Reef Check California: Citizen Scientist monitoring of rocky reefs and kelp forests: Creating a baseline for California’s North Coast MPAs

Final Report

North Coast MPA Baseline Monitoring

2014-2016

Jan Freiwald, Anna Neumann

Reef Check California

Reef Check California: Citizen Scientist monitoring of rocky reefs and kelp forests: Creating a baseline for California's North Coast MPAs

---

May 30th, 2017

Jan Freiwald, Anna Neumann

Reef Check Foundation
13723 Fiji Way, B-2
Marine del Rey, CA 90292 USA

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

Cover Photo: Sloan Lofy–Mendocino County, California

Contents

Figures and Tables

Figures

Tables

List of Acronyms

CDFW – California Department of Fish and Wildlife

GLM–General Linear Model

HSU – Humboldt State University

MLPA–Marine Life Protection Act

MPA–Marine Protected Area

MOCI–Multivariate Ocean Conditions Index

NCSR–North Coast Study Region

NED–Nearshore Ecosystem Database

PISCO–Partnership for Interdisciplinary Studies of Coastal Oceans

RCCA–Reef Check California

SMCA–State Marine Conservation Area

SMR–State Marine Reserve

UPC–Uniform Point Contact

YOY–Young of Year

Executive Summary

Marine protected areas (MPAs) were implemented along California's North Coast Study Region (NCSR) in 2012 as a result of the California Department of Fish and Game's implementation of the Marine Life Protection Act (MLPA) legislation. A collaborative, comprehensive monitoring program was created in order to characterize the marine ecosystems of the region and to establish a baseline for detecting future effects of MPAs on these communities. Reef Check California (RCCA), along with several other research groups, participated in this monitoring project to characterize the shallow reef and kelp forest ecosystems of the NCSR. RCCA is a program of the Reef Check Foundation that aims to provide critically needed data on California's nearshore rocky reefs and kelp forests to improve science-based management and decision making regarding California's marine resources and policies. RCCA's objectives for the NCSR baseline monitoring were to use highly trained and certified citizen scientists to conduct baseline characterizations of the shallow rock and kelp forest ecosystems in the region inside and outside of MPAs. All of RCCA's volunteer citizen scientists complete a rigorous four-day training process and subsequent annual recertification programs. During the baseline monitoring period, RCCA held 12 trainings and recertifications in the NCSR, adding a total of 150 new volunteer divers to the RCCA monitoring program. Volunteer divers were recruited from local diving communities as well as from Humboldt State University and the Bodega Marine Laboratory.

RCCA volunteer citizen scientists conducted 18 visual scuba transects at each monitoring site to survey densities and sizes of ecologically and economically important fish, invertebrate and algal species and to characterize the physical habitats. Transects were 30-meters long and 2-meters wide swaths above the rocky reef substrate. Divers counted and sized key species of fish (35 species), counted invertebrates (33 species) and algae (9 species), and estimated the percent cover of substrate types and vertical relief of the seafloor. Over the baseline monitoring of 2014-2015, RCCA conducted 18 surveys at eight monitoring sites in the NCSR. Three of these sites have been surveyed since 2007.

The data from these surveys were analyzed at multiple scales to provide baseline characterization of the kelp forest ecosystems at the time of MPA implementation. We characterized the biological community at the RCCA monitoring sites by summarizing the physical and biological characteristics of each of the sites. These summaries will serve as a reference point in the future as long-term monitoring continues.

RCCA detected significant differences in the mean sizes of fish species inside versus outside of the Point Cabrillo SMR. The larger size of several of the common fish species (black rockfish (*Sebastes melanops*), kelp greenling (*Hexagrammos decagrammus*), striped surfperch (*Embiotoca lateralis*) in this marine reserve could be an early indicator

of the success of the MPA and serve as an example of relatively fast responses to protection. The highest overall fish biomass recorded during the baseline surveys at any of the RCCA sites was also at the Frolic Cove site in the Point Cabrillo SMR. Even if these size and biomass differences between the monitoring sites existed prior to the establishment of the SMR, the reserve would likely maintain this trend especially for species with small home ranges such as kelp greenling and striped surfperch.

When comparing fish densities across all eight monitoring sites, the less exposed sites in southern Mendocino County have much lower rockfish densities than the exposed sites to the north. Specifically, the two abundant rockfish species, black rockfish and blue rockfish (*Sebastes mystinus*), show a gradient in density from north to south. With the exception of Mendocino Headlands, these two species are present at very low densities at the southern sites. A similar gradient is observed in fish species richness with the northern exposed sites having higher species richness than the southern sites (Figure 1).

Invertebrate species richness showed an inverse trend with sites in the south being more species rich than the sites to the north (Figure 1). Red abalone (*Haliotis rufescens*) densities varied across sites with Mendocino Headlands having much higher densities than any of the other sites sampled. While abalone size frequency distributions varied across the region, most sites have red abalone populations with a mode in their size distributions at or just above the legal size at which red abalone can be taken by recreational fishers.

Analyses of the community structure in the study region demonstrated that kelp forest communities at the RCCA study sites are highly structured. This structure is also reflected in the fish communities, and two distinct fish assemblages were identified. The northern, exposed sites have a different assemblage than the southern, protected sites. The northern sites have higher densities of the common fish species (blue rockfish, black rockfish, kelp greenling, striped surfperch) as well as higher species richness than the southern assemblage. Specifically, some of the less common rockfish species have higher densities or are only found at the northern sites. Cabezon (*Scorpaenichthys marmoratus*), an important invertebrate predator, were only recorded at some of the northern sites and Mendocino Headlands but absent from the southern sites.

The NCSR baseline monitoring took place during a period of very uncommon ocean conditions along the California coast. Starting in 2013, conditions referred to as the ‘warm blob’ developed, leading to unusually high water temperatures. This ‘warm blob’ was followed by an El Niño event in 2015, that continued to produce unusually warm waters and a lack of upwelling. Further, a widespread outbreak of the sea star wasting disease caused sea star populations to plummet on California’s rocky reefs just prior to the baseline period (Figure 2). These events had repercussions affecting the entire kelp forest ecosystems in the NCSR. Purple (*Strongylocentrotus purpuratus*) and red sea urchins

(*Mesocentrotus franciscanus*) are now very abundant, and the canopy forming bull kelp (*Nereocystis luetkeana*), as well as understory kelps such as *Pterygophora* (*Pterygophora californica*) have almost completely disappeared from the reefs (Figure 2). Prior to the baseline period, urchins were present in low numbers and kelps were dominating the reefs, providing three-dimensional habitat structure for fish and food for invertebrates such as red abalone. Now, these reefs are denuded of kelp and large urchin barrens have formed. Fish population densities during the baseline period resemble densities seen at the three sites monitored by RCCA since 2007, and they do not show significant decreases after the onset of the warm water conditions and subsequent changes to the kelp forest community. However, any results from the baseline monitoring must be interpreted with these very unusual events taken into account. The massive and rapid changes to the kelp forest ecosystem demonstrate the importance of ongoing monitoring. In order to detect MPA effects and understand how they interact with changing environmental conditions or sudden events such as disease outbreaks, annual, long-term monitoring is necessary.

We have identified several species as good candidates as indicator species for long-term MPA monitoring programs based on their abundance in RCCA surveys, their presence across the NCSR and their ecological and/or economic importance. These species are not only abundant throughout the NCSR but are also found in the other MLPA study regions, making it possible to integrate monitoring results across regions. The fish species that should be included in any continued MPA monitoring are black rockfish, blue rockfish, kelp greenling, striped surfperch, cabezon and lingcod (*Ophiodon elongates*). Given their ecological and economic importance, red urchins, purple urchins and red abalone should also be monitored as well. Several non-exploited species of invertebrates, such as bat stars (*Patiria miniata*) and California sea cucumbers (*Parastichopus californicus*), should also be included as indicator species. Given the recent changes in the invertebrate community, it is important that species not observed during the baseline program, such as sunflower stars (*Pycnopodia helianthoides*), are included in any continuing MPA monitoring program. Similarly, bull kelp and Pterygophora, the dominate canopy forming species, which were largely absent during the baseline period, should also be included. For these species, densities prior to the baseline years need to be considered when evaluating ecosystem states in the future.

