047
Striped perch	*Embiotoca lateralis*	2.11	0.390
Common name	**Scientific name**	**Mean Density**	**Std Error**
Flat abalone	*Haliotis wallensis*	0.08	0.083
Pinto abalone	*Haliotis kantschatkana*	0.00	0.000
Red abalone	*Haliotis rufescens*	19.00	1.907
Rock scallop	*Crassedoma giganteum*	0.08	0.083
Wavy/red turban snail	*Lithopoma undosum*	0.00	0.000
Giant keyhole limpet	*Megathura crenulata*	0.08	0.083
Gumboot chiton	*Cryptochiton stelleri*	1.50	0.399
Purple urchin	*Strongylocentrotus purpuratus*	3.08	1.644
Red urchin	*Strongylocentrotus franciscanus*	9.58	3.011
Rock crab	*Cancer spp.*	0.00	0.000
Sheep/masking crab	*Loxorhynchus grandis & L. crispatus*	0.08	0.083
Bat star	*Patiria miniata*	127.90	40.061
Giant spined star	*Pisaster giganteus*	10.17	2.239
Short spined sea star	*Pisaster brevispinus*	4.42	1.305
Sunflower/sun star	*Solaster stimpsoni, S. dawsoni, Pycnopodia helianthoides*	2.33	0.310
CA sea cucumber	*Parastichopus californicus*	0.00	0.000
Large anemone	*Urticina* spp., *Metridium* spp., *Anthopleura* spp.	9.17	1.021

Narrative

Project Goals and Objectives

Reef Check California (RCCA) is a community-based reef monitoring network. RCCA's goal is to improve marine management in California in two ways: by providing critically needed data on California's near-shore rocky reef ecosystems through the use of volunteer scuba divers; and by educating and empowering the public to become active stewards of their marine environment. RCCA does this by engaging California's public in scientific monitoring of kelp forests and marine protected areas (MPAs). The participation in RCCA training and surveys fosters the support of science-based management of marine resources in participants and their communities. Reef Check California has been surveying California's near-shore rocky reefs and kelp forests since 2006 and monitors annually 75 primary sites from Mendocino to San Diego Counties and additional sites when conditions allow. Survey teams are organized and lead by trained Reef Check staff and sites are surveyed at roughly the same times each year. Before participating in surveys, volunteer divers go through an intensive 32 hr training and are only certified to do transect surveys after passing classroom and field-testing for each transect type. They are required to be recertified and tested by RCCA staff and before collecting data each year. Since the inception of the program RCCA has trained over 1000 divers in California and each year there is a team of about 250 active volunteers composed of newly trained or recently recalibrated members.

NCCSR Program Objectives

The Reef Check California program's objectives for the NCCSR baseline monitoring were:

1. To use highly trained and certified citizen scientists to conduct scientifically robust shallow subtidal baseline characterization of MPAs and reference areas using the RCCA protocol.
    a. Continue to monitor the abundance of key indicator species annually at 5 existing sites
    b. Add abalone and urchin size distribution surveys to the PISCO SCUBA project surveys at 10 sites located inside MPAs and associated reference sites
    c. Add full RCCA survey within Stewarts Pt. SMR coordinated with PISCO (1 site)
2. Build capacity for baseline and future long-term monitoring needs by conducting 1 community training (16 divers/yr) for the first 2 yrs of the project.
3. Post all data on web and produce integrated final report with collaborators.

Surveys

a. Existing RCCA sites

In 2010 RCCA completed surveys at four of our five existing long-term sites. Our site 'Ocean Cove' was not surveyed because of adverse conditions on numerous attempts. In 2011 we also surveyed four of our five sites and were unable to survey our site 'Stornetta', which is located in Sea Lion Cove SMCA, due to adverse conditions. Instead of adding a new site within the Steward Point SMR we added two sites inside and outside of the Point Arena SMR in 2011. These sites can be accessed more predictably and were chosen as identical locations of two of PISCO's sites to ensure some data overlap between the programs and the long-term monitoring of this MPA and a reference site. With the addition of these two sites we were able to survey beyond our proposed objectives. We continued to monitor our NCCSR sites in 2012, including the two new sites as well as our long-term sites.

The location of RCCA's existing sites in the study region allowed us to contribute to the characterization of the study region as a whole. Due to their placement at easy to access dive sites before the MPA implementation and the need for consistency in RCCA long-term monitoring, site locations were not moved in response of the MPA implementation and therefore not every site can be matched up for a direct inside/outside comparison in order to investigate initial responses of the ecosystem to MPA implementation. Newly established sites are placed inside and out of the Pt. Area SMR and their locations are identical to sites monitored by PISCO during the baseline project in order to facilitate comparisons to baseline information as these sites are monitored for the long-term by RCCA citizen scientists.

b. Abalone surveys with PISCO

In both 2010 and 2011, Reef Check California collaborated with the Partnership of Interdisciplinary Study of Coastal Oceans' (PISCO) subtidal monitoring team to conduct urchin and abalone density and size frequency surveys at each of PISCO's study sites. A total of 35 sites were surveyed by the collaborative team and abalone and urchin surveys were completed at all sites. This number far exceeds the proposed number of abalone/urchin surveys in the initial objectives (10 sites) and will provide a much more detailed picture of the populations of these species inside and outside of MPAs at the time of implementation. This success highlights the benefit and synergistic effects of collaborative efforts in the baseline monitoring of difficult and expensive-to-access subtidal habitats.

Reef Check began monitoring sites within the NCCSR in 2006 leading to a seven-year dataset consisting of 38 total surveys, as of the close of the 2012 survey season. Through our community and university partnerships and the support of the baseline monitoring program we have built the capacity to continue to monitor these sites annually well beyond the scope of the baseline program.

Capacity Building

During the two-year baseline monitoring period RCCA held five community trainings in Monterey, Sonoma, and Mendocino counties, adding a total of 67 new volunteer divers to the program. Included in this list is our first ever 2011 community training in Fort Bragg, where we trained eight very experienced divers with extensive local knowledge of the north coast. Volunteers from each of these three regions made up the NCCSR teams, traveling from north, south and east to survey our remote sites. The actual number of newly trained divers surveying the NCCSR region exceeded the proposed objective of 32 divers (16 per year).

In addition to our community trainings we trained and recertified divers from Humboldt State University (HSU). The HSU scientific diving program is our strongest partner in the region, not only providing a large pool of volunteers (45 newly trained and 21 recertified over the two year baseline period) but also in their continued commitment to surveying sites in Mendocino County. Additionally, we trained students and instructors from University of California, Santa Cruz (UCSC), California State University Monterey Bay (CSUMB), and Moss Landing Marine Laboratories in conjunction with their scientific diving classes. These partnerships ensure that each year a substantial number of experienced scientific divers are trained in the RCCA monitoring protocol at nearly no cost to Reef Check. These divers in turn bolster the program by adding to the number of divers and also in our capacity to utilize state and federal vessels (which accept AAUS certified divers only) to reach remote survey sites. These divers, particularly from HSU, have formed the core of our north/central and north coast survey teams and have helped to build the capacity for long-term monitoring of the NCCSR region and to expand our scope in the North Coast Study Region.

A major programmatic success since 2011 is that the high proportion of retained volunteers (> 50%) from previous years outweighs the proportion of newly trained volunteers. In other words, we are able to conduct less training and still have roughly the same number of active volunteers each year. This phenomenon is telling of the value of the experience volunteers have while being involved in MPA monitoring and it raises the level of proficiency of Reef Check California survey teams. This makes the program more cost effective, productive and reliable, and positions it well for the sustainable long-term monitoring of MPAs.

Citizen Science MPA monitoring

RCCA's involvement in the NCCSR baseline monitoring demonstrates the effectiveness of using citizen scientists for data collection even in logistically challenging environments such as the rocky reefs and kelp forests along the North Central coast. Of special importance is the inclusion of regionally specific information, knowhow and understanding that locally experienced divers bring to the monitoring effort. In the NCCSR, RCCA's diver network includes experienced volunteers that add local knowledge to the monitoring project that, in many cases, cannot be provided by RCCA staff or for that matter staff from other academic monitoring program that are not based in the study region. In turn these volunteers become educated in the scientific methods and gain a deeper understanding of their local marine ecosystem that they would not have without participating hands on in the scientific monitoring of the MPAs.

> "Reef Check makes me feel hopeful. It is a great program that allows the networking of science professionals and people like myself who want to do something to help."
> – Bill Field, Avrey & Reese Builders -- Sebastopol

Volunteer divers, such as Bill, who are often scuba instructors themselves, can take the information and skills learned though their participation in Reef Check to educate their own students. A good example of this was the harmful algae bloom and related invertebrate die-off in fall of 2011 along the Sonoma County coast. By participating in surveys documenting this event, local RCCA citizen scientists had firsthand knowledge and could inform others about the events off their local coast.

An important benefit of involving the pubic (i.e. volunteers) in the monitoring of California's MPAs, is that RCCA's training, education and monitoring provide an avenue for the public to be directly involved in the MPA management process from initial design and implementation to long-term monitoring and ecosystem condition assessment. RCCA's training and continued engagement of community members and students in scientific surveys provides an immersion-learning environment in which participants can gain knowledge of the ecosystems off their coast and engage in a meaningful effort to conserve and manage their marine resources.

> "I partner with Reef Check because there is a need for more surveying in Northern California ….Our involvement with Reef Check California has made our 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, Diving Safety Officer, Humboldt State University

RCCA thus trains, engages and educates the public and turns them into ocean stewards. The diversity of our volunteers, from commercial and recreational fishermen, to recreational divers, ocean enthusiasts,

and professionals from a wide range of fields, allows us to reach and impact demographically diverse constituencies. In contrast to many citizen science programs that have an educational focus, RCCA's goal is to collect and provide scientifically rigorous data to inform marine management. The fact that volunteers are involved in a program that provides data to marine managers and decision makers, through its participation the MPA baseline monitoring programs, is a real motivation for volunteers to continue to be involved.

> "Reef Check California has taught me to respect the ocean environment on a much higher level...The fact that [Reef Check] puts 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."
> – Michelle Hoalton, Vice President of an engineering firm -- Huntington Beach

Therefore, RCCA's participation in the baseline monitoring is a two way street: it provides a way to collect scientific data in a cost-effective way and at the same time the program's participation in scientific programs such as this keeps volunteers motivated to continue their efforts.

Survey Methods

Reef Check California surveys consist of random (i.e. haphazard) 30 m x 2 m benthic transects to monitor key species of fishes (35 species), invertebrates (33 species), algae (5 species & 4 invasive species), and to characterize the reef substrate and relief. Species are selected because of their ecological or economic importance or because they are of specific management concerns. On each transect species are identified and counted, and, in the case of fish, abalones, and urchins, sized. Abalone and sea urchins are sized to the nearest centimeter and fish sizes are recorded in three size classes. This approach to sizing fish has been changed in 2013 - after completion of baseline monitoring in the NCCSR - so that now fish are sized to the nearest centimeter as well. This change to the protocol was initiated because it became apparent that larger size classes limit the ability to investigate early signs of MPA effects that are likely to be reflected in changes to population size structures. Going forward this new protocol will allow us to investigate these changes as we continue long-term monitoring.

Allocation of transects are stratified into inshore (5 -12m) and offshore (12-20m) strata. In each stratum, three core transect, consisting of a fish, invertebrate, algae, and uniform point contact (UPC) transect are conducted by a dive team on alternate passes along the same transect. Additionally, six fish transects are placed around the core transects in each stratum. Transects are conducted parallel to shore or along depth isobaths within an area that corresponds to 250 m of linear coastline. The RCCA species list is the same for the entire state allowing for analyses at various spatial scales. Reef Check California's monitoring protocol can be found at: http://reefcheck.org/rcca/monitoring_protocol.php.

Data quality assurance is an important aspect of any monitoring program and is an especially critical part to the data collection and management process in a citizen science program such as RCCA in which many individuals are involved across a state. Reef Check has build data quality assurance and control mechanisms into its protocol at every step from the collection in the field to the final public data release. Immediately following each dive, each team member must review their datasheet for completeness and legibility. The team leader verifies this prior to collection of each datasheet and discusses any potential outliers with the team member. If a consensus on any data cannot be reached, the team leader will flag the datasheet for further review by the data manager. All data are entered into a database through RCCA's online Nearshore Ecosystem Database (NED). This system allows data entry

from anywhere and has built in data checking capabilities identifying outliers (e.g., unusually high numbers of a species, species that are not usually found in a give geographic region). Unusual data are flagged for review. If data are flagged they are discussed with the person that collected the data and then they are reviewed by RCCA staff. In a third step all data entries are checked by RCCA staff by comparing them to the field datasheets and finally automated data checks (e.g., outliers, unusual observations and data entry errors) are run on the entire database before the annual release of the database. All of RCCA's data can be viewed and downloaded at: http://ned.reefcheck.org

The data collected as part of the NCCSR baseline monitoring program (RCCA data and data collected in collaboration with PISCO) as well as detailed metadata can also be found at: http://oceanspaces.org/data.

Financial Report

Reef Check California budget and actual costs for NCCSR baseline monitoring

Category Reimbursement	Category Budget	Total Cost to Date	Remaining Balance
Salaries	$ 95,136.25	$ 95,239.00	$ (102.75)
Benefits	$ 23,064.75	$ 23,036.60	$ 28.15
Supplies	$ 21,125.00	$ 20,293.39	$ 831.61
Travel	$ 13,014.00	$ 12,930.01	$ 83.99
Other Costs			$ -
Indirect	$ 18,251.00	$ 17,896.51	$ 354.49
TOTAL	**$ 170,591.00**	**$ 169,395.51**	**$ 1,195.49**

The above budget and actual costs represents the project expenses as of the end of March 2013. The budget represents the current budget after two approved budget change requests and therefore differs from the original budget submitted at the beginning of the project in 2010. Budget changes were carried out in September 2011 and in November 2012 to transfer funds from benefits to salary and from indirect costs to salaries, respectively. After these budget adjustments, the current actual costs do not exceed the budgeted cost by more than 10% in any category. Most of the requested funds have been spent as intended and presented in the revised budget. The remaining balance of $1,195.49 will be spent over the coming months as we work with collaborators and the MPA Monitoring Enterprise on integrating the project's final reports of the baseline monitoring into a final combined report for the study region and as we continue the long-term monitoring of RCCA's sites in the study region in 2013.

Baseline Characterization

Locations of Sites

Reef Check California has established a total of seven subtidal rocky reef monitoring sites within the North Central Coast Study Region (NCCSR). Three of the sites are located within MPAs, and four are located outside of MPAs. Five of the sites were established before implementation of the NCCSR MPAs, and two sites were established as part of the Baseline Program (Table 2).

Table 2. RCCA monitoring sites and survey dates within the NCCSR.

Site	Survey year	Survey Month	Latitude	Longitude
Ft Ross	2007	8	38.5106	-123.2450
Ft Ross	2008	10		
Ft Ross	2009	10		
Ft Ross	2010	9		
Ft Ross	2011	9		
Ft Ross	2012	9	38.5106	-123.2450
Stillwater Cove Sonoma	2007	10	38.5402	-123.2888
Stillwater Cove Sonoma	2008	10		
Stillwater Cove Sonoma	2009	7		
Stillwater Cove Sonoma	2010	7		
Stillwater Cove Sonoma	2010	10		
Stillwater Cove Sonoma	2011	10		
Stillwater Cove Sonoma	2012	6		
Stillwater Cove Sonoma	2012	9		
Ocean Cove	2007	10	38.5551	-123.3056
Ocean Cove	2008	11		
Ocean Cove	2009	10		
Ocean Cove	2011	10		
Ocean Cove	2012	9		
Gerstle Cove	2006	11		
Gerstle Cove	2007	3		
Gerstle Cove	2007	10		
Gerstle Cove	2008	3		
Gerstle Cove	2008	10		
Gerstle Cove	2009	6		
Gerstle Cove	2009	10		
Gerstle Cove	2010	6		
Gerstle Cove	2010	10		
Gerstle Cove	2011	4		
Gerstle Cove	2011	9		
Gerstle Cove	2012	7		
Gerstle Cove	2012	11		
Point Arena Ref	2011	9	38.9080	-123.7191
Point Arena Ref	2012	10		
Stornetta	2007	9	38.9372	-123.7319
Stornetta	2010	10		
Point Arena MPA	2011	9	38.9448	-123.7405
Point Arena MPA	2012	10		

The RCCA sites are located in two groups, three sites near the the northern boundary of the study region at Point Arena, and four sites are located within sheltered coves along the Sonoma coast. The sites in the coves are typically shallow and accessable from shore whereas the sites near Point Arena are accesable by boat (Figure 3).

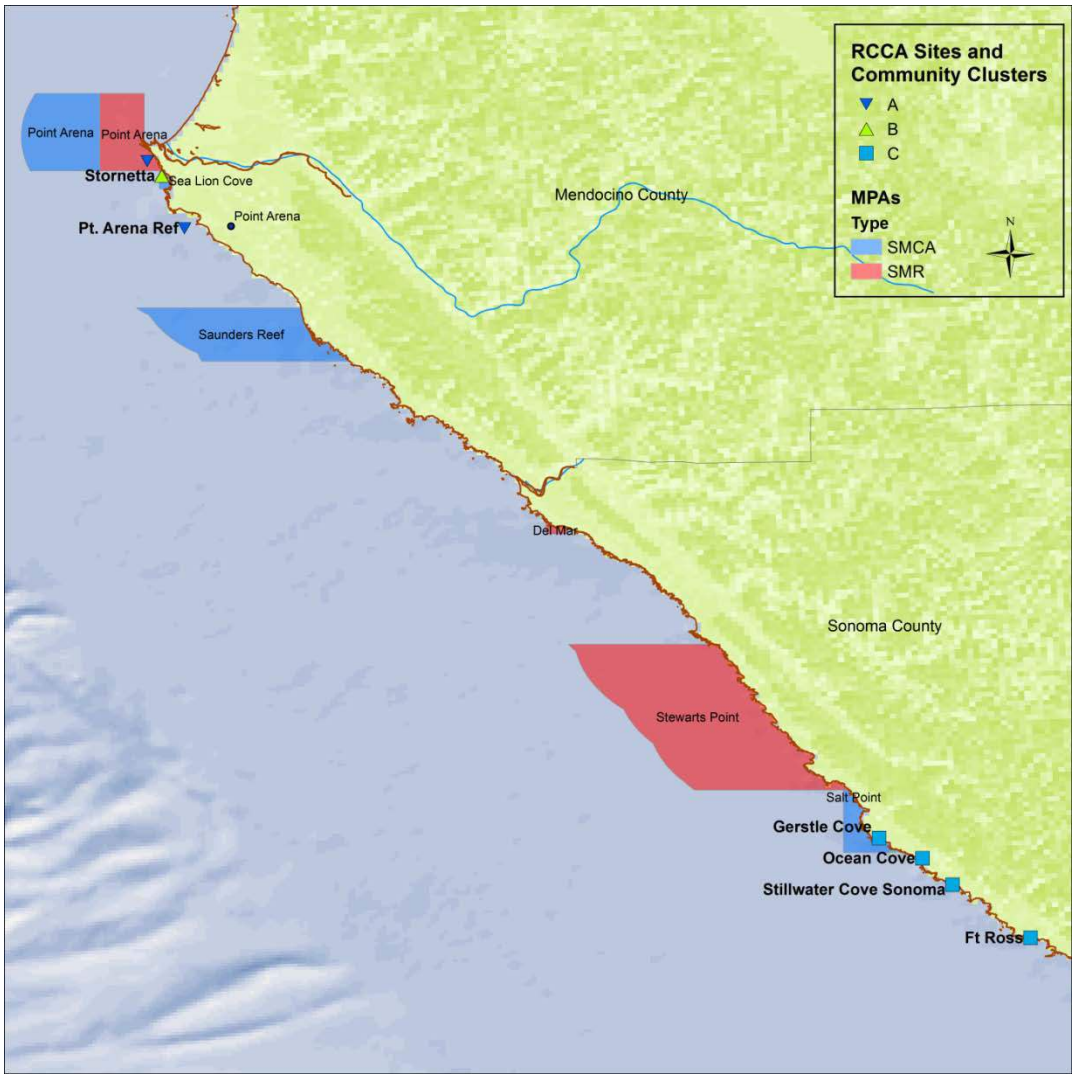

Figure 3. RCCA monitoring sites in NCCSR. Community clusters are indicated as identified by the analysis of community dissimilarities (see Figure 11).

Site Characteristics

Site Descriptions

Included in the following pages are descriptions of the physical and biological characteristics of each of the Reef Check sites located in the NCCSR based on the 2010 and 2011 baseline surveys for the sites that were already present in the study region and data from 2011 and 2012 for the two Point Arena sites that were established in 2011. Since the 'Stornetta' site was only surveyed in 2010 all analysis for this site are based on one year of data only.

For each site the mean densities of fish, invertebrate and algae species are summarized in table format. Pertinent additional information is described in a short narrative for each site. Fish, invertebrate and algae densities are presented as the mean density and associated standard error for a 60 m^2 area. Mean densities are calculated across the two baseline survey years (i.e. 2010/11 or 2011/12) at each site and the associated standard error is estimated across all transects from both years. During RCCA surveys, fish densities are estimated along 18 transects, each covering 60 m^2 (30 X 2m). Invertebrate and algae densities are estimated along six 60 m^2 (30 X 2m) transects. A detailed survey protocol can be found at: http://reefcheck.org/rcca/monitoring_protocol.php

The physical characteristics of Reef Check California's monitoring sites are described in terms of reef substrate type and the reef relief in four categories, respectively. They are presented as the percentage of each substrate type and relief category as determined by uniform point contact surveys of 30 points along six 30 meters long transects at each sites. Rugosity (vertical relief) is estimated by determining the greatest height difference that exists within a 1 meter by 0.5 meter box at each point along the transect. Additionally, the primary biological substrate cover (attached organisms) is described in nine categories of organisms (only organisms actually found at a site are presented in the tables). Substrate and relief are characterized as follows:

Substrate categories:

- Sand – Grain size less than 0.5 cm (including shell debris, silt and clay)
- Cobble – Grain size 0.5 cm – 15 cm
- Boulder – Rocky substrate ranging in size from 15 cm to 1m in diameter
- Bedrock – Rocky substrate larger than 1 meter in diameter
- Other materials such as metal or concrete are recorded as 'other' when encountered

Relief Categories:

- 0 to 10 cm difference between highest and lowest point
- 10 cm to 1 m difference between highest and lowest point
- 1m to 2 m difference between highest and lowest point
- More than 2 m difference between highest and lowest point

Fort Ross

Reef Check California's 'Fort Ross' site is located at 38.510° North and 123.245° West and has been surveyed annually since 2007. The monitoring transects are located south east of the rocky outcropping that divides the cove at Fort Ross State Park into a western and eastern cove. This site is accessible from the beach. There are no take restrictions other than the general fishing regulations at this site, and it is a popular abalone diving sites in Sonoma County.

Figure 4. RCCA Fort Ross site. Approximate survey area is indicated in yellow and orientation of core transects in red.

Table 3.Physical characteristics and primary substrate cover at Fort Ross site (2010-2011).

Average depth	7.28 meters

Substrate type	**Percentage**
Bedrock	54%
Boulders	22%
Cobble	14%
Sand	10%

Relief	**Percentage**
0-10cm	2%
10 cm-1meter	68%
1-2meter	27%
>2 meters	3%

Substrate Cover	**Percentage**
Articulated coralline	7.3%
Brown seaweed	9.1%
Crustose coralline	28.5%
Green seaweed	2.4%
Mobile invertebrates	0.6%
None	11.8%
Other brown seaweed	4.5%
Red seaweed	15.2%
Sessile invertebrates	20.6%

Table 4. Fish densities (60m^2) at Fort Ross site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Black and yellow rockfish	*Sebastes chrysomelas*	0.39	0.134
Black rockfish	*Sebastes melanops*	0.83	0.277
Blue rockfish	*Sebastes mystinus*	5.50	1.904
Brown rockfish	*Sebastes auriculatus*	0.03	0.028
China rockfish	*Sebastes nebulosus*	0.06	0.039
Copper rockfish	*Sebastes caurinus*	0.06	0.056
Gopher rockfish	*Sebastes carnatus*	1.11	0.248
Grass rockfish	*Sebastes rastrelliger*	0.00	0.000
Kelp rockfish	*Sebastes atrovirens*	0.11	0.087
Vermilion/canary rockfishes	*Sebastes miniatus*	0.03	0.028
Yellowtail/olive rockfishes	*Sebastes serranoides*	0.03	0.028
Young of the Year rockfishes	*Sebastes* spp.	1.28	0.535
Cabezon	*Scorpaenichthys marmoratus*	0.08	0.047
Kelp greenling	*Hexagrammos decagrammus*	1.53	0.205
Lingcod	*Ophiodon elongatus*	0.17	0.063
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.000
Black perch	*Embiotoca jacksoni*	0.19	0.096
Pile perch	*Rhacochilus vacca*	0.33	0.098
Rainbow perch	*Hypsurus caryi*	0.00	0.000
Rubberlip perch	*Rhacochilus toxotes*	0.08	0.047
Striped perch	*Embiotoca lateralis*	2.11	0.390

Table 5. Invertebrate densities (60m^2) at Fort Ross site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Flat abalone	*Haliotis wallensis*	0.08	0.083
Pinto abalone	*Haliotis kantschatkana*	0.00	0.000
Red abalone	*Haliotis rufescens*	19.00	1.907
Rock scallop	*Crassedoma giganteum*	0.08	0.083
Wavy/red turban snail	*Lithopoma undosum*	0.00	0.000
Giant keyhole limpet	*Megathura crenulata*	0.08	0.083
Gumboot chiton	*Cryptochiton stelleri*	1.50	0.399
Purple urchin	*Strongylocentrotus purpuratus*	3.08	1.644
Red urchin	*Strongylocentrotus franciscanus*	9.58	3.011
Rock crab	*Cancer spp.*	0.00	0.000
Sheep/masking crab	*Loxorhynchus grandis & L. crispatus*	0.08	0.083
Bat star	*Patiria miniata*	127.90	40.061
Giant spined star	*Pisaster giganteus*	10.17	2.239
Short spined sea star	*Pisaster brevispinus*	4.42	1.305
Sunflower/sun star	*Solaster stimpsoni, S. dawsoni, Pycnopodia helianthoides*	2.33	0.310
CA sea cucumber	*Parastichopus californicus*	0.00	0.000
Large anemone	*Urticina* spp., *Metridium* spp., *Anthopleura* spp.	9.17	1.021

Table 6. Algae densities (60m^2) at Fort Ross site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Bull kelp	*Nereocystis luetkeana*	111.52	25.221
Giant kelp	*Macrocystis pyrifera*	0.00	0.000
Laminaria spp	*Laminaria* spp	0.92	0.398
Pterygophora	*Pterygophora californica*	240.81	33.431
Southern sea palm	*Eisenia arborea*	0.00	0.000

Stillwater Cove

Reef Check California's 'Stillwater Cove' site is located at 38.540° North and 123.288° West and has been surveyed annually since 2007. The monitoring transects are located within the cove along the northern shore of the cove. This site is accessible from the beach. There are no take restrictions other than the general fishing regulations at this site, and it is a popular abalone diving sites in Sonoma County.

Figure 5. RCCA Stillwater Cove, Sonoma site. Approximate survey area is indicated in yellow and orientation of core transects in red.

Table 7. Physical characteristics and primary substrate cover at Stillwater Cove site (2010-2011)

Average depth	6.58 meters

Substrate type	Percentage
Bedrock	48.89%
Boulders	34.81%
Cobble	13.15%
Other	0.74%
Sand	2.41%

Relief	Percentage
0-10cm	3.70%
10 cm-1meter	79.07%
1-2meter	14.63%
>2 meters	2.59%

Substrate Cover	Percentage
Articulated coralline	39.81%
Brown seaweed	2.96%
Crustose coralline	20.74%
Green seaweed	0.19%
Mobile invertebrates	10.93%
None	4.63%
Other brown seaweed	17.04%
Red seaweed	0.19%
Sessile invertebrates	3.52%

Table 8. Fish densities (60m^2) at Stillwater Cove site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Black and yellow rockfish	*Sebastes chrysomelas*	0.41	0.114
Black rockfish	*Sebastes melanops*	0.09	0.040
Blue rockfish	*Sebastes mystinus*	2.37	1.667
Brown rockfish	*Sebastes auriculatus*	0.00	0.000
China rockfish	*Sebastes nebulosus*	0.02	0.019
Copper rockfish	*Sebastes caurinus*	0.02	0.019
Gopher rockfish	*Sebastes carnatus*	0.00	0.000
Grass rockfish	*Sebastes rastrelliger*	0.00	0.000
Kelp rockfish	*Sebastes atrovirens*	0.04	0.026
Vermilion/canary rockfishes	*Sebastes miniatus*	0.02	0.019
Yellowtail/olive rockfishes	*Sebastes serranoides*	0.02	0.019
Young of the Year rockfishes	*Sebastes* spp.	0.78	0.392
Cabezon	*Scorpaenichthys marmoratus*	0.07	0.036
Kelp greenling	*Hexagrammos decagrammus*	1.48	0.199
Lingcod	*Ophiodon elongatus*	0.04	0.026
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.000
Black perch	*Embiotoca jacksoni*	0.04	0.026
Pile perch	*Rhacochilus vacca*	0.35	0.225
Rainbow perch	*Hypsurus caryi*	0.02	0.019
Rubberlip perch	*Rhacochilus toxotes*	0.04	0.026
Striped perch	*Embiotoca lateralis*	1.59	0.386

Table 9. Invertebrate densities (60m^2) at Stillwater Cove site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Flat abalone	*Haliotis wallensis*	0.00	0.000
Pinto abalone	*Haliotis kantschatkana*	0.00	0.000
Red abalone	*Haliotis rufescens*	28.44	2.614
Rock scallop	*Crassedoma giganteum*	0.11	0.111
Wavy/red turban snail	*Lithopoma undosum*	0.06	0.056
Giant keyhole limpet	*Megathura crenulata*	0.06	0.056
Gumboot chiton	*Cryptochiton stelleri*	2.56	0.506
Purple urchin	*Strongylocentrotus purpuratus*	2.00	1.069
Red urchin	*Strongylocentrotus franciscanus*	5.11	2.253
Rock crab	*Cancer spp.*	0.00	0.000
Sheep/masking crab	*Loxorhynchus grandis & L. crispatus*	0.00	0.000
Bat star	*Patiria miniata*	188.66	29.438
Giant spined star	*Pisaster giganteus*	1.83	0.643
Short spined sea star	*Pisaster brevispinus*	0.39	0.270
Sunflower/sun star	*Solaster stimpsoni, S. dawsoni, Pycnopodia helianthoides*	1.56	0.422
CA sea cucumber	*Parastichopus californicus*	0.00	0.000
Large anemone	*Urticina* spp., *Metridium* spp., *Anthopleura* spp.	6.78	0.674

Table 10. Algae densities (60m^2) at Stillwater Cove site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Bull kelp	*Nereocystis luetkeana*	46.37	17.551
Giant kelp	*Macrocystis pyrifera*	0.00	0.000
Laminaria spp	*Laminaria* spp	6.50	3.720
Pterygophora	*Pterygophora californica*	113.54	24.790
Southern sea palm	*Eisenia arborea*	0.83	0.538

Ocean Cove

Reef Check California's 'Ocean Cove' site is located at 38.555° North and 123.305° West and has been surveyed annually since 2007. The monitoring transects are located within the cove along the northern and southern shores of the cove. This site is accessible from the beach. There are no take restrictions other than the general fishing regulations at this site, and it is a popular abalone diving sites in Sonoma County.