RCCA’s baseline data provide a quantitative characterization of species densities in the NCSR’s kelp forest communities that will serve as a reference point for future measures of MPA performance. Moreover, RCCA’s citizen science monitoring program expanded in the region and developed the capacity for sustained long-term monitoring beyond the initial baseline monitoring. Already, RCCA has built on its long-term time series of monitoring data throughout the North Coast Study Region and throughout California as it has continued to monitor its baseline sites in 2016 and 2017.

Executive Summary Figures

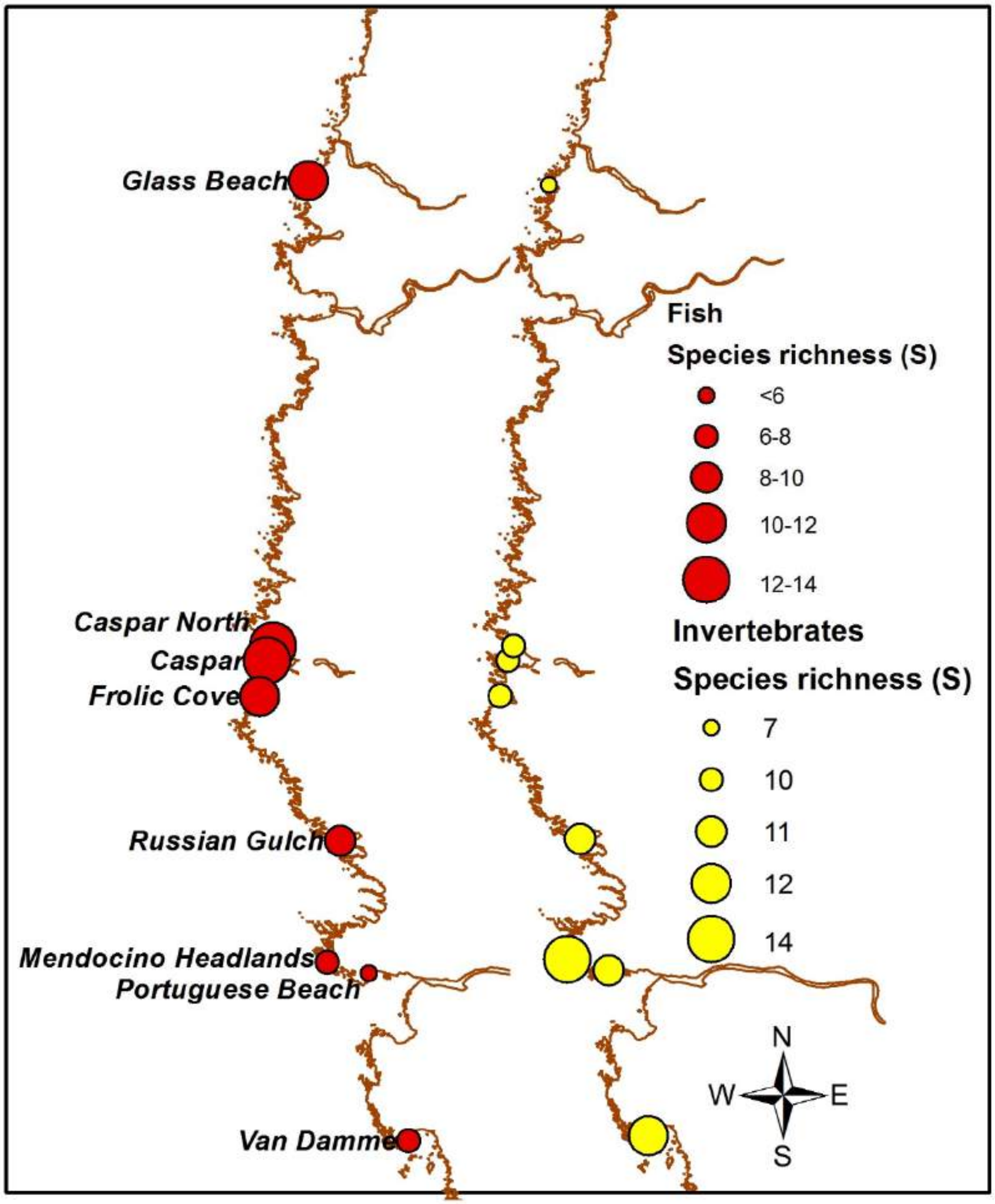


Figure 1. Fish species richness (red circles) and biomass (blue circles) at RCCA study sites along the NCSR during the baseline monitoring period (2014-2015). Fish communities were most species rich in at northern most sites and biomass was greatest within the Point Cabrillo SMR (Frolic Cove).

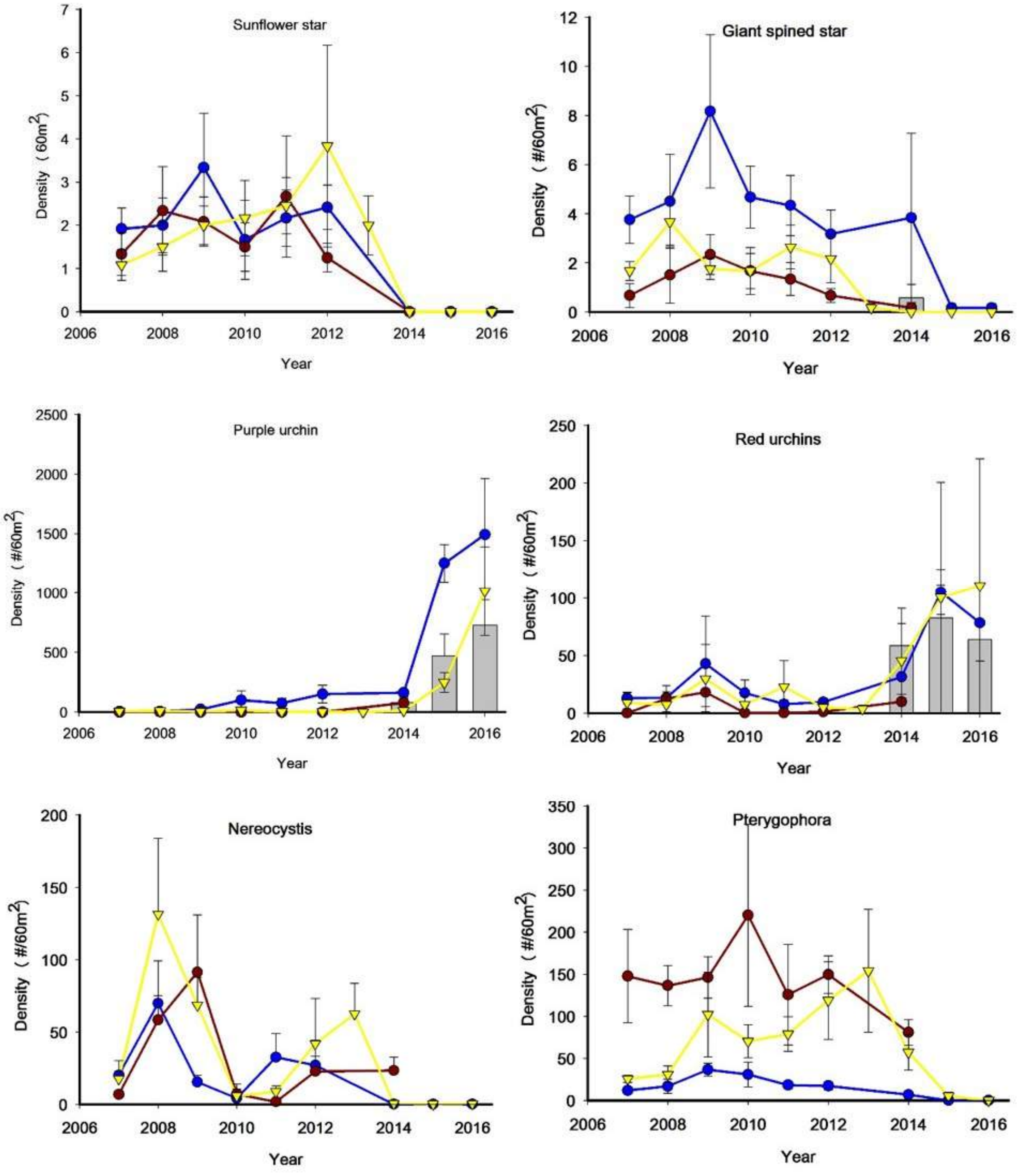


Figure 2. RCCA's long-term kelp forest monitoring data from the NCSR shows the massive changes that kelp forest communities experienced prior to and during the baseline monitoring period. Once common sea stars disappeared from the reefs, urchin populations in the NCSR region increased over 100-fold and are forming barrens on many reefs. At the same time, canopy forming kelps have disappeared at most sites. Lines show data from long-term sites (blue triangles – Mendocino Headlands, red circles – Portuguese Beach, yellow squares – Van Damme). Gray bars represent mean densities from all baseline monitoring sites. (Error bars are ± SE).