Figure 6. RCCA Ocean Cove site. Approximate orientation of core transects in red.

Table 11. Physical characteristics and primary substrate cover at Ocean Cove site (2010-2011)

Average depth	6.63 meters

Substrate type	**Percentage**
Bedrock	84.44%
Boulder	11.67%
Cobble	3.89%
Sand	0.00%

Relief	**Percentage**
0-10cm	2.22%
10 cm-1meter	59.44%
1-2meter	21.11%
>2 meters	17.22%

Substrate Cover	**Percentage**
Articulated coralline	43.33%
Brown seaweed	5.56%
Crustose coralline	13.89%
None	7.22%
Other brown seaweed	0.56%
Red seaweed	25.00%
Sessile invertebrates	4.44%

Table 12. Fish densities (60m^2) at Ocean Cove site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Black and yellow rockfish	*Sebastes chrysomelas*	0.89	0.227
Black rockfish	*Sebastes melanops*	0.44	0.166
Blue rockfish	*Sebastes mystinus*	1.44	0.364
Brown rockfish	*Sebastes auriculatus*	0.00	0.000
China rockfish	*Sebastes nebulosus*	0.00	0.000
Copper rockfish	*Sebastes caurinus*	0.00	0.000
Gopher rockfish	*Sebastes carnatus*	0.00	0.000
Grass rockfish	*Sebastes rastrelliger*	0.00	0.000
Kelp rockfish	*Sebastes atrovirens*	0.17	0.167
Vermilion/canary rockfishes	*Sebastes miniatus*	0.00	0.000
Yellowtail/olive rockfishes	*Sebastes serranoides*	0.00	0.000
Young of the Year rockfishes	*Sebastes* spp.	1.94	0.865
Cabezon	*Scorpaenichthys marmoratus*	0.06	0.056
Kelp greenling	*Hexagrammos decagrammus*	2.56	0.364
Lingcod	*Ophiodon elongatus*	0.00	0.000
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.000
Black perch	*Embiotoca jacksoni*	0.00	0.000
Pile perch	*Rhacochilus vacca*	0.06	0.056
Rainbow perch	*Hypsurus caryi*	0.00	0.000
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.000
Striped perch	*Embiotoca lateralis*	2.28	0.651

Table 13. Invertebrate densities (60m^2) at Ocean Cove site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Flat abalone	*Haliotis wallensis*	0.00	0.000
Pinto abalone	*Haliotis kantschatkana*	0.00	0.000
Red abalone	*Haliotis rufescens*	33.00	9.245
Rock scallop	*Crassedoma giganteum*	0.17	0.167
Wavy/red turban snail	*Lithopoma undosum*	0.00	0.000
Giant keyhole limpet	*Megathura crenulata*	1.33	0.494
Gumboot chiton	*Cryptochiton stelleri*	1.67	0.333
Purple urchin	*Strongylocentrotus purpuratus*	0.00	0.000
Red urchin	*Strongylocentrotus franciscanus*	0.00	0.000
Rock crab	*Cancer spp.*	0.00	0.000
Sheep/masking crab	*Loxorhynchus grandis & L. crispatus*	0.17	0.167
Bat star	*Patiria miniata*	43.38	16.748
Giant spined star	*Pisaster giganteus*	0.50	0.342
Short spined sea star	*Pisaster brevispinus*	0.50	0.224
Sunflower/sun star	*Solaster stimpsoni, S. dawsoni, Pycnopodia helianthoides*	0.17	0.167
CA sea cucumber	*Parastichopus californicus*	0.00	0.000
Large anemone	*Urticina* spp., *Metridium* spp., *Anthopleura* spp.	7.17	2.330

Table 14. Algae densities (60m^2) at Ocean Cove site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Bull kelp	*Nereocystis luetkeana*	117.92	42.118
Giant kelp	*Macrocystis pyrifera*	0.00	0.000
Laminaria spp	*Laminaria spp*	28.83	14.398
Pterygophora	*Pterygophora californica*	227.56	51.268
Southern sea palm	*Eisenia arborea*	0.00	0.000

Gerstle Cove

Reef Check California's 'Gerstle Cove' site is located at 38.566° North and 123.329° West and has been surveyed twice annually since 2006. The monitoring transects are located throughout the cove. This site is accessible from the beach. This site is located within the Gerstle Cove State Marine Reserve where all take is prohibited.

Figure 7. RCCA Gerstle Cove site. Approximate survey area is indicated in yellow and orientation of core transects in red.

Table 15. Physical characteristics and primary substrate cover at Gerstle Cove site (2010-2011).

Average depth	4.24 meters

Substrate type	**Percentage**
Bedrock	65.14%
Boulders	19.86%
Cobble	6.25%
Other	0.14%
Sand	8.61%

Relief	**Percentage**
0-10cm	5.69%
10 cm-1meter	84.44%
1-2meter	9.58%
>2 meters	0.28%

Substrate Cover	**Percentage**
Articulated coralline	45.56%
Brown seaweed	1.25%
Crustose coralline	14.17%
Green seaweed	1.11%
Mobile invertebrates	1.81%
None	11.53%
Other brown seaweed	2.22%
Red seaweed	19.86%
Sessile invertebrates	2.50%

Table 16. Fish densities (60m^2) at Gerstle Cove site (2010-2011)

Common name	Scientific name	Mean Density	Std Error
Black and yellow rockfish	*Sebastes chrysomelas*	0.41	0.101
Black rockfish	*Sebastes melanops*	0.01	0.014
Blue rockfish	*Sebastes mystinus*	0.17	0.064
Brown rockfish	*Sebastes auriculatus*	0.00	0.000
China rockfish	*Sebastes nebulosus*	0.00	0.000
Copper rockfish	*Sebastes caurinus*	0.00	0.000
Gopher rockfish	*Sebastes carnatus*	0.00	0.000
Grass rockfish	*Sebastes rastrelliger*	0.01	0.014
Kelp rockfish	*Sebastes atrovirens*	0.01	0.014
Vermilion/canary rockfishes	*Sebastes miniatus*	0.00	0.000
Yellowtail/olive rockfishes	*Sebastes serranoides*	0.01	0.014
Young of the Year rockfishes	*Sebastes* spp.	0.35	0.139
Cabezon	*Scorpaenichthys marmoratus*	0.04	0.024
Kelp greenling	*Hexagrammos decagrammus*	1.89	0.188
Lingcod	*Ophiodon elongatus*	0.07	0.031
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.000
Black perch	*Embiotoca jacksoni*	0.00	0.000
Pile perch	*Rhacochilus vacca*	0.26	0.202
Rainbow perch	*Hypsurus caryi*	0.00	0.000
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.000
Striped perch	*Embiotoca lateralis*	0.91	0.179

Table 17. Invertebrate densities (60m^2) at Gerstle Cove site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Flat abalone	*Haliotis wallensis*	0.04	0.042
Pinto abalone	*Haliotis kantschatkana*	0.00	0.000
Red abalone	*Haliotis rufescens*	17.04	2.044
Rock scallop	*Crassedoma giganteum*	0.00	0.000
Wavy/red turban snail	*Lithopoma undosum*	0.04	0.042
Giant keyhole limpet	*Megathura crenulata*	0.21	0.134
Gumboot chiton	*Cryptochiton stelleri*	2.13	0.556
Purple urchin	*Strongylocentrotus purpuratus*	3.08	1.651
Red urchin	*Strongylocentrotus franciscanus*	5.42	2.291
Rock crab	*Cancer spp.*	0.25	0.124
Sheep/masking crab	*Loxorhynchus grandis & L. crispatus*	0.08	0.058
Bat star	*Patiria miniata*	91.40	14.372
Giant spined star	*Pisaster giganteus*	0.42	0.133
Short spined sea star	*Pisaster brevispinus*	0.46	0.170
Sunflower/sun star	*Solaster stimpsoni, S. dawsoni, Pycnopodia helianthoides*	1.63	0.334
CA sea cucumber	*Parastichopus californicus*	0.04	0.042
Large anemone	*Urticina* spp., *Metridium* spp., *Anthopleura* spp.	3.92	0.593

Table 18. Algae densities (60m^2) at Gerstle Cove site (2010-2011).

Common name	Scientific name	Mean Density	Std Error
Bull kelp	*Nereocystis luetkeana*	7.42	3.427
Giant kelp	*Macrocystis pyrifera*	0.00	0.000
Laminaria spp	*Laminaria spp*	1.13	0.435
Pterygophora	*Pterygophora californica*	29.80	8.505
Southern sea palm	*Eisenia arborea*	0.00	0.000

Point Arena Reference

Reef Check California's 'Point Arena Reference' site is located at 38.908° North and 123.719° West. This site has been surveyed in 2011 and 2012. The monitoring transects are located south-west of the Point Arena pier and is only accessible by boat. There are no take restrictions other than the general fishing regulations at this site.

Figure 8. RCCA Pt Arena Reference site.

Table 19. Physical characteristics and primary substrate cover at Point Arena Reference site (2011-2012).

Average depth	13.55 meters

Substrate type	Percentage
Bedrock	93.61%
Boulders	3.33%
Cobble	2.50%
Sand	0.56%

Relief	Percentage
0-10 cm	4.44%
10 cm-1 meter	64.44%
1-2 meter	18.89%
>2 meters	12.22%

Substrate Cover	Percentage
Articulated coralline	0.28%
Brown seaweed	2.50%
Crustose coralline	43.33%
Mobile invertebrates	5.83%
None	9.17%
Other brown seaweed	11.67%
Red seaweed	16.67%
Seagrasses	0.28%
Sessile invertebrates	10.28%

Table 20. Fish densities (60m^2) at Point Arena Reference site (2011-2012).

Common name	Scientific name	Mean Density	Std Error
Black and yellow rockfish	*Sebastes chrysomelas*	0.06	0.063
Black rockfish	*Sebastes melanops*	0.00	0.000
Blue rockfish	*Sebastes mystinus*	1.03	0.540
Brown rockfish	*Sebastes auriculatus*	1.34	1.059
China rockfish	*Sebastes nebulosus*	0.00	0.000
Copper rockfish	*Sebastes caurinus*	0.03	0.031
Gopher rockfish	*Sebastes carnatus*	0.00	0.000
Grass rockfish	*Sebastes rastrelliger*	0.00	0.000
Kelp rockfish	*Sebastes atrovirens*	0.28	0.081
Vermilion/canary rockfishes	*Sebastes miniatus*	0.00	0.000
Yellowtail/olive rockfishes	*Sebastes serranoides*	0.97	0.165
Young of the Year rockfishes	*Sebastes* spp.	0.03	0.031
Cabezon	*Scorpaenichthys marmoratus*	0.25	0.078
Kelp greenling	*Hexagrammos decagrammus*	0.00	0.000
Lingcod	*Ophiodon elongatus*	0.00	0.000
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.000
Black perch	*Embiotoca jacksoni*	0.00	0.000
Pile perch	*Rhacochilus vacca*	0.28	0.136
Rainbow perch	*Hypsurus caryi*	0.00	0.000
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.000
Striped perch	*Embiotoca lateralis*	0.38	0.160

Table 21. Invertebrate densities (60m^2) at Point Arena Reference site (2011-2012).

Common name	Scientific name	Mean Density	Std Error
Flat abalone	*Haliotis wallensis*	0.00	0.000
Pinto abalone	*Haliotis kantschatkana*	0.17	0.112
Red abalone	*Haliotis rufescens*	19.90	9.901
Rock scallop	*Crassedoma giganteum*	0.17	0.167
Wavy/red turban snail	*Lithopoma undosum*	0.00	0.000
Giant keyhole limpet	*Megathura crenulata*	0.08	0.083
Gumboot chiton	*Cryptochiton stelleri*	1.33	0.355
Purple urchin	*Strongylocentrotus purpuratus*	203.93	67.488
Red urchin	*Strongylocentrotus franciscanus*	53.40	13.971
Rock crab	*Cancer spp.*	0.00	0.000
Sheep/masking crab	*Loxorhynchus grandis & L. crispatus*	0.00	0.000
Bat star	*Patiria miniata*	0.00	0.000
Giant spined star	*Pisaster giganteus*	13.67	3.246
Short spined sea star	*Pisaster brevispinus*	8.92	1.328
Sunflower/sun star	*Solaster stimpsoni, S. dawsoni, Pycnopodia helianthoides*	0.92	0.417
CA sea cucumber	*Parastichopus californicus*	0.08	0.083
Large anemone	*Urticina* spp., *Metridium* spp., *Anthopleura* spp.	0.75	0.250

Table 22. Algae densities (60m^2) at Point Arena Reference site (2011-2012).

Common name	Scientific name	Mean Density	Std Error
Bull kelp	Nereocystis luetkeana	88.17	48.354
Giant kelp	Macrocystis pyrifera	0.00	0.000
Laminaria spp	Laminaria spp	4.17	1.870
Pterygophora	Pterygophora californica	6.50	3.439
Southern sea palm	Eisenia arborea	0.00	0.000

Stornetta

Reef Check California's 'Stornetta' site is located at 38.937° North and 123.731° West. Due to difficult accessibility this site has only been surveyed in 2007 and 2010. The monitoring transects are located on both sides of Sea Lion Rock. This site is only accessible by small boat. This site is located within Sea Lion Cove State Marine Conservation Area where all take of marine invertebrates and algae is prohibited.

Figure 9. RCCA Stornetta site. Approximate orientation of core transects in red.

Table 23. Physical characteristics and primary substrate cover at Stornetta site (2010).

Average depth	4.47 meters

Substrate type	Percentage
Bedrock	67.22%
Boulders	15.56%
Cobble	14.44%
Sand	2.78%

Relief	Percentage
0-10cm	10.56%
10 cm-1meter	89.44%
1-2meter	0.00%
>2 meters	0.00%

Substrate Cover	Percentage
Articulated coralline	45.56%
Crustose coralline	25.00%
None	13.33%
Other brown seaweed	2.22%
Red seaweed	13.33%
Sessile invertebrates	0.56%

Table 24. Fish densities (60m^2) at Stornetta site (2010).

Common name	Scientific name	Mean Density	Std Error
Black and yellow rockfish	*Sebastes chrysomelas*	0.00	0.000
Black rockfish	*Sebastes melanops*	0.06	0.056
Blue rockfish	*Sebastes mystinus*	0.06	0.056
Brown rockfish	*Sebastes auriculatus*	0.00	0.000
China rockfish	*Sebastes nebulosus*	0.00	0.000
Copper rockfish	*Sebastes caurinus*	0.00	0.000
Gopher rockfish	*Sebastes carnatus*	0.00	0.000
Grass rockfish	*Sebastes rastrelliger*	0.00	0.000
Kelp rockfish	*Sebastes atrovirens*	0.00	0.000
Vermilion/canary rockfishes	*Sebastes miniatus*	0.00	0.000
Yellowtail/olive rockfishes	*Sebastes serranoides*	0.00	0.000
Cabezon	*Scorpaenichthys marmoratus*	0.11	0.076
Kelp greenling	*Hexagrammos decagrammus*	0.78	0.222
Lingcod	*Ophiodon elongatus*	0.06	0.056
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.000
Black perch	*Embiotoca jacksoni*	0.06	0.056
Pile perch	*Rhacochilus vacca*	0.11	0.111
Rainbow perch	*Hypsurus caryi*	0.00	0.000
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.000
Striped perch	*Embiotoca lateralis*	5.00	2.315

Table 25. Invertebrate densities (60m^2) at Stornetta site (2010).

Common name	Scientific name	Mean Density	Std Error
Flat abalone	*Haliotis wallensis*	0.50	0.342
Pinto abalone	*Haliotis kantschatkana*	0.00	0.000
Red abalone	*Haliotis rufescens*	33.63	6.279
Rock scallop	*Crassedoma giganteum*	0.00	0.000
Wavy/red turban snail	*Lithopoma undosum*	2.33	0.803
Giant keyhole limpet	*Megathura crenulata*	0.00	0.000
Gumboot chiton	*Cryptochiton stelleri*	2.17	0.792
Purple urchin	*Strongylocentrotus purpuratus*	0.17	0.167
Red urchin	*Strongylocentrotus franciscanus*	0.67	0.667
Rock crab	*Cancer spp.*	0.33	0.333
Sheep/masking crab	*Loxorhynchus grandis & L. crispatus*	0.00	0.000
Bat star	*Patiria miniata*	0.50	0.342
Giant spined star	*Pisaster giganteus*	0.17	0.167
Short spined sea star	*Pisaster brevispinus*	0.33	0.333
Sunflower/sun star	*Solaster stimpsoni, S. dawsoni, Pycnopodia helianthoides*	0.67	0.211
CA sea cucumber	*Parastichopus californicus*	0.17	0.167
Large anemone	*Urticina* spp., *Metridium* spp., *Anthopleura* spp.	0.50	0.342

Table 26. Algae densities (60m^2) at Stornetta site (2010).

Common name	Scientific name	Mean Density	Std Error
Bull kelp	*Nereocystis luetkeana*	11.00	6.028
Giant kelp	*Macrocystis pyrifera*	0.00	0.000
Laminaria spp	*Laminaria* spp	20.00	4.967
Pterygophora	*Pterygophora californica*	158.02	54.367
Southern sea palm	*Eisenia arborea*	0.00	0.000

Point Arena MPA

Reef Check California's 'Point Arena MPA' site is located at 38.944° North and 123.740° West. This site has been surveyed in 2011 and 2012. The monitoring site is located south of Point Arena Lighthouse and is only accessible by boat. This site is located within the Point Arena State Marine Reserve where all take is prohibited.

Figure 10. RCCA Point Arena MPA site.

Table 27. Physical characteristics and primary substrate cover at Point Arena MPA site (2010-2011).

Average depth	13.7 meters

Substrate type	Percentage
Bedrock	96.67%
Boulders	1.33%
Cobble	2.00%
Sand	0.00%

Relief	Percentage
0-10 cm	0.00%
10 cm-1 meter	60.67%
1-2 meter	10.00%
>2 meters	29.33%

Substrate Cover	Percentage
Articulated coralline	2.00%
Brown seaweed	1.33%
Crustose coralline	40.00%
Mobile invertebrates	7.33%
None	7.00%
Other brown seaweed	6.00%
Red seaweed	23.33%
Sessile invertebrates	13.00%

Table 28. Fish densities (60m^2) at Point Arena site (2011-2012).

Common name	Scientific name	Mean Density	Std Error
Black and yellow rockfish	*Sebastes chrysomelas*	0.09	0.063
Black rockfish	*Sebastes melanops*	2.86	0.952
Blue rockfish	*Sebastes mystinus*	2.00	0.721
Brown rockfish	*Sebastes auriculatus*	0.09	0.091
China rockfish	*Sebastes nebulosus*	0.09	0.063
Copper rockfish	*Sebastes caurinus*	0.00	0.000
Gopher rockfish	*Sebastes carnatus*	0.14	0.075
Grass rockfish	*Sebastes rastrelliger*	0.00	0.000
Kelp rockfish	*Sebastes atrovirens*	0.68	0.413
Vermilion/canary rockfishes	*Sebastes miniatus*	0.05	0.045
Yellowtail/olive rockfishes	*Sebastes serranoides*	0.00	0.000
Young of the Year rockfishes	*Sebastes* spp.	0.82	0.643
Cabezon	*Scorpaenichthys marmoratus*	0.23	0.130
Kelp greenling	*Hexagrammos decagrammus*	1.32	0.297
Lingcod	*Ophiodon elongatus*	0.23	0.130
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.000
Black perch	*Embiotoca jacksoni*	0.00	0.000
Pile perch	*Rhacochilus vacca*	0.00	0.000
Rainbow perch	*Hypsurus caryi*	0.00	0.000
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.000
Striped perch	*Embiotoca lateralis*	0.68	0.458

Table 29. Invertebrate densities (60m^2) at Point Arena MPA site (2011-2012).

Common name	Scientific name	Mean Density	Std Error
Flat abalone	*Haliotis wallensis*	0.10	0.100
Pinto abalone	*Haliotis kantschatkana*	0.50	0.224
Red abalone	*Haliotis rufescens*	4.80	2.772
Rock scallop	*Crassedoma giganteum*	0.20	0.200
Wavy/red turban snail	*Lithopoma undosum*	0.00	0.000
Giant keyhole limpet	*Megathura crenulata*	0.00	0.000
Gumboot chiton	*Cryptochiton stelleri*	2.00	0.966
Purple urchin	*Strongylocentrotus purpuratus*	233.30	112.777
Red urchin	*Strongylocentrotus franciscanus*	145.26	24.418
Rock crab	*Cancer spp.*	0.10	0.100
Sheep/masking crab	*Loxorhynchus grandis & L. crispatus*	0.00	0.000
Bat star	*Patiria miniata*	0.00	0.000
Giant spined star	*Pisaster giganteus*	4.20	0.867
Short spined sea star	*Pisaster brevispinus*	2.10	0.795
Sunflower/sun star	*Solaster stimpsoni, S. dawsoni, Pycnopodia helianthoides*	1.00	0.632
CA sea cucumber	*Parastichopus californicus*	0.00	0.000
Large anemone	*Urticina* spp., *Metridium* spp., *Anthopleura* spp.	1.20	0.442

Table 30. Algae densities (60m^2) at Point Arena MPA site (2011-2012).

Common name	Scientific name	Mean Density	Std Error
bull kelp	Nereocystis luetkeana	28.70	8.574
giant kelp	Macrocystis pyrifera	0.00	0.000
laminaria spp	Laminaria spp	1.60	1.056
pterygophora	Pterygophora californica	92.29	74.269
so. sea palm	Eisenia arborea	0.00	0.000

North Central Coast Ecosystems

RCCA sites in the NCCSR are located between Fort Ross and Point Arena. In order to characterize community composition and structure of the kelp forest and rocky reef ecosystem in the region based on the seven RCCA sites we conducted a cluster analysis of the biological communities including fish, invertebrates and algae.

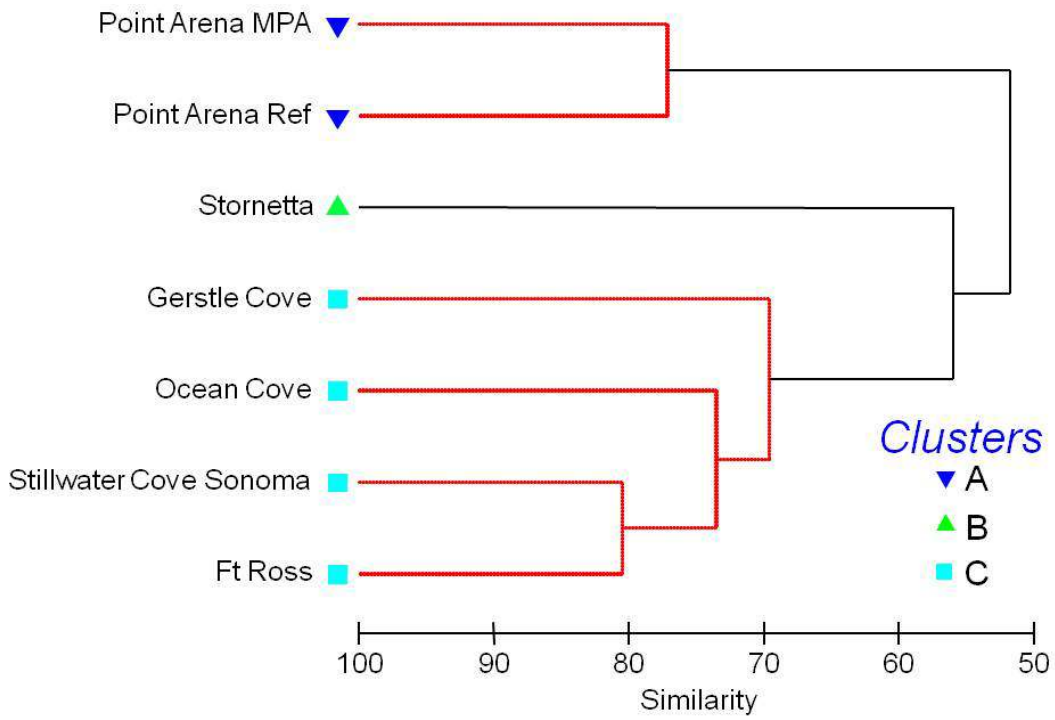

Figure 11. Cluster analysis of study sites in the NCCSR. Red branches identify clusters based on a SIMPROF test with a significance of 0.05.

The cluster analysis was performed in Primer 6. In order to account for the large differences in the densities of the different taxonomic groups, species' means were weighted by the inverse of the average density of the respective taxonomic group: fishes, invertebrates and algae. This balances the contributions to community patterns between the groups so that the pattern is not dominated by algae which are naturally more common then fish or invertebrates. To insure that the analysis is not biased towards abundant individual species the weighted data then square root transformed before the Bray Curtis similarity resemblance matrix was generated. Data for all sites other than the Pt. Arena MPA and Pt. Arena Reference sites are based on surveys conducted in 2010 and 2011. For the two Point Arena sites data from 2011/12 was used since these sites were established in 2011. Using the BEST function in Primer the habitat variables that most closely correlate with the identified clusters were determined. In a SIMPER analysis the species contributing most to the community patterns were identified for each pair wise comparison of clusters.

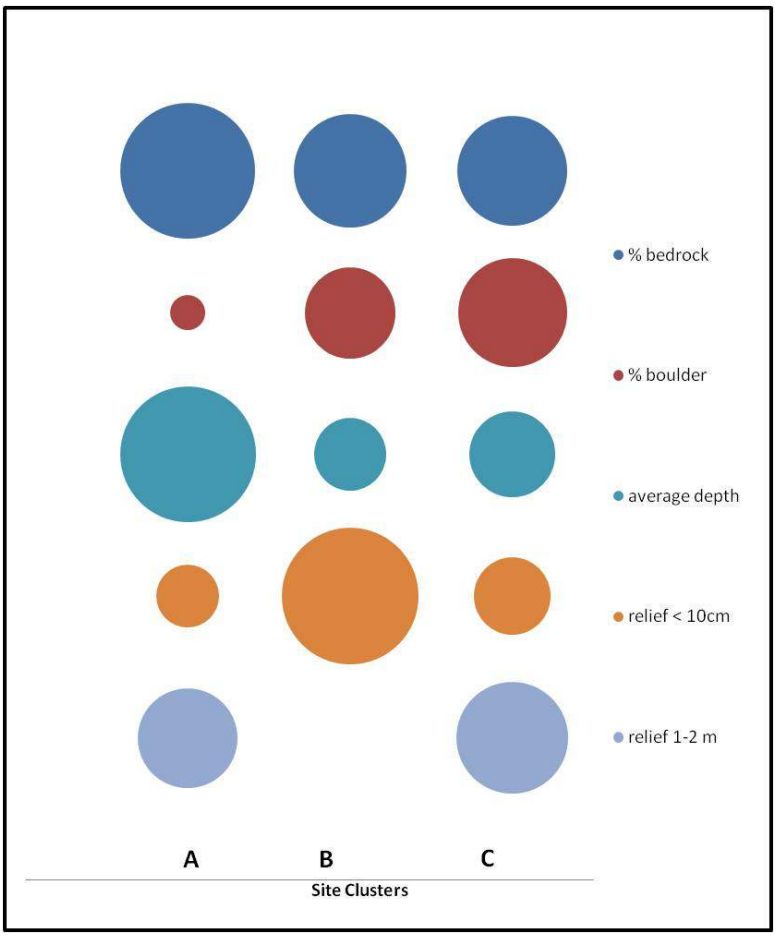

Figure 12. Physical habitat variables that best explain the differences between clusters of sites. Bubble size represents the relative percentages of the environmental variables best explaining the differences in the community clusters among the sites.

The four most southern sites cluster in one group and show no structure based on a SIMPROF significance level of 0.05. According to this test the Stornetta site is dissimilar to all other sites and the two deeper sites inside and out of the Point Arena SMR are similar to each other (Figure 11). Overall the three clusters that were identified show large dissimilarities of 45 -50%. Of the environmental variables measured during RCCA UPC surveys, consisting of substrate types and relief as well as average site depth, average depth and low relief showed the strongest correlations with the identified clusters (80% correlation). Depth separates the two Point Arena sites from the others and low relief is much more common at the 'Storrenta' site than any in the other two groups (Figure 12). Boulders also seemed to be distributed differently among clusters but were not identified as one of the key variables in the BEST analysis.

Based on the SIMPER analysis the differences in the communities within the different clusters seem to be driven by many species (Table 31-Table 33). In all three comparisons sea urchins, black or blue rockfish and striped perch contributed strongly to the differences between clusters.

Overall, this analysis identified strong community differences between the sites in the shallow coves along the Sonoma Coast and the sites around Point Arena, Mendocino. This suggests that MPAs are located within distinct kelp forest communities that are distributed geographically along the coast from north to south.

Table 31. Results of SIMPER analysis among the southern sites (cluster C) and the Stornetta site.

	Southern sites	Stornetta	Average dissimilarity = 44.06			
Species	Group c Av.Abund (weighted and transf.)	Group b Av.Abund (weighted and transf.)	Av.Diss	Diss/SD	Contrib%	Cum.%
Bat Star	3.02	0.21	6.94	3.29	15.74	15.74
Blue rockfish	2.24	0.38	4.24	1.65	9.62	25.37
YOY rockfish	1.63	0	3.96	3.26	8.98	34.35
Striped perch	2.11	3.64	3.92	2.38	8.89	43.24
Black and yellow rockfish	1.16	0	2.9	3.73	6.57	49.81
Kelp greenling	2.21	1.44	1.96	2.31	4.44	54.25
Bull kelp	1.27	0.54	1.81	1.47	4.1	58.35
Pterygophora	1.92	2.07	1.57	1.22	3.57	61.92
Large anemone	0.76	0.21	1.33	9.18	3.01	64.93
Black rockfish	0.82	0.38	1.21	1.28	2.75	67.68
Red urchin	0.56	0.24	1.08	3.06	2.45	70.13
Wavy & red turban snail	0.03	0.45	1.03	7.72	2.34	72.47
Kelp rockfish	0.43	0	1.03	2.15	2.34	74.81
Laminaria spp	0.41	0.73	1	1.78	2.27	77.08
Gopher rockfish	0.43	0	0.87	0.5	1.98	79.06
Pile perch	0.78	0.54	0.77	2.91	1.75	80.81
Purple urchin	0.36	0.12	0.75	2.07	1.71	82.51
Black perch	0.26	0.38	0.74	1.74	1.68	84.2
Giant spined star	0.43	0.12	0.69	1.01	1.57	85.77
Red abalone	1.44	1.7	0.68	1.07	1.53	87.3
Lingcod	0.35	0.38	0.47	1.21	1.06	88.36
Flat abalone	0.04	0.21	0.43	3.46	0.97	89.33
Rubberlip perch	0.2	0	0.43	0.85	0.97	90.3

Table 32. Results of SIMPER analysis among the southern sites (cluster C) and the deep Pt. Arena sites (cluster A).