Introduction

Organizational Background

Founded in 1996, the Reef Check Foundation is a California based 501(c)3 non-profit organization dedicated to the conservation of the world's reef ecosystems. Reef Check's mission is to empower local communities to protect and rehabilitate reefs worldwide. It does so through grassroots research, conservation and community education. The Reef Check Foundation works to protect and improve the health and sustainability of the world's reefs through the use of citizen science and community-based conservation. It also strives to apply effective and innovative approaches to integrating scientific research, public education and ocean conservation (Freitag and Pfeffer 2013, Thiel et al. 2014, Theobald et al. 2015). Headquartered in southern California, the Reef Check Foundation has built a global network of volunteers that monitor reefs worldwide through three programs: the Tropical Reefs Program, the Baja California/Mexico Program and the California Program. With a staff of eight fulltime employees, it coordinates coral reef monitoring worldwide as well as temperate rocky reef monitoring through its Baja California/Mexico and California Programs.

Program Goals and Objectives

Reef Check California (RCCA) runs the Reef Check Foundation's California Program including its community-based rocky reef monitoring network. RCCA's goal is to improve marine management in California in three ways: 1) by collecting critically needed data on California's near-shore rocky reef ecosystems through the use of volunteer scuba divers; 2) by making these data available to resource managers, universities, researchers and the general public; and 3) by educating and empowering the public to become active stewards of their marine environment. RCCA accomplishes these goals by engaging citizen scientists to work with RCCA on the scientific monitoring of kelp forests and marine protected areas (MPAs). Through intensive training of volunteer scuba divers, subtidal surveys of kelp forests and MPAs, and through community engagement, RCCA fosters public support of science-based management of marine resources. RCCA has been surveying California's near-shore rocky reefs and kelp forests annually since 2006 and currently monitors about 90 primary sites from Mendocino to San Diego Counties. 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 must go through an intensive 32-hour training and are only certified to do surveys once they have satisfactorily passed the classroom and field-tests for each survey type. Volunteers must be recertified and tested each year by RCCA staff prior to collecting data. Given the trainings, capabilities and time commitments required of the volunteer divers, their level of competence is high. Since the inception of the program, RCCA has trained over 1200 divers in California, and each year there is a team of about 250 active volunteers composed of newly trained or returning citizen scientists.

NCSR Baseline Program Objectives

Since 2007, Reef Check California has surveyed rocky reefs and kelp forests in northern California, collecting ten years of data from the MLPA North Coast Study Region (NCSR). The goal of this baseline monitoring project was to quantify key attributes of species, populations, communities and habitat variables that constitute representative kelp forest ecosystems within and outside of MPAs in the North Coast Study Region. The sampling design, selected response variables (i.e. key species) and analytical approaches are intended to provide scientists, managers, stakeholders and policymakers with a baseline for future assessment of the effectiveness of the NCSR MPAs. The outcomes from this study will also provide recommendations for long-term monitoring metrics and survey protocols for the NCSR.

Specifically, the objectives of the NCSR Baseline Program are, as follows:

1. Provide a quantitative baseline characterization of the rocky reef and kelp forest ecosystem feature inside and outside of MPAs in the NCSR.
2. Assess the condition of the rocky reef and kelp forest ecosystems by analyzing RCCA's dataset in the context of newly implemented MPAs.
3. Explore the baseline characterizations for potential indicators of the state of the kelp forest ecosystem (i.e. ecosystem indicators) and make recommendations for long-term monitoring.
4. Build capacity for long-term MPA monitoring through the continued involvement of community members in the monitoring of MPAs.
5. Expand existing online data dissemination and illustration tools to inform managers, stakeholders, policymakers and the public about the status of the marine environment in the NCSR.

Methods

Survey Site Selection

Prior to the baseline monitoring period, RCCA survey sites in the NCSR were selected based on a variety of factors including, but not limited to, local interest by the diving community, historical data and recommendations by resource managers. Other factors considered when selecting survey sites were logistic feasibility (i.e. access via shore or commercial dive boat) and the presence of RCCA dive teams in the area. During the MPA baseline monitoring (2014-2015), supplementary sites were added inside and/or outside of MPAs to complete the monitoring array in regions where sites for MPA/Reference comparison did not exist. For these sites, care was taken to choose locations of similar reef habitat inside and outside of MPAs. All sites are surveyed at least once a year around the same date. The purpose of this standardization of sampling time is to reduce inter-annual variability in the data due to seasonal differences in the rocky reef communities.

Survey Methods

Reef Check California monitoring consists of visual surveys performed by scuba divers. At each site, buddy teams of divers conduct eighteen 30 m x 2 m benthic transects, to monitor key species of fishes (35 species), invertebrates (33 species), and algae (five species & four invasive species) and to characterize the reef substrate and relief (Appendix A). RCCA's survey methods are based on visual census survey methods developed by the Partnership of Interdisciplinary Studies of Coastal Oceans (PISCO) and have been modified to be taught in a reasonable amount of time to volunteer scuba divers (Gillett et al. 2012). Species are selected based on their ecological or economic importance or because they are of specific management concerns. A list of the species and the rationale for their selection is provided in Appendix A. Transects are placed parallel to shore, along isobaths in a stratified random manner across two depth zones. Allocation of transects is stratified into inshore (5 m-12 m) and offshore (12 m-20 m) strata and, in each zone, transects are randomly placed on rocky reef substrate. In each stratum, three core transects, 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 line. 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 coastline and is considered a site (Figure 3).

Along each transect, species are identified, counted, and, in the case of fish and abalone, sized. Fish are sized to the nearest centimeter from the mouth to the tip of the tail (total length). Abalone were sized to the nearest centimeter in 2014-2015 and to the nearest millimeter starting in 2016. This change was made to standardize abalone data between the California Department of Fish and Wildlife and RCCA.

The RCCA species list is the same for the entire state allowing for analyses at various spatial scales. A detailed description of Reef Check California's monitoring protocol is provided in Appendix B and the entire monitoring and training manual can be found at: http://reefcheck.org/rcca/monitoring_protocol.php.