	Southern sites	Deep Pt Arena sites				
			Average dissimilarity = 45.62			
Species	Group c Av.Abund (weighted and transf.)	Group a Av.Abund (weighted and transf.)	Av.Diss	Diss/SD	Contrib%	Cum.%
Purple urchin	0.36	4.34	7.85	7.63	17.21	17.21
Bat star	3.02	0	5.93	3.74	12.99	30.2
Red urchin	0.56	2.84	4.44	2.94	9.73	39.93
Black rockfish	0.82	2.2	2.77	1.68	6.08	46.01
Pterygophora	1.92	1	2.13	1.55	4.67	50.68
Striped perch	2.11	1.1	1.96	2.18	4.29	54.97
Blue rockfish	2.24	2.09	1.84	1.32	4.03	59
Gopher rockfish	0.43	0.73	1.56	4.23	3.43	62.43
Pile perch	0.78	0	1.53	3.06	3.35	65.78
Black and yellow rockfish	1.16	0.45	1.41	2.68	3.1	68.88
Bull kelp	1.27	1.21	1.1	1.39	2.42	71.3
Kelp rockfish	0.43	0.82	1.05	1.26	2.31	73.61
YOY rockfish	1.63	1.23	1.05	1.21	2.3	75.91
Giant spined star	0.43	0.84	1.03	1.45	2.26	78.17
Kelp greenling	2.21	1.74	0.97	1.46	2.13	80.3
Red abalone	1.44	0.98	0.94	1.4	2.05	82.35
Large anemone	0.76	0.29	0.9	4.68	1.98	84.33
Lingcod	0.35	0.8	0.89	1.69	1.96	86.29
Short spined star	0.3	0.65	0.83	1.46	1.81	88.1
Laminaria spp	0.41	0.27	0.48	1.02	1.05	89.15
China rockfish	0.15	0.25	0.47	1.18	1.03	90.18

Table 33. Results of SIMPER analysis among the deep Pt. Arena sites (cluster A) and the Stornetta sites.

	Deep Pt. Arena sites	Stornetta	Average dissimilarity = 58.85			
Species	Group a Av.Abund (weighted and transf.)	Group b Av.Abund (weighted and transf.)	Av.Diss	Diss/SD	Contrib%	Cum.%
Purple urchin	4.34	0.12	10.23	17.88	17.39	17.39
Striped perch	1.1	3.64	6.21	4.22	10.56	27.95
Red urchin	2.84	0.24	6.2	3.58	10.54	38.49
Black rockfish	2.2	0.38	4.33	3.02	7.36	45.84
Blue rockfish	2.09	0.38	4.12	14.82	7.01	52.85
YOY rockfish	1.23	0	2.96	5.88	5.03	57.88
Pterygophora	1	2.07	2.7	1.19	4.59	62.47
Kelp rockfish	0.82	0	1.89	1.17	3.21	65.68
Gopher rockfish	0.73	0	1.8	2.83	3.07	68.75
Giant spined star	0.84	0.12	1.8	1.77	3.06	71.81
Red abalone	0.98	1.7	1.71	1.77	2.9	74.71
Bull kelp	1.21	0.54	1.68	1.28	2.86	77.57
Pile perch	0	0.54	1.32	9.55	2.24	79.81
Short spined star	0.65	0.17	1.21	1.35	2.06	81.87
Laminaria spp	0.27	0.73	1.12	11	1.89	83.76
Wavy & red turban snail	0	0.45	1.09	9.55	1.85	85.62
Black and yellow rockfish	0.45	0	1.08	36.27	1.84	87.46
Lingcod	0.8	0.38	1	5.91	1.71	89.17
Black perch	0	0.38	0.93	9.55	1.59	90.75

Long-term Population Trends at Reef Check Sites

Reef Check California has monitored its four core sites in the NCCSR since 2007: Fort Ross, Stillwater Cove, Ocean Cove and Gerstle Cove. Surveys at these sites were conducted by RCCA citizen scientists on an annual basis. In order to put baseline characterization results for 2010 and 2011 into a historical context we have plotted the population densities of the most abundant fish and invertebrate species at these sites for the entire time series for 2007-2012. We have only included sites within the southernmost kelp forest community cluster (Cluster C in Figure 11) identified above, because we have the most consistent time series from this section along the coast and in order to be able to make regional inferences without confounding them by community differences between sites. Figures 13 - 16 show the densities for four fish species: of black and yellow rockfish, kelp greenling, blue rockfish, and black rockfish and three invertebrate species: red abalone, red urchins and purple urchins.

To investigate regional population trends for these species we used an ANOVA approach to test for site and year effects and their interaction. Data were square root transformed for this analysis and site and year were treated as fixed factors. Most species showed a significant year by site interaction indicating that there is no clear regional population trend for these species (Table 34).

Table 34. Species with significant site by year interactions in ANOVA test. Significant interactions indicate that there is no clear regional population trend for these species over the time period from 2007-2012.

Species	Interaction	Df	F	P
Black and yellow rockfish	Site*year	3	2.39	0.03
Black rockfish	Site*year	3	4.92	0.002
Kelp greenling	Site*year	3	6.84	0.00002
Purple urchins	Site*year	3	2.68	0.048

Three species did not show a significant site by year interaction. Of these species, blue rockfish and red abalone populations did not significantly change over the monitoring period (year: $F_{(1/7)} = 6.10$, $P = 0.068$ and $F_{(1/7)} = 3.48$, $P = 0.063$, respectively) on the regional scale; whereas red urchins seem to be declining in the study region over the 6 year monitoring window (Table 35).

We also performed ANOVA's for each species at each site independently of each other to investigate population trends at the site level. Of all site and species combinations only nine statistically significant trends were found. All four fish species and red abalone show increasing trends at RCCA's Ocean Cove site, where as species with significant trends at Stillwater Cove show a decreasing trend between 2007 and 2012 (Table 35). Overall, the analysis of the densities of the most abundant and management relevant species over RCCA's 6 year time series does not show clear trends of declining of increasing populations in the study region. In fact most species do not show regional trends with the exception of red urchins which seem to be declining. Even at individual sites population trends are variable in most species without showing a clear trajectory. One site, Ocean Cove, seems to have consistent increases in abundant species over the monitoring period and at Stillwater Cove species with significant population trends are decreasing. The high variability in population density estimates, as shown in Figure 13 - 16, in the inter-annual densities estimates at individual sites as well as the fact that on a regional scale most species exhibit site by year indicate that long-term monitoring has to be conducted at high enough special resolution and sufficient replication over time to detect population level changes should they

occur. This consideration becomes even more important as monitoring would be conducted across different kelp forest communities as identified in the previous section and variability will increase as more types of communities are monitored.

Red abalone and red urchins are two of the most management relevant species in the north central coast study region and their populations are not only monitored by RCCA but the Department of Fish and Wildlife (DFW) also conducts abalone and urchin surveys. In addition to RCCA and DFW, PISCO monitored red abalone and urchin populations during the baseline monitoring period. Results from a comparison of the red abalone and red urchin density data from sites monitored by all three programs are reported in the final report of PISCO's subtidal baseline monitoring project for the NCCSR.

Table 35. Significant changes in population density over the six years of monitoring at the regional scale (for red urchins) and at individual RCCA sites in Sonoma County.

Species	Site	Source	DF	F	P	Trend
Red urchin	Entire region	Year	3	12.41	0.0005	Decrease
Black and yellow rockfish	Ocean Cove	year	1	4.77	0.0315	Increase
Black rockfish	Ocean Cove	year	1	14.30	0.0003	Increase
Blue rockfish	Ocean Cove	year	1	8.83	0.0038	Increase
Kelp greenling	Ocean Cove	year	1	5.64	0.0197	Increase
Kelp greenling	Stillwater Cove	year	1	12.96	0.0004	Decrease
Purple urchin	Stillwater Cove	year	1	7.32	0.0095	Decrease
Red abalone	Ocean Cove	year	1	4.85	0.0361	Increase
Red urchin	Gerstle Cove	year	1	7.41	0.0080	Decrease
Red urchin	Stillwater Cove	year	1	13.36	0.0007	Decrease

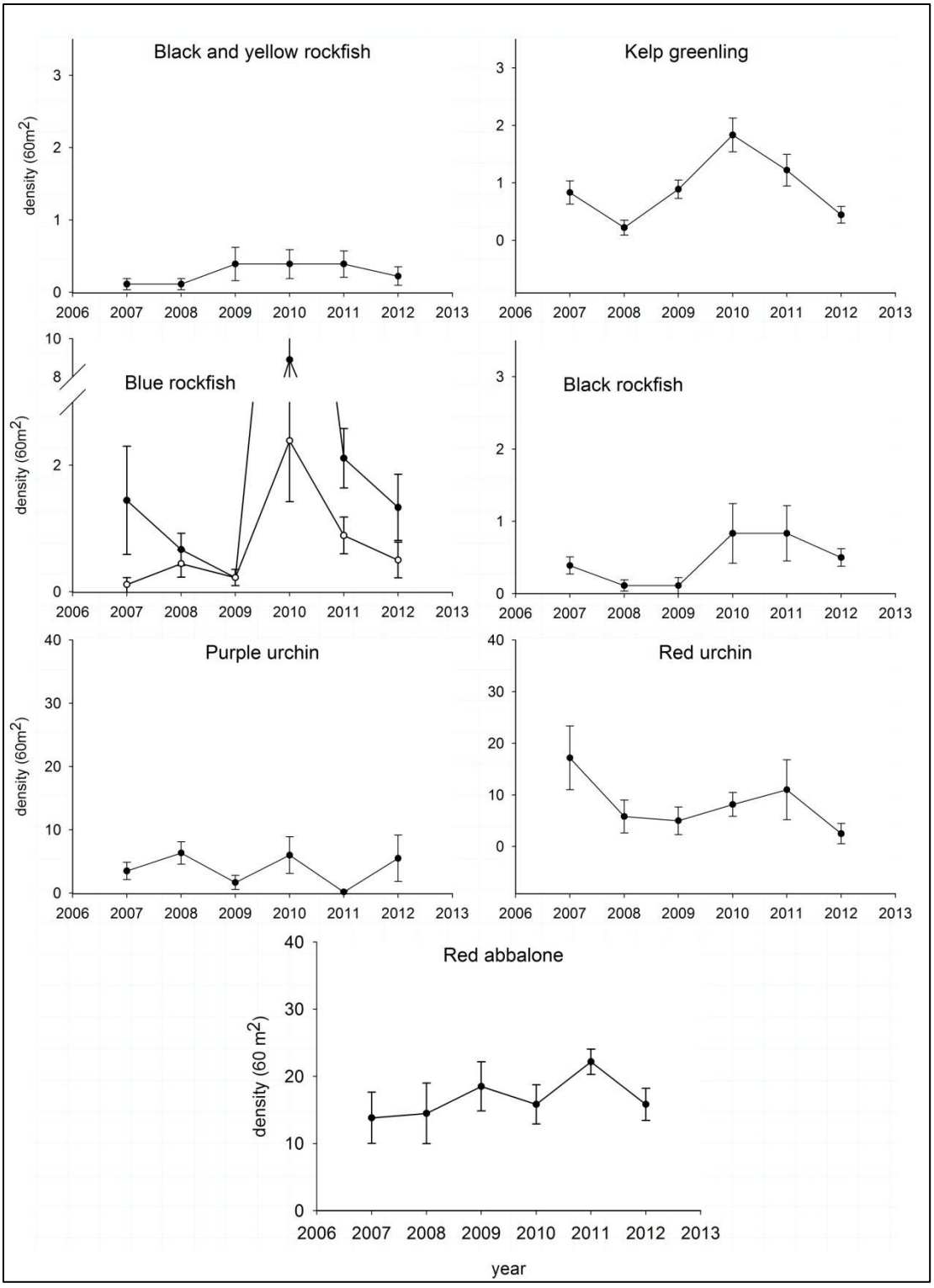

Figure 13. Population trends of seven most abundant and management relevant species at RCCA's Fort Ross site. Mean densities (+/- SE) are reported. For blue rockfish data is shown with (solid circles) and without juveniles individuals (empty circles).

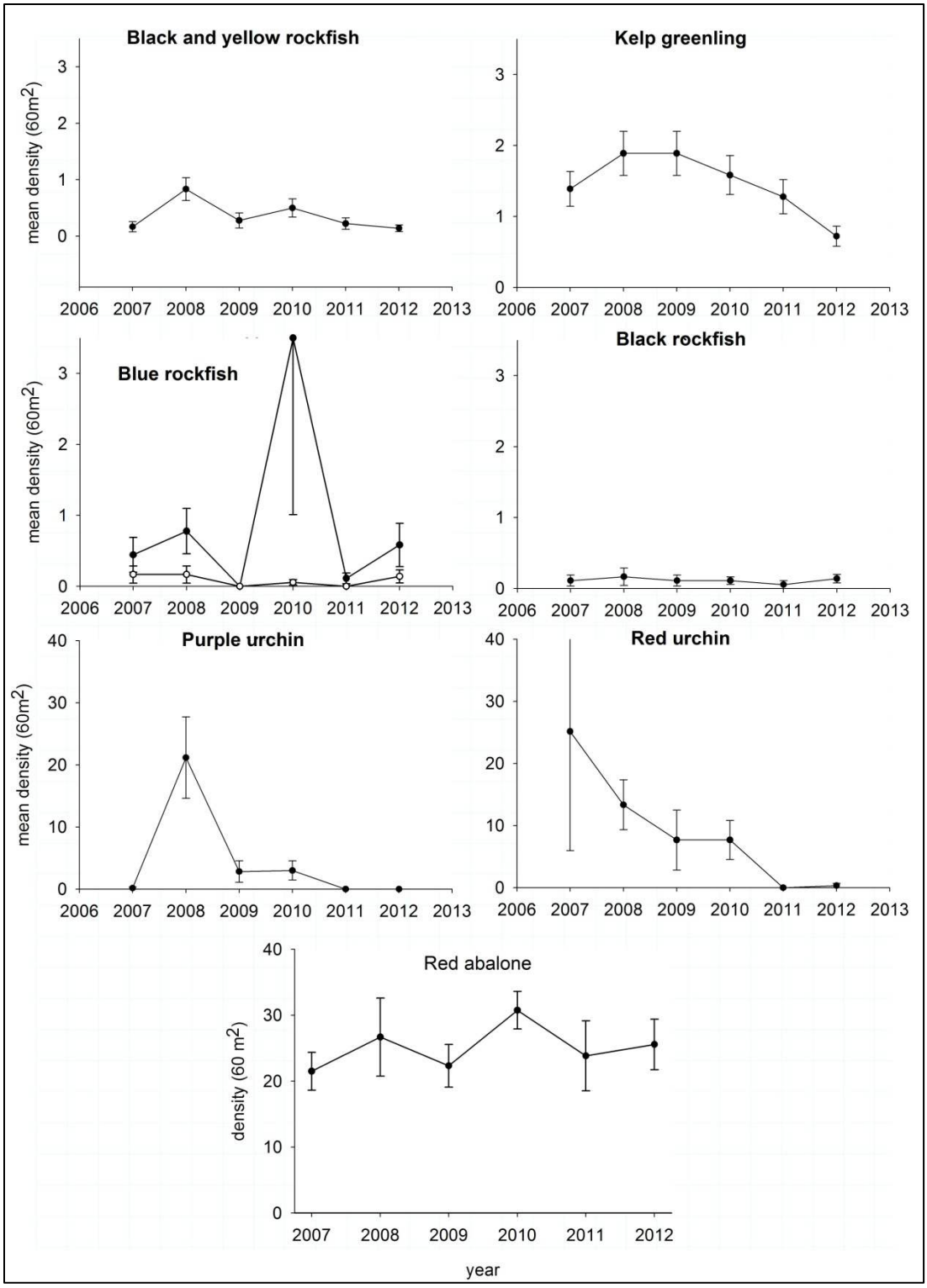

Figure 14. Population trends of seven most abundant and management relevant species at RCCA's Stillwater Cove site. Mean densities (+/- SE) are reported. For blue rockfish data is shown with (solid circles) and without juveniles individuals (empty circles).

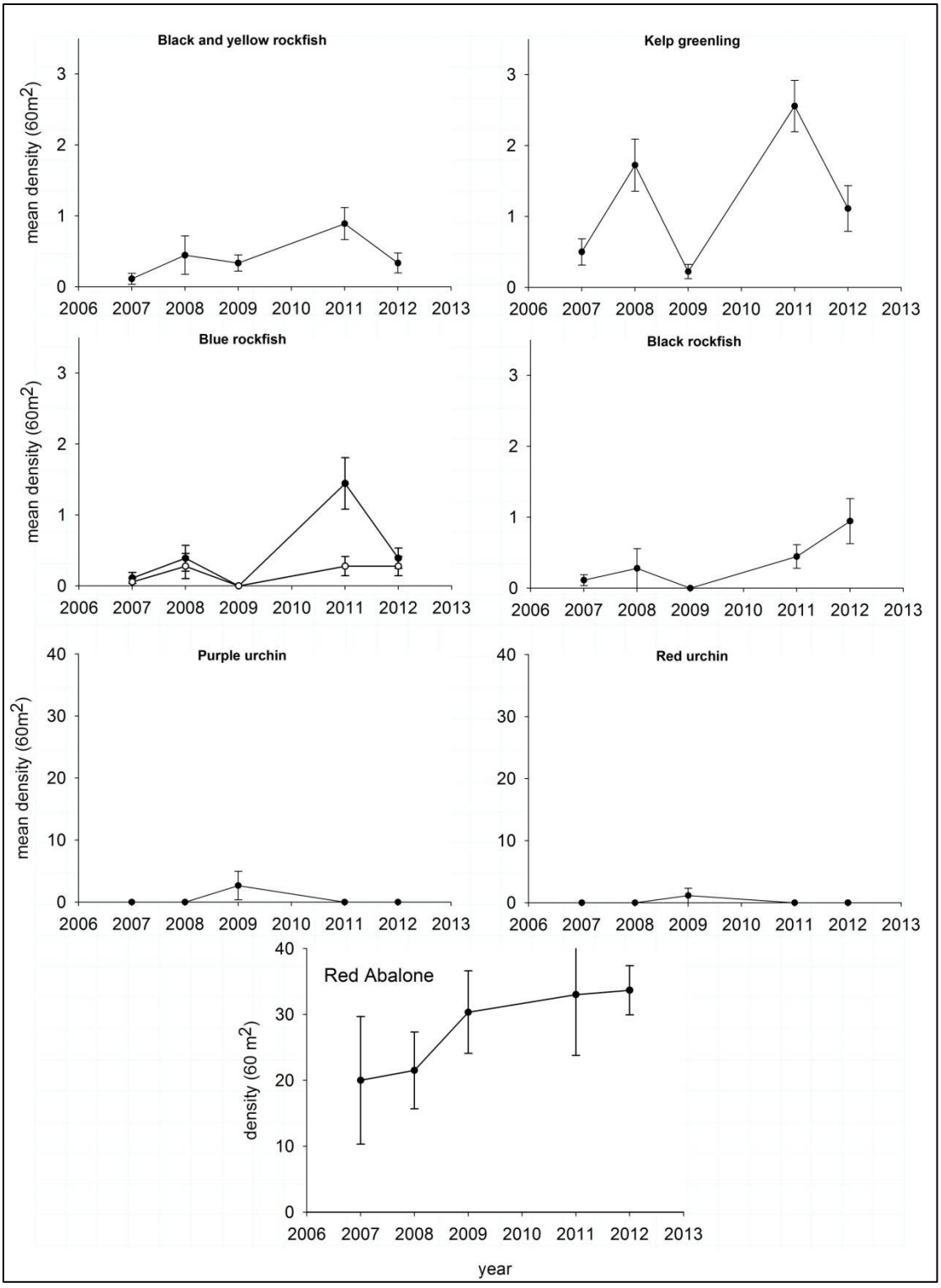

Figure 15. Population trends of seven most abundant and management relevant species at RCCA's Ocean Cove site. Mean densities (+/- SE) are reported. For blue rockfish data is shown with (solid circles) and without juveniles individuals (empty circles).

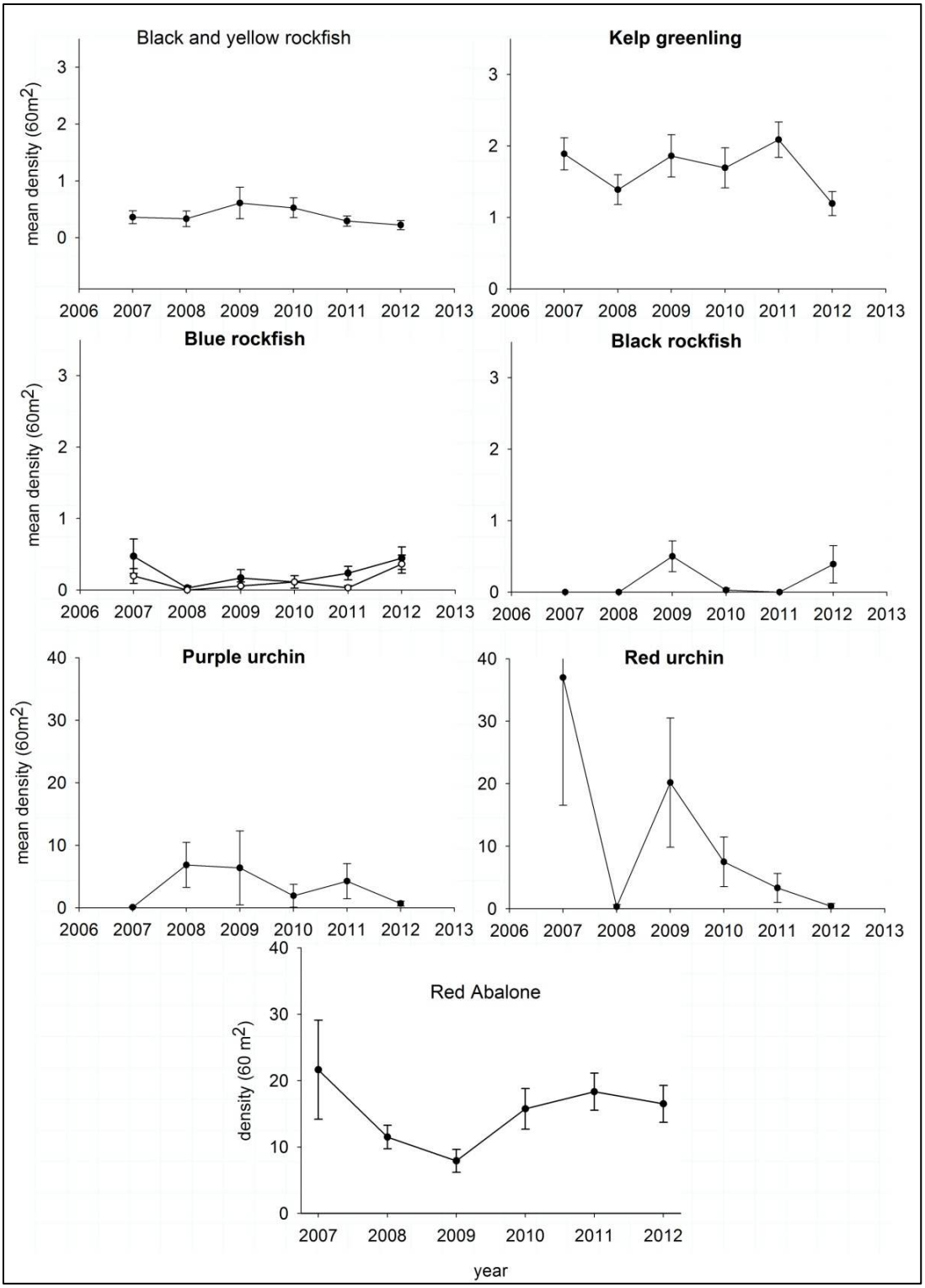

Figure 16. Population trends of seven most abundant and management relevant species at RCCA's Gerstle Cove site. Mean densities (+/- SE) are reported. For blue rockfish data is shown with (solid circles) and without juveniles individuals (empty circles).

Abalone and Red Urchin Size Frequency Surveys (PISCO/RCCA)

Reef Check California collaborated with the UCSC PISCO team in 2010 and 2011 to conduct abalone and red urchin size frequency surveys at the PISCO survey sites in the study region. A total of 35 sites were surveyed by the collaborative team (Figure 17), which far exceeds the proposed number of collaborative surveys (10 sites) and will provide a much more detailed picture of the abalone populations within and outside of MPAs at the time of implementation of the MPAs. This success highlights the benefit and synergistic effects of collaborative efforts in the baseline monitoring of difficult and expensive-to-access subtidal habitats. In the following pages the size frequency distributions of red abalone (*Haliotis rufescens*) and red urchins (*Strongylocentrotus franciscanus*) are shown in relation to the NCCSR MPAs that were surveys. Graphs representing the size frequency distribution of populations at the sites inside and outside of the MPAs are compared for each MPA (Figure 19Figure 32). The sites and their assignment as either an MPA or reference site are shown in Table 37. The abalone and urchin densities are presented in PISCO's final report on the kelp forest baseline monitoring in the NCCSR. These abalone and urchin data provide a baseline against which future changes in size frequencies inside and outside of the respective MPAs can be assessed.

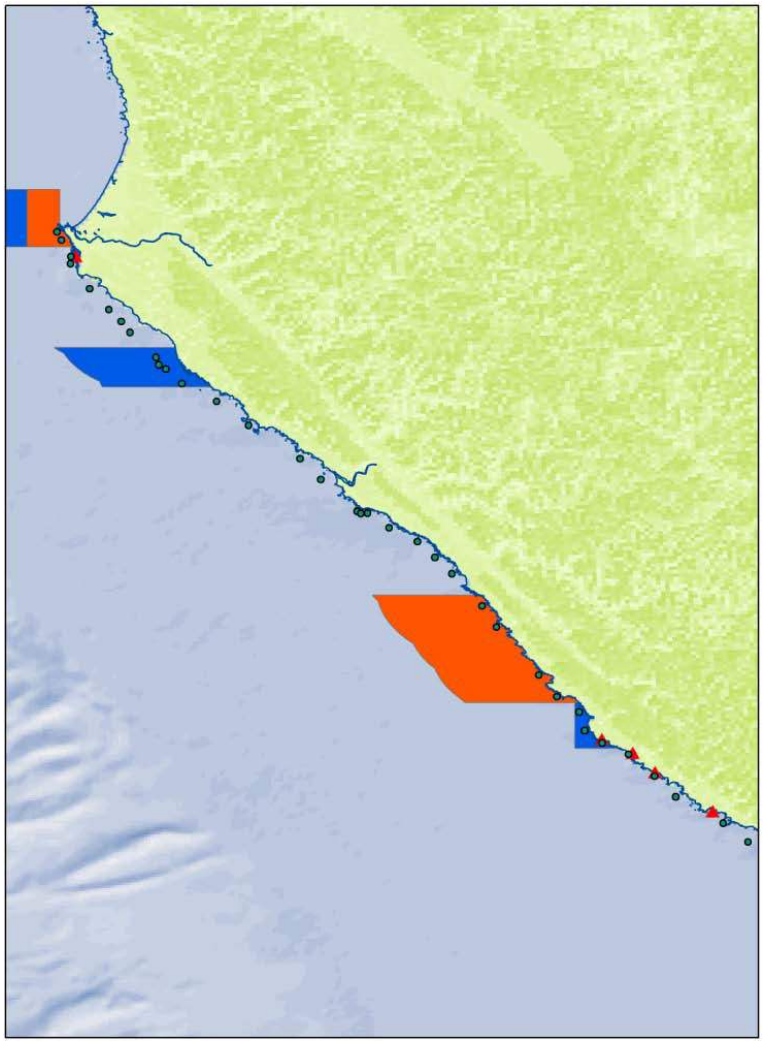

Figure 17. 35 PISCO/RCCA sites surveys in NCCSR where abalone sizes were recorded.

Abalone size frequency distributions show that at all MPA/references site groups the median red abalone size is just above the legal harvest size of 17.cm (7 inches) (Figure 19Figure 25). We used an ANOVA to investigate effects of MPA group (i.e. site), year and MPAs on the mean sizes of red abalone. The full model showed no significant interaction between the factors site, year and MPA and therefore the interaction terms were removed. Abalone sizes did not differ across survey years or inside MPAs vs. outside of MPAs. Only the factor 'MPA group' had a statistically significant effect documenting the variability in abalone sizes throughout the study region (Table 36). An MPA effect would not be expected after only a short time period of protection, therefore the non-significant result rather documents that the abalone sizes were similar inside and outside of MPAs across the region at the implementation of the protection. This information will be critical for future studies investigating MPA effects since it

demonstrates that no significant size differences were present at MPA implementation. As changes in the size frequency distribution of organisms is one of the initial responses expected when MPAs successfully protect populations from exploitation, this baseline indicating that there were no initial differences in the abalone sizes at the newly protected areas vs. unprotected sites is a critical reference point.

In late August 2011, a harmful algae bloom (HABs) event occurred along the Sonoma County coast causing a sudden and unexpected die-off of invertebrates, including red abalone. Despite the fact that 2011 surveys that were conducted after the event showed a significant decline in red abalone densities (as reported in PISCO's finale baseline monitoring report) there was no effect on abalone sizes between 2010 and 2011 indicating the event's mortality was not size selective. The decline in red abalone densities after the HABs event is also clearly seen in RCCA's data from the Gerstle Cove sites were semiannual surveys are conducted (Figure 18). A similar decline in red abalone densities was documented at this site in 2007 between the spring and fall surveys but the event seemed to be localized and was not reported from other sites.

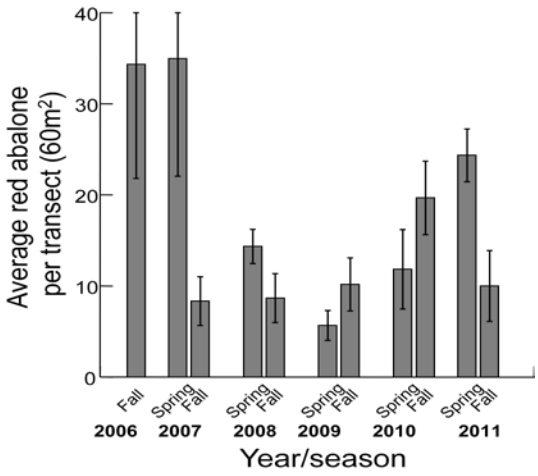

Figure 18. Red abalone densities at Gerstle Cove, Sonoma.

Table 36. ANOVA of red abalone sizes inside vs. outside of MPA over the baseline monitoring period.

Factor	Df	F	P
Site (i.e. MPA group)	5	8.05	<0.0001
Year	1	1.63	0.2057
MPA	1	0.37	0.5426

Graphs representing the size frequency distribution of red urchins at the sites shown in Table 37 inside and outside of the MPAs are compared for each MPA in Figure 26Figure 32. We used an ANOVA to investigate effects of MPA group (i.e. site), year and MPAs on the mean sizes of red urchins. The full model showed no significant interaction between the factors site, year and MPA and therefore the interaction terms were removed. Red urchin sizes did not differ inside MPAs vs. outside of MPAs ($F_{(1/7)}$ = 0.21, P = 0.6456) but did significantly differ between sites ($F_{(1/7)}$ = 2.49, P = 0.0384) and urchins were significantly smaller in 2011 (mean size = 8.66 cm +/- 0.035 SE) than in 2010 (mean size = 10.2 +/- 0.036 SE) ($F_{(1/7)}$ = 33.55, P <0.0001). This is a different result than for red abalone for which no size difference was detected among years despite the die-off in 2011. It is unclear if the die-off was size selective in this species but these results suggest that there might have been higher mortality in larger individuals leading to a shift in the size distribution. Figure 32 shows that the size classes over 10 cm are less abundant in 2011 than 2010. This decrease in urchin size in combination with the declining trend of red

urchin populations in the Sonoma County region shown in RCCA long-term data suggests that special attention should be paid to the monitoring and management of this commercially important species.

Table 37. PISCO/RCCA surveys sites in NCCSR.