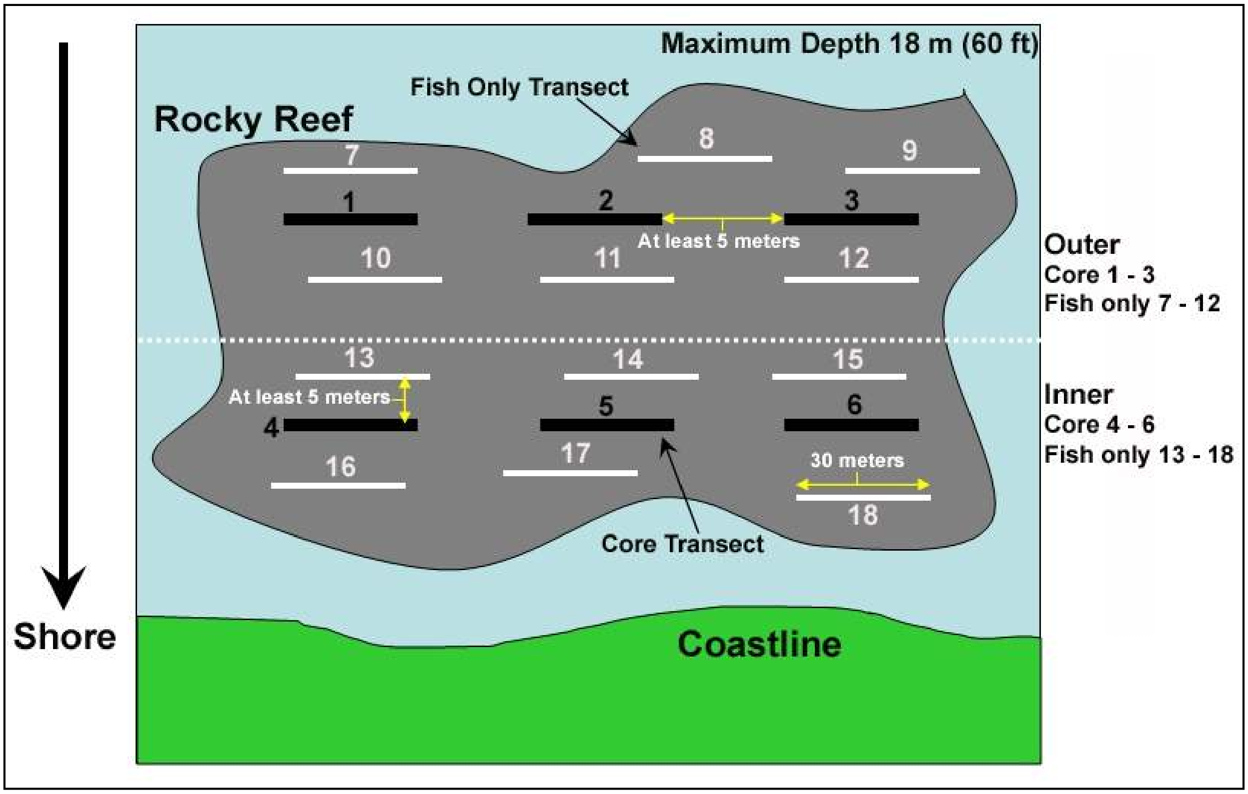


Figure 3. Diagram of RCCA transect allocation on a rocky reef. A site consists of six core transects, (black: 3 inshore, 3 offshore), plus an additional 12 randomly placed fish transects (white, 6 in each zone). All transects are 30 m in length.

Fish sampling

Targeted fish species are counted and sized by the lead diver in a buddy team along 18 transects at each study site. Each fish is identified to species and its total length is recorded. Fish are counted by searching along the 30 m long x 2 m wide swath on the substrate and in the bottom two meters of the water column. Cracks and crevices in the reef are searched using flashlights, but no rocks are moved to during the search.

Invert and algae sampling

Individual invertebrates and algae are counted along six 30 m long x 2 m wide transects at each site. Typically, a diver slowly swims one direction counting targeted invertebrates and then swims back counting targeted macroalgae. Cracks and crevices are searched and understory algae are pushed aside to reveal invertebrates. No organisms are moved. If more than 50 individuals of one species are counted, the search for this species ends and the distance along the transect at which 50 individuals were reached is recorded (sub-sampling). This sub-sampling procedure was used for red abalone (*Haliotis rufescens*) prior to 2016, and all abalone were also measured to the nearest centimeter. As of 2016, all abalone found on the transect are counted and (for the NCSR) measured to the nearest millimeter using specially designed calipers.

Physical habitat sampling

The physical characteristics of RCCA's monitoring sites are described in terms of substrate type, vertical relief, and percent cover of sessile space-occupying organisms. Variables are measured by uniform point contact (UPC) surveys of 30 points along six 30 m transects at each site. Substrate type is recorded as sand, cobble (0.5 cm-15 cm diameter), boulder (15 cm-1 m diameter) or bedrock (>1 m diameter). Vertical relief (rugosity) is estimated by determining the greatest height difference that exists within 0.5 m to either side of the point and the 0.5 m in front of the point, at every UPC point along the transect. This rugosity is recorded as one of four categories (0 cm-10 cm, 10 cm-1 m, 1 m-2 m, and >2 m). The primary biological substrate cover (attached organisms) is described as one of nine categories of organisms or (rarely) as bare rock (Appendix A).

Data Quality Assurance

Data quality assurance is an important aspect of any monitoring program and is a crucial part of the data collection and management process in a citizen science program, such as RCCA, in which many individuals are involved across a large geographic area (Schroeter et al. 2009, Bonter and Cooper 2012, Dickinson and Bonney 2012). Reef Check California has built data quality assurance and control mechanisms into its protocol at every step, from the collection in the field to the final public data release (Freitag et al. 2016). 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. Errors in the data or omissions detected at this stage can be corrected by repeating the transect in question. 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 counts of a species or species that are not usually found in a given geographic region). Unusual data detected during data entry are flagged for review. Flagged data are discussed with the person that collected the data and then reviewed by RCCA staff. In a third step, all data entries are checked by RCCA staff by comparing them to the field datasheets to detect data entry errors. 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://data.reefcheck.org. The data collected as part of the NCSR baseline monitoring program, as well as detailed metadata, can also be found at: http://oceanspaces.org/data.

Analytical Methods

Baseline characterization of study sites

To characterize the biological communities and populations at the RCCA survey sites, fish, invertebrate and algae densities are calculated as the mean density and associated standard error for a 60 m^2 area (i.e. area of a transect). For each site, mean densities are calculated across the two baseline survey years (2014, 2015) and the associated standard error is estimated between both years. In the instances when a site was only surveyed in one of the baseline monitoring years, then the mean represents densities from that year.

Community structure

To illustrate patterns of community similarity characterizing the region during the baseline period and to test for significant differences in community structure we used Bray-Curtis similarity matrices to generate cluster dendrograms in PRIMER (Clarke 2006). MDS plots were then generated to aid in visualizing the similarities among samples. These analyses were conducted for the entire community comprised of the fish, invertebrate and algae assemblages. 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 than fish or invertebrates. To ensure that the analysis is not biased towards abundant individual species, the weighted data was then square-root transformed. Square-root transformation is a weak transformation that reduces the effects of very abundant species while not overly emphasizing the presence or absence of rare species in defining the community similarities (Clark et al. 2014).

Similarity matrices were calculated using standardized and transformed mean density estimates for each site from the two years sampled. Bray-Curtis similarity indices were calculated for each pair-wise comparison of these mean samples using the formula:

$$d^{BCS} = 100(1 - \frac{\sum_{k=1}^{n} \left| y_{i,k} - y_{j,k} \right|}{\sum_{k=1}^{n} \left(y_{i,k} + y_{j,k} \right)})$$

Where d^{BCS} is the Bray-Curtis similarity index between the samples *i* and *j*, *k* is an index of the set of species being compared between samples, *n* is the total number of these species and $y_{i,k}$ is the observed number of species *k* in sample *i*. These values range from a value of 100 (all species present in equal abundances) to 0 (no species seen in common between samples). Cluster analyses were performed using the group-average linking method and all distinctions detected between groups were evaluated using the

SIMPROV test (α = 0.05). Using the same approach, we also generated dendrograms for fish and invertebrate assemblages separately.

Temporal trends in long-term data

To investigate temporal trends of population densities and to put densities observed during the baseline monitoring period (2014-2015) into a longer-term perspective, we used RCCA's time series data beginning in 2007. To test for significant increases or decreases in population densities of key species, we used a linear regression for each species at each site. For these analyses, the response variable was square-root transformed (SAS v.9.4).

Results and Discussion

Baseline Surveys

Reef Check California proposed to survey 8 sites in the NCSR in 2014 and 2015 as part of the baseline monitoring program. RCCA completed seven sites in 2014 and seven sites in 2015 all located in Mendocino County (Figure 4, Table 1). Several of these sites were monitored previously by RCCA (beginning in 2007), providing a decade-long time series of monitoring data from these sites. RCCA continued to survey its sites in Mendocino County in 2016. For the baseline characterization of this region, we used the data from 2014 and 2015 in order to be consistent with the two-year time period used for baseline characterization in the other MLPA study regions. Due to difficulties finding a dive boat on the North Coast, the proposed sites in and outside of the 10 Mile SMR were not surveyed during the baseline period. In addition to the 6 sites completed in 2016, 5,000 additional abalone size measurements were gathered as part of a new project in collaboration with The Nature Conservancy.

The location of RCCA's existing sites in the North Coast Study Region allowed us to contribute to the characterization of the region as well as to provide long-term data for the region. Due to their placement before the MPA implementation and the need for consistency in RCCA long-term monitoring, site locations were not moved in response to the MPA implementation. Fortunately, the existing monitoring sites allowed us to monitor inside and out of the new MPAs. Additional sites were added to accommodate monitoring inside and outside of MPAs where no long-term sites existed.

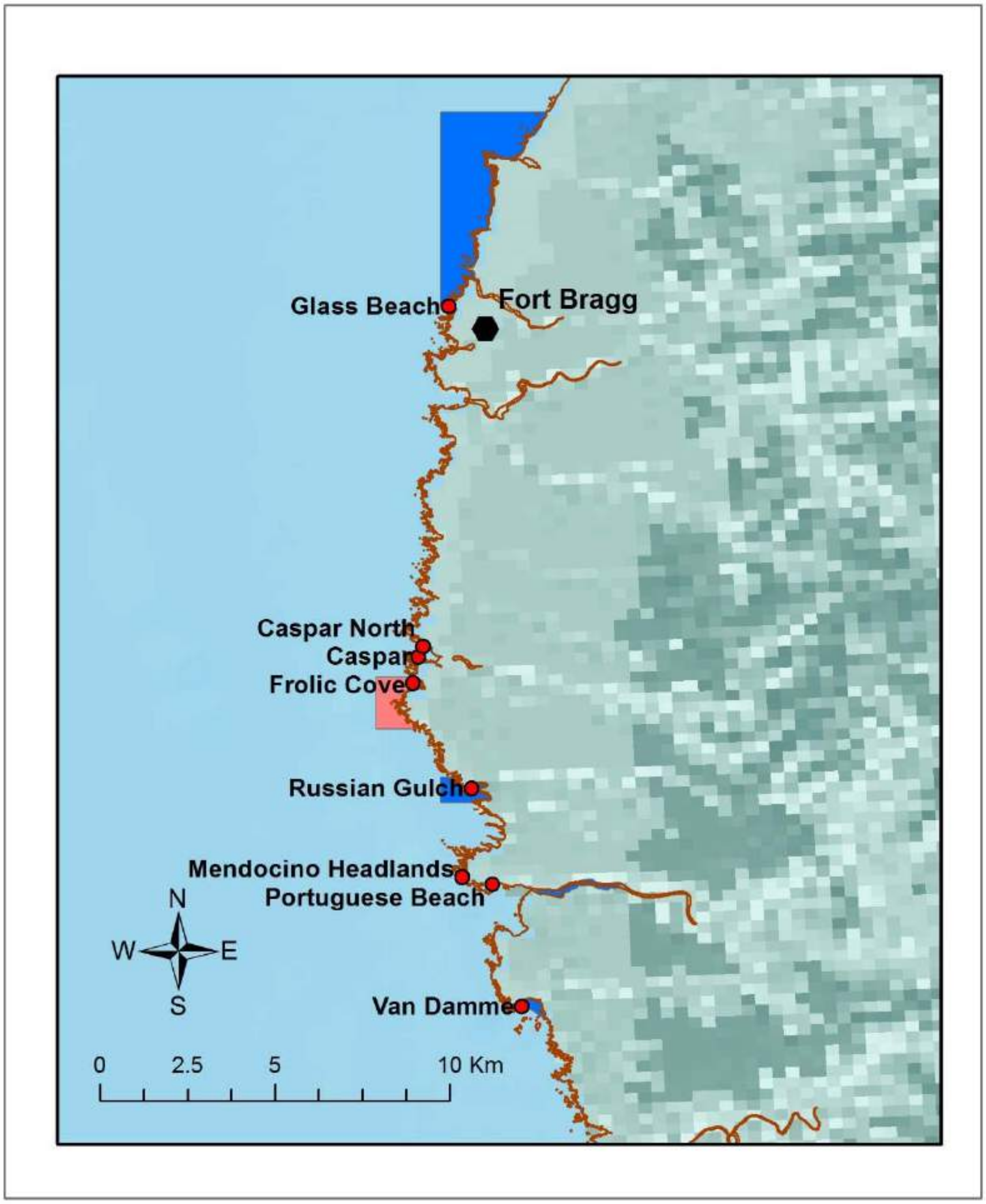


Figure 4. RCCA sites (red dots) found within the NCSR. Blue boxes indicate SMCAs while red boxes indicate SMRs.

Background and Larger Scale Processes During Baseline Period

The NCSR baseline monitoring took place during a period of very uncommon ocean conditions along the California coast. In recent years, the coastal waters along California have experienced very unusual warm temperatures. Starting in 2013, conditions referred to as the 'warm blob' have developed (Leising et al. 2015, Peterson et al. 2015). This 'warm blob' was followed by an El Niño in 2015 which continued to produce unusually warm waters and a lack of upwelling (García-Reyes and Sydeman 2017) (Figure 5).

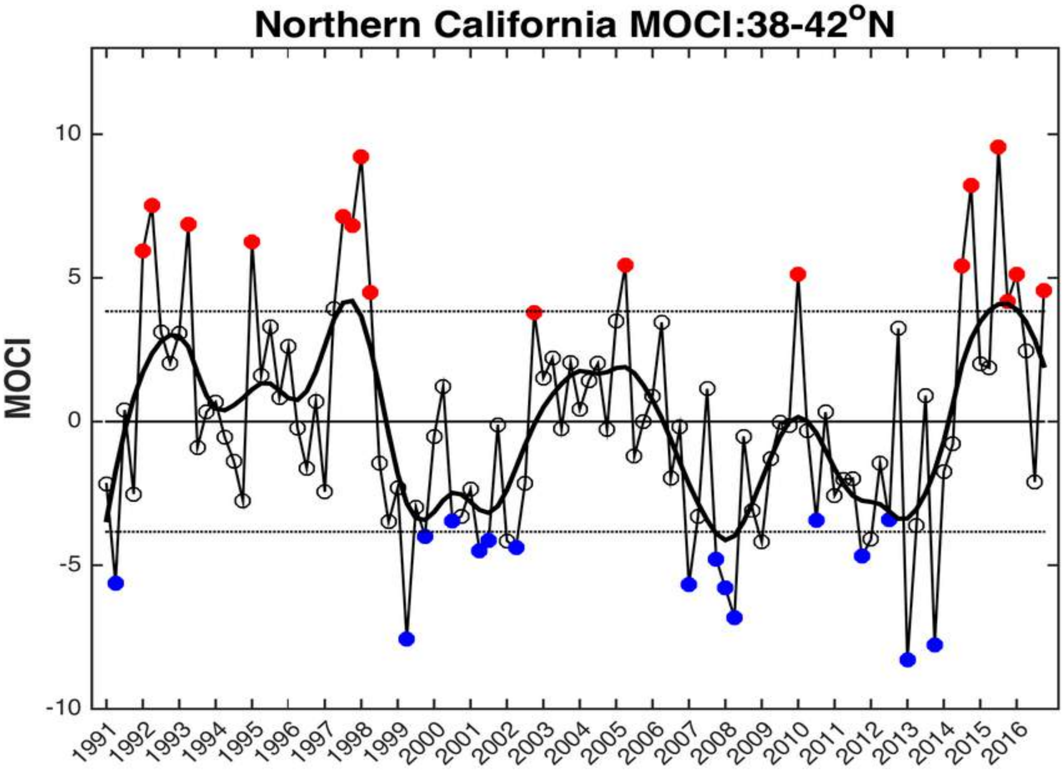


Figure 5. Multivariate Ocean Conditions Index (MOCI). MOCI synthesizes several local and regional ocean and atmospheric conditions that represent, in a holistic manner, the state of the California coastal ocean. Positive values indicate warmer, no-upwelling conditions; negative values indicate the opposite. Figure from García-Reyes and Sydeman 2017.

During this time, water temperatures along the north coast were up to several degrees Celsius warmer than the long-term average. Higher than average water temperatures were particularly prevalent in the NCSR during the fall and winter months of 2014 and in the summer of 2015. These conditions were more pronounced in the southern part of the study region than in the north. In 2016, water temperatures were again more similar to the long-term average than during the two baseline years (Figure 6).