SITE	MPA group	MPA status	Max. depth	Latitude	Longitude
DEL_MAR_MPA_1	Del Mar Landing SMR	SMR	19	38.4871	-123.51562
DEL_MAR_MPA_2	Del Mar Landing SMR	SMR	20.1	38.50151	-123.51281
DEL_MAR_MPA_3	Del Mar Landing SMR	SMR	15.5	38.52177	-123.50758
DEL_MAR_RE_1	Del Mar Landing SMR	reference	19.9	38.53724	-123.49116
DEL_MAR_REF_2	Del Mar Landing SMR	reference	19	38.55381	-123.4698
DEL_MAR_REF_3	Del Mar Landing SMR	reference	20.1	38.56274	-123.45642
DEL_MAR_REF_4	Del Mar Landing SMR	reference	20.1	38.57217	-123.44355
POINT_ARENA_MPA_1	Point Arena SMR	SMR	20	38.58623	-123.74404
POINT_ARENA_MPA_2	Point Arena SMR	SMR	20.2	38.59765	-123.74052
POINT_ARENA_REF_1	Point Arena SMR	reference	19.8	38.61415	-123.7191
POINT_ARENA_REF_2	Point Arena SMR	reference	20	38.65073	-123.70432
POINT_ARENA_RE_3	Point Arena SMR	reference	20.1	38.6668	-123.69521
POINT_ARENA_REF_4	Point Arena SMR	reference	20	38.69138	-123.68838
SALT_POINT_MPA_1	Salt Point SMR	SMR	20.7	38.70378	-123.34668
SALT_POINT_MPA_2	Salt Point SMR	SMR	19.8	38.71557	-123.34266
SALT_POINT_MPA_3	Salt Point SMR	SMR	20.3	38.72604	-123.32922
SALT_POINT_MPA_4	Salt Point SMR	SMR	20.5	38.73729	-123.30908
SALT_POINT_REF_1	Salt Point SMR	reference	21	38.73736	-123.28933
SALT_POINT_REF_2	Salt Point SMR	reference	21.3	38.73895	-123.27335
SALT_POINT_REF_3	Salt Point SMR	reference	20.4	38.76295	-123.23712
SALT_POINT_REF_4	Salt Point SMR	reference	17.7	38.77883	-123.21817
SAUNDERS_MPA_1	Saunders Reef SMCA	SMCA	19.5	38.80408	-123.66841
SAUNDERS_MPA_2	Saunders Reef SMCA	SMCA	19.8	38.82226	-123.66661
SAUNDERS_MPA_3	Saunders Reef SMCA	SMCA	21.3	38.83573	-123.66129
SAUNDERS_MPA_4	Saunders Reef SMCA	SMCA	20.6	38.84695	-123.64898
SAUNDERS_REF_1	Saunders Reef SMCA	reference	21	38.85035	-123.62233
SAUNDERS_REF_2	Saunders Reef SMCA	reference	21	38.85586	-123.5981
SAUNDERS_REF_3	Saunders Reef SMCA	reference	20.6	38.87487	-123.55918
SAUNDERS_REF_4	Saunders Reef SMCA	reference	19.7	38.88296	-123.54342
SEA_LION_MPA_1	Sea Lion Cove SMCA	SMCA	19.7	38.89199	-123.73328
SEA_LION_REF_1	Sea Lion Cove SMCA	reference	20.8	38.908	-123.73447
STEWARTS_PT_MPA_1	Stewarts Point SMR	SMR	22	38.92769	-123.42064
STEWARTS_PT_MPA_2	Stewarts Point SMR	SMR	20.9	38.93241	-123.40953
STEWARTS_PT_MPA_3	Stewarts Point SMR	SMR	20.7	38.94484	-123.37745
STEWARTS_PT_MPA_4	Stewarts Point SMR	SMR	20.7	38.95117	-123.36371

Red abalone at Salt Point SMCA: abalone were surveyed at four sites inside the Salt Point SMCA and at four sites located south of the Salt Point SMCA. The recreational take of red abalone is allowed in the SMCA.

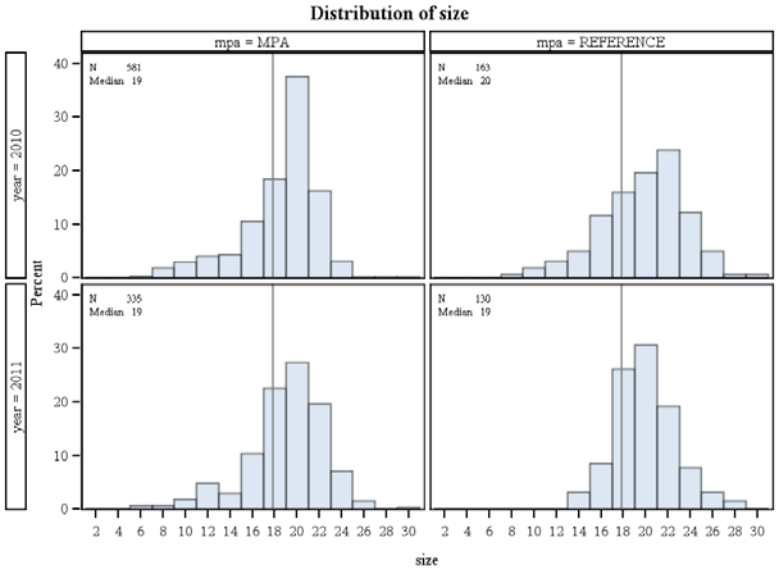

Figure 19. Red abalone size frequency distributions inside and out of the Salt Point SMCA. Size distributions are shown from both survey years. Vertical lines indicate legal size.

Red abalone at Stewards Point SMR: abalone were surveyed at four sites inside the Stewards Point SMR and at four sites located north of the SMR where abalone harvest is allowed.

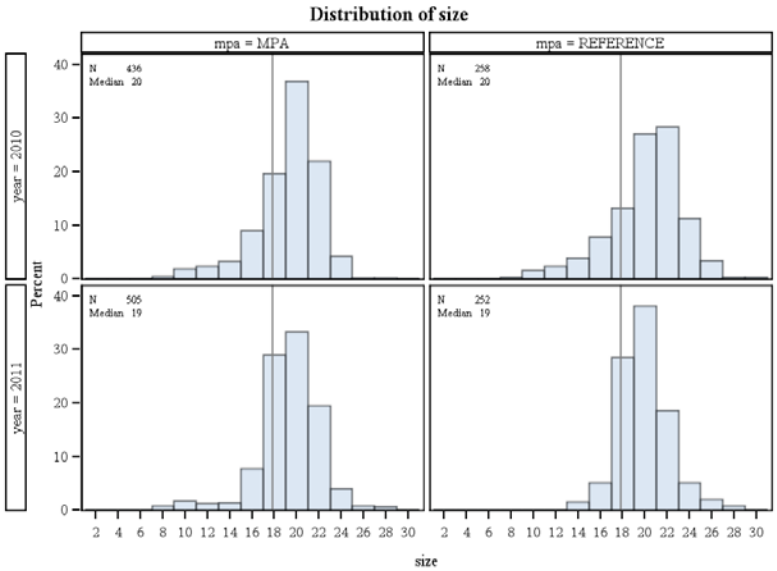

Figure 20. Red abalone size frequency distributions inside and out of the Stewards Point SMR. Size distributions are shown from both survey years. Vertical lines indicate legal size.

Red abalone at Del Mar SMR: abalone were surveyed at four sites inside the Del Mar SMR and at four sites located south of the SMR where abalone harvest is allowed.

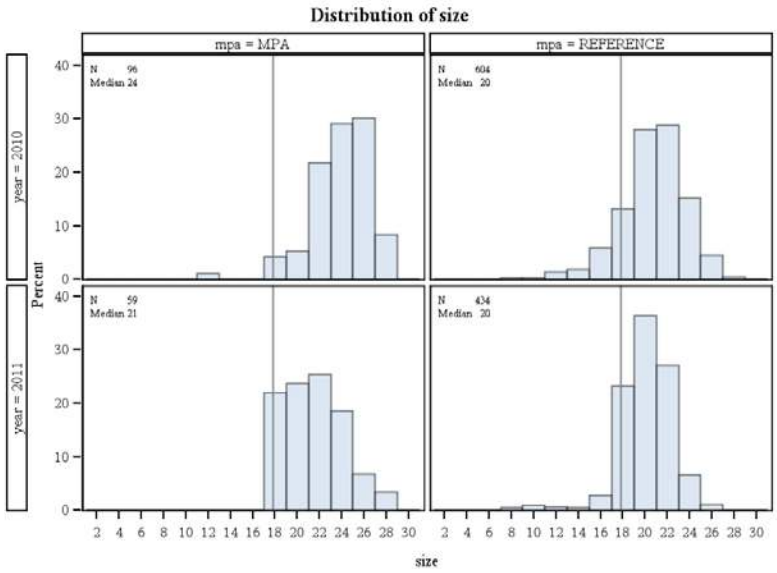

Figure 21. Red abalone size frequency distributions inside and out of the Del Mar SMR. Size distributions are shown from both survey years. Vertical lines indicate legal size.

Red abalone at Sanders Reef SMCA: abalone were surveyed at four sites inside the Sanders Reef SMCA and at four sites located south of the SMCA where abalone harvest is allowed. Abalone harvest is not allowed in this SMCA.

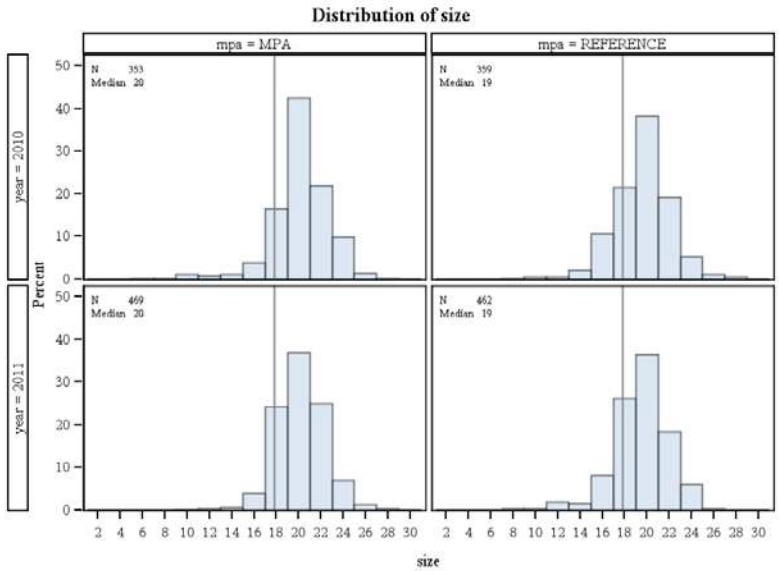

Figure 22. Red abalone size frequency distributions inside and out of the Sanders Reef SMCA. Size distributions are shown from both survey years. Vertical lines indicate legal size.

Red abalone at Sea Lion Cove SMCA: abalone were surveyed at one sites inside the Sea Loin Cove SMCA and at one sites located south of the SMCA where abalone harvest is allowed. Abalone harvest is not allowed in this SMCA.

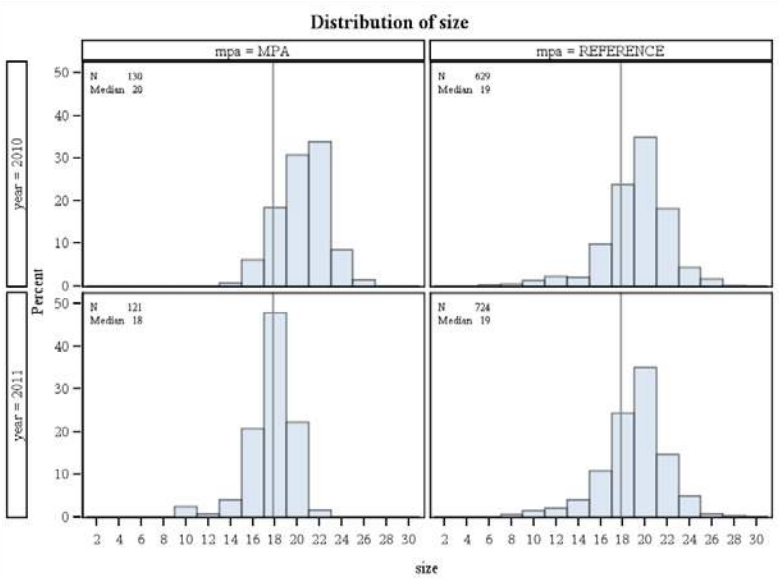

Figure 23. Red abalone size frequency distributions inside and out of the Sea Loin Cove SMCA. Size distributions are shown from both survey years. Vertical lines indicate legal size.

Red abalone at Point Arena SMR: abalone were surveyed at two sites inside the Point Arena SMR and at four sites located south of the SMCA where abalone harvest is allowed.

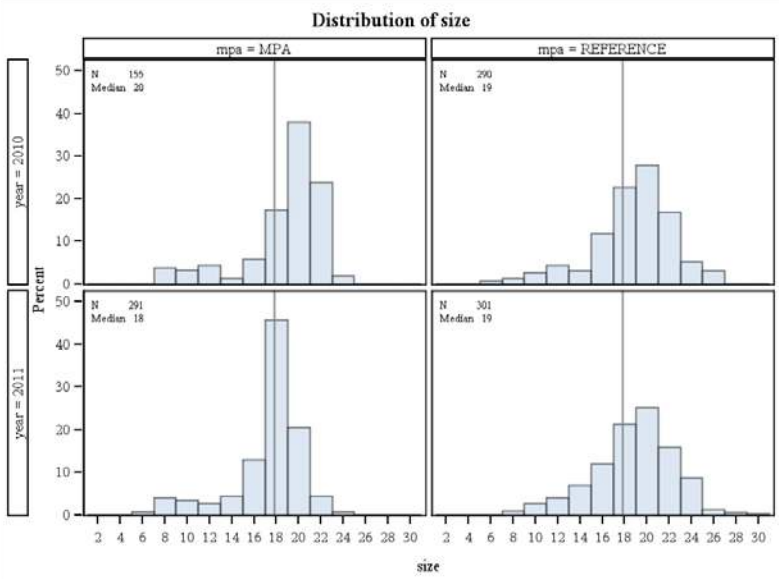

Figure 24. Red abalone size frequency distributions inside and out of the Point Arena SMR. Size distributions are shown from both survey years. Vertical lines indicate legal size.

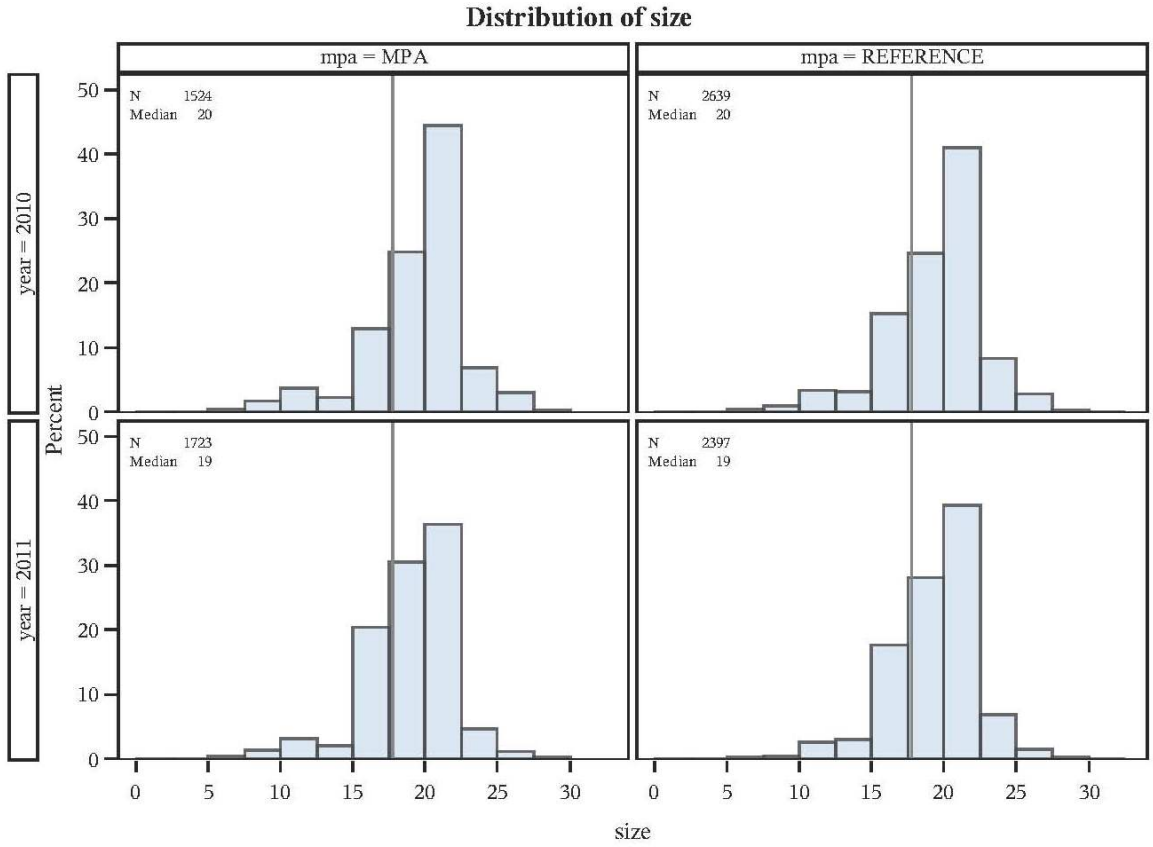

Figure 25. Red abalone size frequency distributions inside and out of the MPAs for the NCCSR. Size distributions are shown from both survey years. Vertical lines indicate legal size.