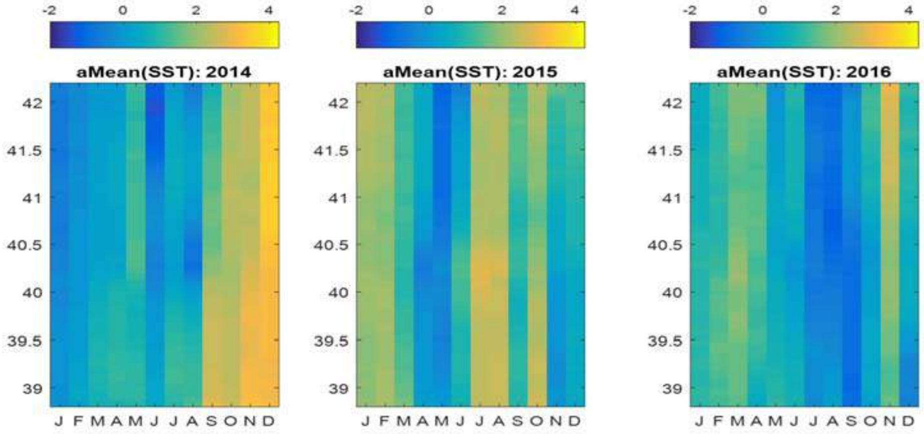


Figure 6. Month-by-latitude anomalies in mean sea surface temperature (SST) for the baseline years and 2016 (year vs. 2003-2016). Figure from Bjorkstedt *et al.* NCSR Ocean Context Report.

Another important large-scale event along the American west coast during the baseline monitoring period was the emergence and spread of the sea star wasting disease (Hewson et al. 2014, Menge et al. 2016). As a result of this widespread outbreak, sea star populations have plummeted on California's rocky reefs and two important predators, the sunflower star (*Pycnopodia helianthoides*) and the giant spined sea star (*Pisaster giganteus*) have all but disappeared from most subtidal reefs (Figure 7). These unusual ocean conditions, as well as the loss of important species from the kelp forest ecosystem, must be considered when interpreting the results of the NCSR baseline monitoring. For instance, the unusual conditions warrant considering the baseline results in light of a longer-term time series of ecological and environmental data from the NCSR or elsewhere in order to account for very unusual species densities during the baseline period.

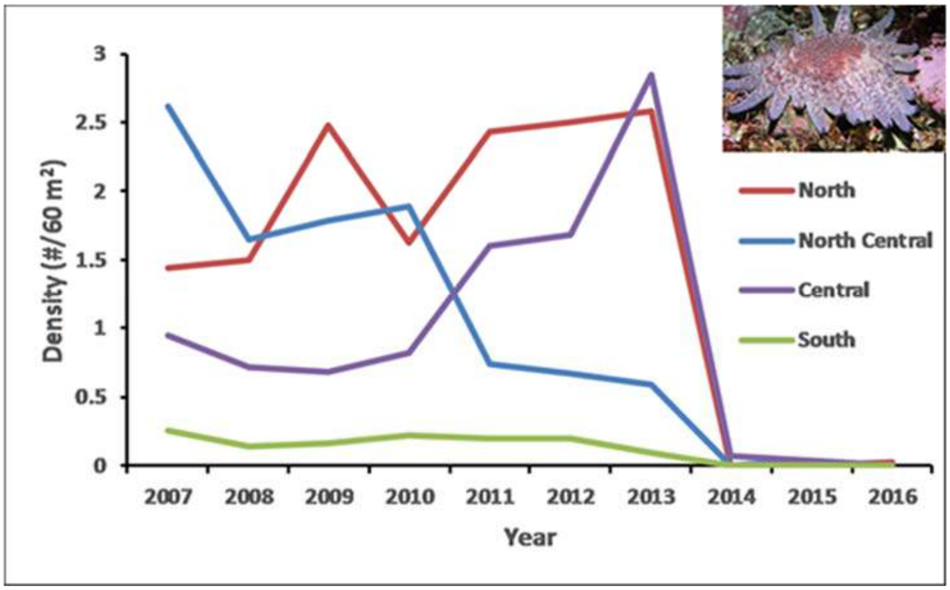


Figure 7. Density of sunflower stars observed in all MLPA study regions monitored in California during RCCA annual surveys.

Baseline Characterization of Study Sites

To characterize the biological community at the RCCA monitoring sites during the baseline monitoring period (2014-2015), we summarized the physical and biological characteristics of each of RCCA's sites located in the NCSR (Appendix C). The mean values of species densities and their associated standard error at sites inside and outside of MPAs provide a snapshot of the habitat and ecological community that can be used to evaluate changes in populations and community structure over time. For each site, the mean densities of fish, invertebrate and algae species, as well as the physical substrate and primary substrate cover (i.e. attached organisms), are summarized. To highlight the type of information that is summarized in Appendix C, we describe the physical habitat and ecological community of the study sites during the baseline monitoring period below. This is followed by graphs summarizing the densities of selected species at all sites.

Table 1. Location of RCCA monitoring sites in the NCSR and the years in which they were surveyed.

Site	Latitude	Longitude	07	08	09	10	11	12	13	14	15	16
Trinidad	41.0550	-124.1400		X					X			
Glass Beach	39.4517	-123.8147									X	
Caspar North	39.3644	-123.8213								X	X	X
Caspar	39.3617	-123.8225		X		X				X	X	X
Frolic Cove	39.3550	-123.8239								X	X	X
Russian Gulch	39.3280	-123.8088								X	X	X
Mendocino Headlands	39.3053	-123.8112	X	X	X	X	X	X		X	X	X
Portuguese Beach	39.3032	-123.8034	X	X	X	X	X	X		X		
Van Damme	39.2719	-123.7959	X	X	X	X	X	X	X	X	X	X

No invasive species were quantified during the RCCA surveys at any of the study sites. The species list used by RCCA contains species from all biogeographic regions in California. Therefore, range shifts would have been detected if, for example, species typically found further south started to show up in the NCSR during the baseline period. None were seen during surveys in the NCSR. However, we did detect species range shifts in the Central Coast region during those years, where several southern California fish species were see. We also documented a range expansion of the crowned urchin (*Centrostephanus coronatus*) from southern California into central California (Freiwald et al. 2016). One species that has been widely reported as spreading northward during the warm water conditions in 2014/15 is the nudibranch Hopkins rose (*Okenia rosacea*). This species was observed by RCCA divers during surveys in the NCSR (Figure 8). As this species is not on the RCCA species list its presence was not quantified. A limited species list somewhat restricts the ability of a monitoring program to detect invasive species as not all species are searched for. While able to detect range shifts of common species in California, the current protocol limits the ability of the program to detect new invasive species unless they are added to the species list. RCCA has done this for several invasive algae species on its statewide species list. Nevertheless, a secondary effect of the RCCA training is the presences of well-trained observers in the ocean that are more likely to report unusual observations than untrained divers as demonstrated by the reports of the Hopkins rose.

Figure 8. Hopkins rose observed by RCCA diver in the NCSR during the baseline monitoring surveys (photo A. Neumann).

Van Damme

Figure 9. Pinto abalone at Van Damme (photo J. Freiwald)

Van Damme has been an RCCA survey site since 2007 and is located within Van Damme SMCA. Because Van Damme is a large, south-facing cove with an extensive outer reef, it is protected from most swells. This orientation means that this site is accessible for divers in less than ideal conditions, making Van Damme a favorite dive site for spear fisherman, abalone divers and recreational scuba divers. The site was surveyed at depths between 3.4 m and 11.4 m. The middle part of the cove is mostly sand and cobble. However, the northern, southern and outer reefs are primarily low-relief (10 cm-1 m) bedrock structures that are covered in crustose coralline and red algae. The survey site is accessed by shore and usually surveyed twice per year, once in the spring and once in the fall, depending on conditions. Like many sites in the NCSR, Van Damme’s invertebrate community is dominated by purple urchins (*Strongylocentrotus purpuratus*), red abalone and red urchins (*Mesocentrotus franciscanus*). However, Van Damme also has the highest density of pinto abalone (*Haliotis kamtschatkana*) of the RCCA sites in the NCSR and a noticeable population of flat abalone (*Haliotis walallensis*). This site is also the only site in the NCSR where giant kelp (*Macrocystis pyrifera*) is present along with *Pterygophora* (*Pterygophora californica*), bull kelp (*Nereocystis luetkeana*) and *Laminaria* spp*.* Despite the array of kelps present, Van Damme has little in the way of fish populations. Six species of fish are observed at this site, all in low densities relative to other sites in the NCSR. The most abundant fish species observed was kelp greenling (*Hexagrammos decagrammus*).

Russian Gulch

Russian Gulch has been an RCCA site since 2014, and is located within Russian Gulch SMCA. The site is a fairly narrow inlet that faces south/southwest and is protected from the dominate northwestern swells on the North Coast. A gently sloping beach entry makes this site easily accessible by shore. The site was surveyed at depths between 3.2 m and 11.4 m. The middle of the inlet is sand, which is flanked by cobble, then a bedrock structure that has a low relief (10 cm-1 m) and is covered in crustose coralline algae. *Pterygophora* is the dominate kelp present in the site, although bull kelp and *Laminaria* have also been observed. Overall, 11 different species of invertebrates are observed in Russian Gulch. However, unlike many of the sites in the NCSR, purple and red urchins do not dominate the invertebrate community and red abalone and bat star (*Patiria miniata*) densities are high. Kelp greenling and striped surfperch (*Embiotoca lateralis*) are the most commonly observed fish species at this site.

Figure 10. Surface swim at RCCA's Russian Gulch site (photo A. Neumann).

Portuguese Beach

Portuguese Beach has been a RCCA site since 2007 and is located on the southern side of the Mendocino Headlands. Portuguese Beach has traditionally been a challenging site

Figure 11. Portuguese Beach site seen form the beach (photo A. Neumann).

to sample due to low visibility (less than the RCCA 3-meter visibility requirement) caused by discharges of fine sediment by the nearby Big River. The site was surveyed at depths between 4.1 m and 11.6 m. The site is comprised of low-relief (10 cm-1 m) and medium- relief (1 m-2 m) bedrock structure. The site has a wide array of organisms covering the substrate including articulated coralline, brown algae, crustose coralline, sessile invertebrates, red algae as well as a substantial amount of bare rock. The North Coast team was only able to survey the site once during the baseline period (2014) and before the bloom of urchins seen in the region. Therefore, the results for the invertebrate community presented in this report might not reflect current conditions. Similarly, *Pterygophora* and bull kelp densities were high in 2014, but this might have changed later during the baseline period as it did at other sites. Bat stars and red abalone dominated the invertebrate community, while surfperch and kelp greenling had the highest densities for fish. However, there was a noticeable lack of rockfish at this site.

Mendocino Headlands

Figure 12. View of Mendocino Headlands site.

Mendocino Headlands has been an RCCA site since 2007 and is one of the most exposed sites in the NCSR. Comprised of a main surge channel with a rocky outcropping acting as the entry and exit point, the Headlands can only be sampled on calm days with little swell and light wind. The site was surveyed at depths between 5.6 m and 14.5 m. In general, the bottom gradually slopes down with areas of high relief (>2 m) and moderate relief (1 m-2 m) are observed by divers 5% of the time and 19% of the time, respectively. Overall, the bottom composition is bedrock covered in crustose coralline algae, but small patches of sand and cobble appear in places and articulated coralline is also common. During the baseline period (2014-2015), *Pterygophora* was the most commonly observed species of kelp. However, prior to the baseline studies, bull kelp was also present at this site. Like the other sites in the NCSR, purple urchins, red urchins and red abalone dominate the invertebrate community. Densities of red abalone and purple urchin are the greatest here as compared to other sites in the NCSR. This site also has the most species-rich invertebrate community relative to the other NCSR sites, with 14 species observed. Kelp greenling and blue rockfish (*Sebastes mystinus*) were the most commonly observed fish species at the Mendocino Headlands site.

Frolic Cove

Figure 13. RCCA citizen scientist diving at Frolic Cove (photo A. Neumann).

Frolic Cove located within the Point Cabrillo SMR has been surveyed by RCCA since 2014. Frolic Cove is named after the merchant vessel Frolic that sunk offshore in 1850. It has been dubbed as the “most significant shipwreck on the west coast” by historians at the San Francisco Maritime Museum. In failed attempts to salvage goods from the Frolic, a lumber surveyor discovered the virgin Redwood and Douglas Fir forest along the coast, and in 1852, the first lumber mill on the Mendocino coast was established. The survey site is easily accessible from shore with a quarter mile walk along the bluffs. The cove is protected by an outer reef and no major rivers or streams run into the cove, making visibility better than at other sites in the NCSR. The site was surveyed at depths between 3.1 m and 8.1 m. It was comprised of a low-relief (10 cm-1 m) bedrock structure covered in articulated coralline algae. Purple urchins, red urchins and red abalone were the dominate invertebrate species within the cove but at lower densities than at other sites. Kelp greenling and striped surfperch were the most commonly observed fish within Frolic Cove, however, large lingcod (*Ophiodon elongates*) and cabezon (*Scorpaenichthys marmoratus*) were often recorded. Additionally, lingcod within the cove were also found to be more aggressive, charging divers and attacking transect lines.

Caspar Cove

Figure 14. Sunflower star at Caspar North. This is the one of the only two individuals counted statewide by RCCA in 2016 (photo A. Neumann).

Caspar Cove is host to two RCCA sites, one on the southern side (Caspar) and one on the northern side (Caspar North). The northern side of the cove is open to all fishing while the southern side has been closed to urchin fishing since 1989. RCCA has surveyed the Casper site since 2008, while the Caspar North site was implemented in 2014 as part of the baseline monitoring project. When comparing Casper and North Casper from observations made since 2014, the sites are very similar despite the existing urchin fishery in Casper North. Both Caspar and Casper North are roughly 800 m from the beach and are best accessed by small boat or kayak. The Caspar site was surveyed at depths between 3.2 m and 8.4 m. Caspar North was surveyed at depths between 6.1 m and 12.8 m. Both sites had low relief (10 cm-1 m), and the substrate was predominantly bedrock, covered in either crustose or articulated coralline algae. Purple and red urchins dominated the invertebrate community, and densities of red abalone were lower at these sites than other sites in the NCSR. Blue rockfish and kelp greenling were the most commonly observed fish species at the Caspar Cove sites, and the densities and species richness of fish were greater at these sites when compared to other sites in the NCSR.

Glass Beach

Located in Fort Bragg, Glass Beach was traditionally used as the town's dumping site from 1906-1943. Glass, appliances and even vehicles were deposited at three locations and routinely burned to reduce the size of the piles. Today all that remains is the glass which has been transformed into beach glass by years of wave action. Glass Beach is a favorite site for tourist in Fort Bragg with an estimated 1,000-1,200 people visiting the beach on a sunny summer day. As a dive site, Glass Beach is a favorite spot for advanced spear fisherman and abalone divers. It has been an RCCA site since 2015. The site was surveyed at depths between 5.5 m and 9.5 m. The site's substrate is mostly comprised of bedrock and boulders covered in articulated and crustose coralline. In general, the site was classified as a low-relief reef (10 cm-1 m) with an invertebrate community dominated by purple urchins, red abalone and bat stars. The only species of kelp observed at Glass Beach were *Pterygophora* and *Laminaria*, both in very low densities. However, the diversity of fishes was much greater than at other sites with 12 different species of fish observed at this site. The most abundant fishes found were black rockfish (*Sebastes melanops*), blue rockfish, striped surfperch, kelp greenling, lingcod and cabezon.

Figure 15. Glass Beach site as seen from the cliff (photo A. Neumann).

Species Densities at Study Sites

Several species of fish and invertebrates are common throughout the NCSR. We have selected the most common fish and invertebrate species and graphed their densities for each study site (Figure 16 & Figure 17). Mean species densities for all species at each of the RCCA study sites are summarized in Appendix C. Several patterns emerge when comparing fish densities of the common species across sites. Overall, rockfish densities at the less exposed sites at the southern range of the study sites are much lower than at the exposed site to the north (Figure 16). Specifically, the two abundant rockfish species, black and blue rockfish, show a decrease in density from north to south, with the exception of Mendocino Headlands. Kelp greenling and striped surfperch do not present the same geographic gradient; in fact, their densities are greatest at the Mendocino Headland site (Figure 16). Cabezon and lingcod are present at much lower densities than the other four species with cabezon being absent from several of the sites (Figure 16). The absence of this major macro-invertebrate predator at many sites is a significant finding as this species would be able to fill the predatory niche of the sunflower stars that have been lost from the system due to the sea star wasting disease (Figure 32). Lingcod densities are similar across sites with the exception of Glass Beach where their density in 2014 was more than three times greater than at any other site.