Red urchin at Salt Point SMCA: red urchins were surveyed at four sites inside the Salt Point SMCA and at four sites located south of the Salt Point SMCA.

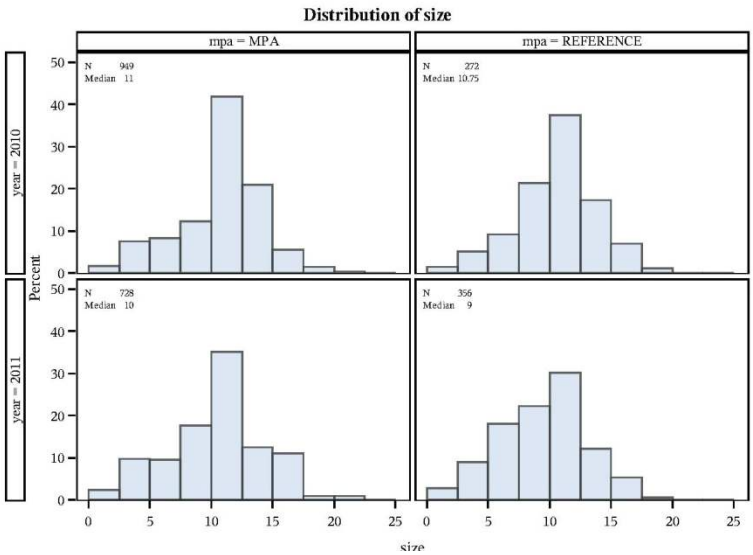

Figure 26. Red urchin size frequency distributions inside and out of the Salt Point SMCA. Size distributions are shown from both survey years.

Red urchin at Stewards Point SMR: red urchins were surveyed at four sites inside the Stewards Point SMR and at four sites located north of the SMR.

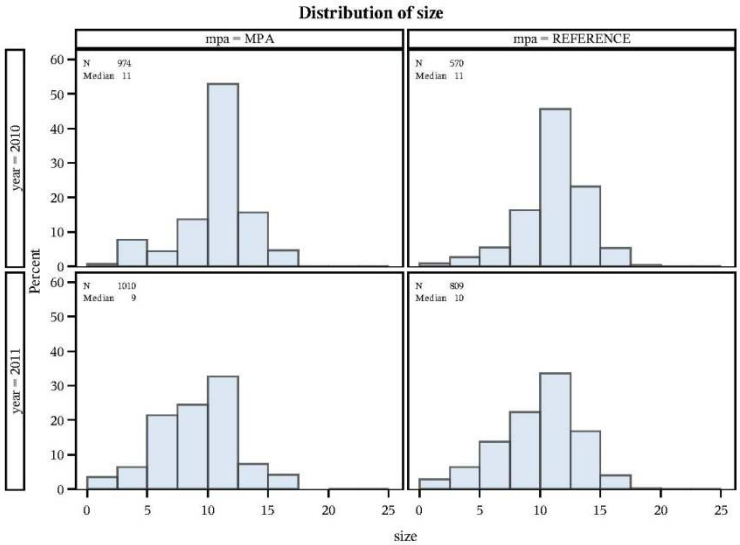

Figure 27. Red urchin size frequency distributions inside and out of the Stewards Point SMR. Size distributions are shown from both survey years.

Red urchin at Del Mar SMR: red urchins were surveyed at four sites inside the Del Mar SMR and at four sites located south of the SMR.

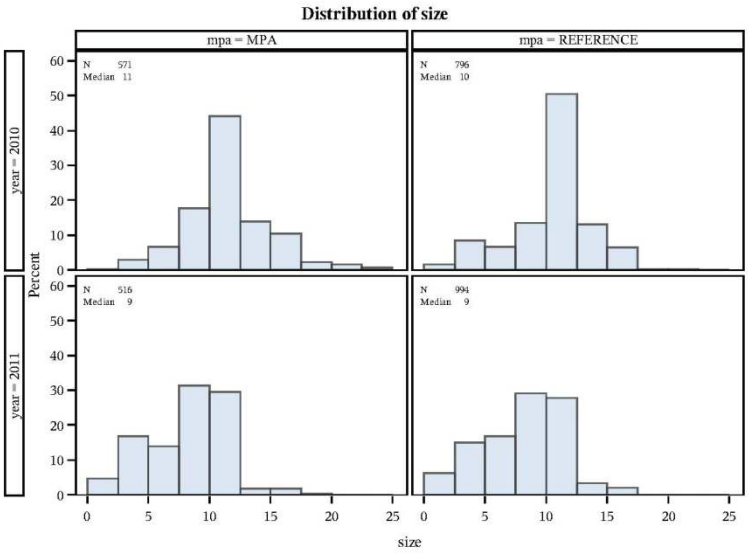

Figure 28. Red urchin size frequency distributions inside and out of the Del Mar SMR. Size distributions are shown from both survey years.

Red urchin at Sanders Reef SMCA: red urchins were surveyed at four sites inside the Sanders Reef SMCA and at four sites located south of the SMCA.

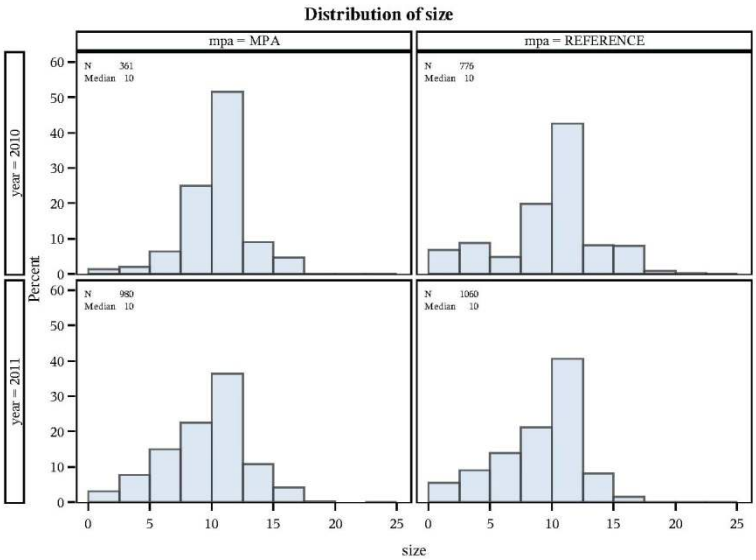

Figure 29. Red urchin size frequency distributions inside and out of the Sanders Reef SMCA. Size distributions are shown from both survey years.

Red urchin at Sea Lion Cove SMCA: red urchins were surveyed at one sites inside the Sea Loin Cove SMCA and at one sites located south of the SMCA.

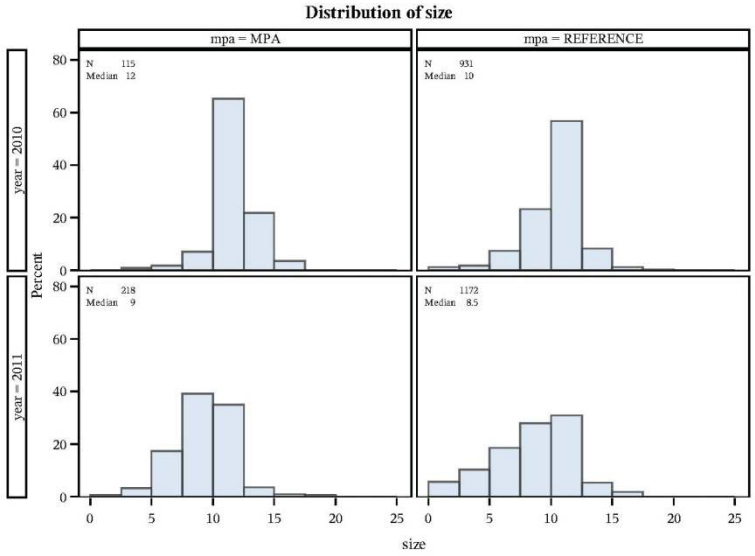

Figure 30. Red urchin size frequency distributions inside and out of the Sea Loin Cove SMCA. Size distributions are shown from both survey years.

Red urchin at Point Arena SMR: red urchin were surveyed at two sites inside the Point Arena SMR and at four sites located south of the SMCA

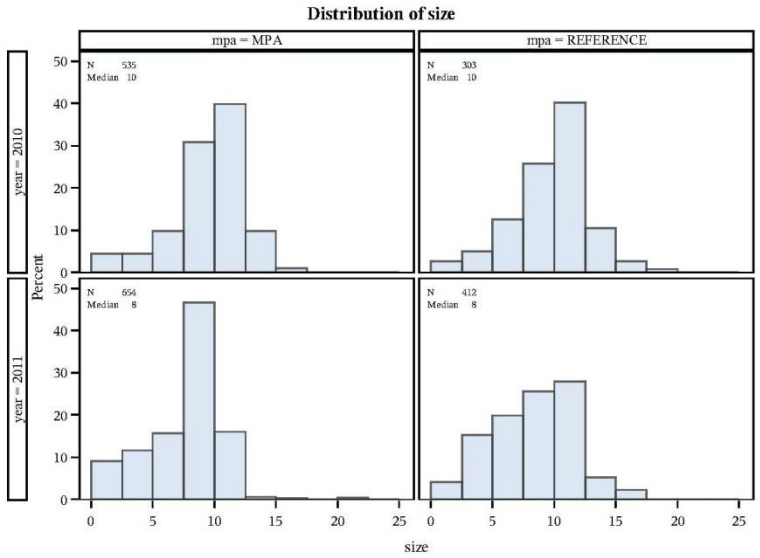

Figure 31. Red urchin size frequency distributions inside and out of the Point Arena SMR. Size distributions are shown from both survey years.

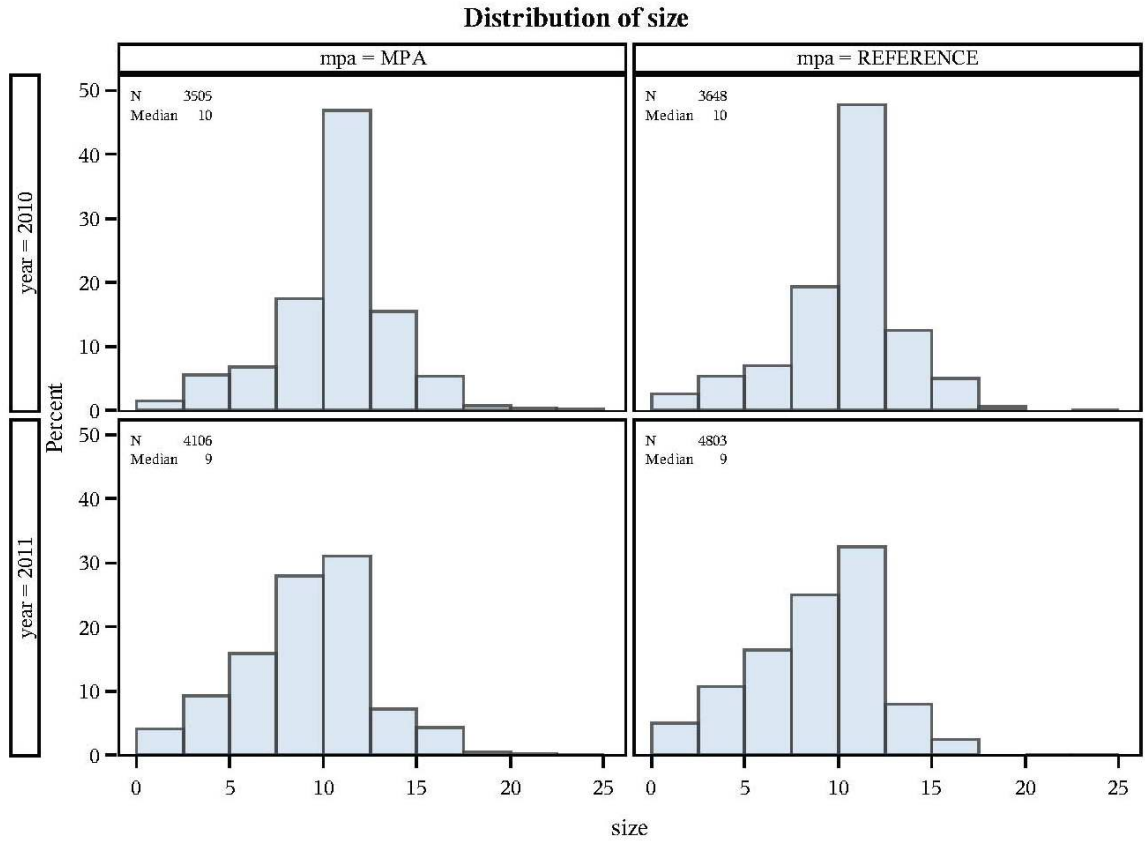

Figure 32. Red urchin size frequency distributions inside and out of the MPAs for the NCCSR. Size distributions are shown from both survey years.

Long-term Monitoring

The cluster analysis of the RCCA data has shown that there are distinct kelp forest communities along the north central coast as well as at different depth within the shallow rocky reef and kelp forest ecosystem. Distinct kelp forest communities within different MPAs might not respond in the same way to protection, responses might differ, for example, based on their trophic structure or species interactions such as predator-prey interactions. These community differences are not only apparent along the coastline but also along a depth gradient and/or inside and outside of sheltered coves that are commonly found along the NCCSR coast. The monitoring plan for the NCCSR presents two strategies for long-term monitoring: ecosystem 'Check ups' and ecosystem assessments of the shallow rocky reef and kelp forest ecosystem. The geographic clustering of kelp forest communities (Figure 11) suggests that a long-term monitoring has to insure that communities inside and out of MPAs in all respective communities are monitored for both types of approaches. Further, the monitoring has to cover the entire depth range for the habitats of interest. Most likely this will require collaborative approaches to long-term monitoring between programs that have the knowhow and technology to monitor rocky habitats at different depth (i.e. divers, ROVs). This is not only important for monitoring of the different reef communities but also for comprehensive population assessments of individual species that might be used for fisheries management. This has become especially apparent for species such as red abalone that are exploited at certain depths (i.e. intertidal, free diver depth) but not at others (i.e. below free diver depth).

RCCA has build the capacity to contribute to long-term monitoring in this region and further analyses of the data and suitable approaches will be explored through collaborations with other project PIs and the soon to be hired Post-Doc at the MPA Monitoring Enterprise and will be further investigated through work that has been started during a NCEAS working group on Kelp Forest Ecosystem Assessments in which RCCA has participated.