When fish densities at the Point Cabrillo SMR are compared to densities at nearby sites where fishing is allowed they do not show a consistent pattern among species (Frolic Cove site (SMR), compared to Caspar and Caspar north sites (outside MPA) in Figure 16). While fish densities for several species at the Frolic Cove site are within the upper range of the densities found throughout the region, they are not significantly greater than the densities at the two neighboring sites in Caspar cove (Table 2).

The only species showing significant differences among the three sites in an ANOVA are blue rockfish (p=<0.000), and striped surfperch (p=0.008). For these two species, differences between sites were tested using a Tukey's posthoc test. Blue rockfish show significant differences in density among all three sites. However, a large number of the blue rockfish individuals observed during the baseline period were either YOYs or one-year-old fish (Figure 28). Therefore, these differences in density were potentially driven by recent recruitment events. Overall, we observed very few large blue rockfish at these sites, indicating that recruitment dynamics might not be persistent and did not create differences in the densities of post-recruitment populations.

In a Tukey's posthoc test, striped surfperch densities at the Frolic Cove site were significantly greater than at the Caspar site (p=0.012) but no significant differences were detected between Frolic Cove and Caspar North (p=0.94). Striped surfperch densities at the two fished sites, Caspar and Caspar North, were also significantly different (p=0.037). Therefore, while there were some significant differences in the species densities at the sites inside and outside of the MPA, these pairwise comparisons show no MPA effect for these sites during the period monitored.

Table 2. Results of ANOVA comparing fish densities among the three sites at Pt. Cabrillo SMR (Casper North, Caspar and Frolic Cove). Data were square-root transformed.

Species	DF	F	P
black rockfish	2	1.04	0.359
blue rockfish	**2**	**17.95**	**0.000**
kelp greenling	2	1.23	0.295
striped perch	**2**	**5.04**	**0.008**
lingcod	2	0.33	0.721
cabezon	2	1.47	0.236

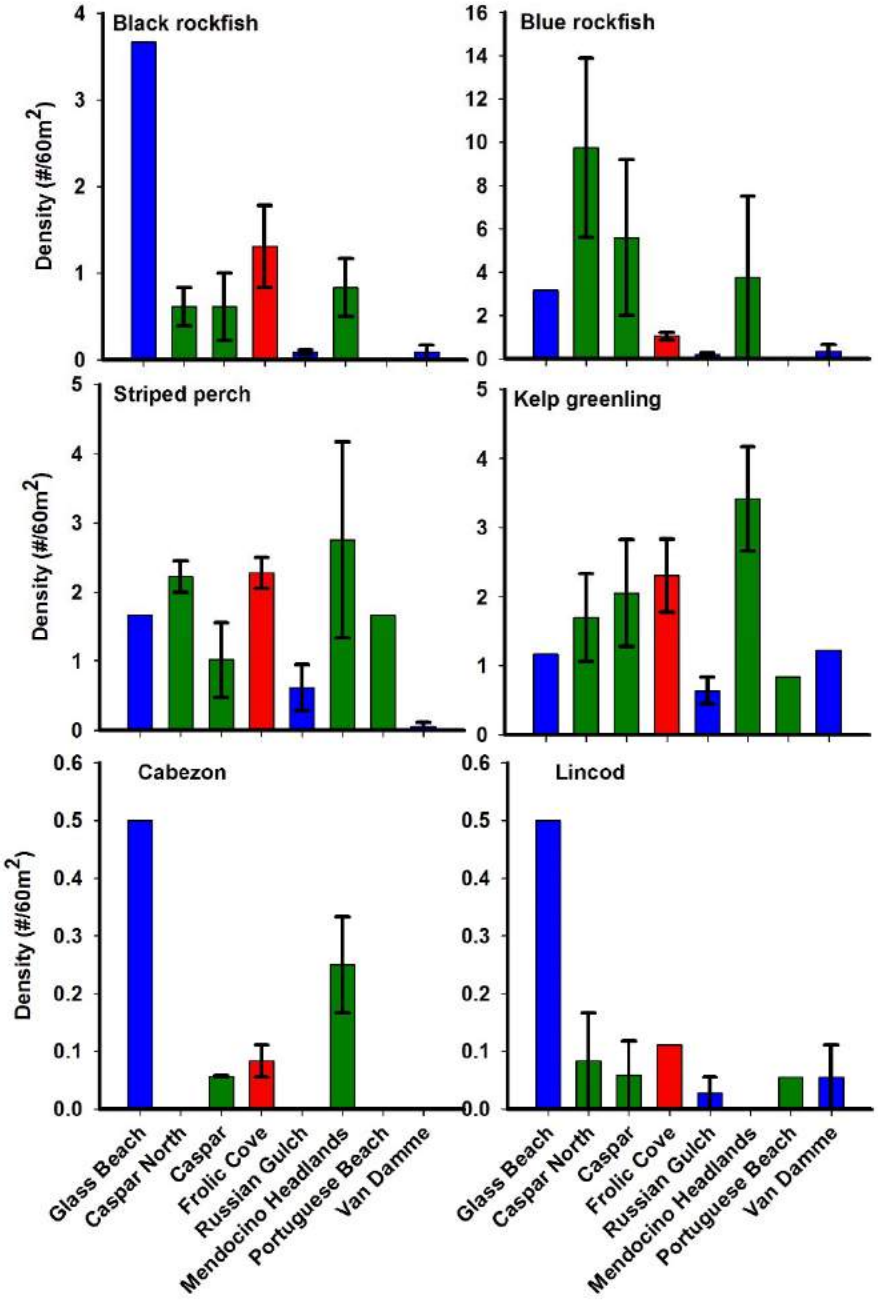


Figure 16. Fish densities at the RCCA study sites during the baseline period. Data from 2014 and 2015 are pooled and error bars show the SE between years. Sites are ordered from north to south. Bars are colored according to the protection level of the sites. Red – SMR, blue – SMCA, green – outside of MPA.

Figure 17 shows average densities for six invertebrate species at the RCCA study sites. These species were either common across the study region, or, in the case of the bat star, were selected because all other sea star species have been decimated by the sea star wasting disease (Figure 32). The California sea cucumber *(Parastichopus californicus*) and the taxonomic group of anemones were selected because, so far, we have not detected any effects of the recent unusual environmental conditions on these groups. Lastly, the two species of sea urchins were selected because their densities have increased over 100-fold since the warm water conditions and the sea star wasting disease occurred (Figure 32). Historically, bat stars and red abalone have been the most common invertebrate species observed during RCCA surveys (Figure 32). This was not the case during the baseline monitoring period of 2014/15. Their densities have been surpassed by the densities of purple and red urchins at several sites (Figure 17). Nevertheless, bat stars and red abalone are still common at most sites. Red abalone have the highest density at Mendocino Headlands despite high abalone fishing pressure at this site. Bat star densities are variable but similar across sites with the exception of Portuguese Beach where they are almost absent (Figure 17). Densities of both sea urchin species are very high at several sites. When comparing their densities across the study sites it is important to remember that Portuguese Beach was only surveyed in 2014, which is before the increases in urchin densities took place in the region. Nevertheless, there are several sites, Glass Beach, Frolic Cove and Russian Gulch, where urchin densities during the baseline years remained closer to what they have been in the region prior to the baseline monitoring period.

When comparing the densities of urchins inside versus outside of the Point Cabrillo SMR (i.e. Frolic Cove site compared to Caspar and Caspar North sites; Figure 17), their densities are much lower in the protected area than at the fished sites (Table 3). For purple urchins this pattern is only significant for the Caspar North site, whereas the densities at Caspar and Frolic Cove are not significantly different from each other (purple urchins Tukey's posthoc: Frolic vs. Caspar: p=0.29, Frolic vs. Caspar North p=0.008). This is likely due to the high variability in purple urchin density at the Caspar site. For red urchins, the Frolic Cove site has a significantly lower density than the two fished sites (Tukey's posthoc: Frolic vs. Caspar: p=0.001, Frolic vs. Caspar North: p<0.0001).

The two sites in Caspar Cove, Caspar North and Caspar, are in two different management areas. At the northern side of the cove, where the Caspar North site is located, commercial urchin fishing is allowed. Whereas, at the southern side of the cove, where the Caspar sites is located, commercial urchin fishing is prohibited. Both sites have very high purple and red urchin densities and we found no significant difference between the densities of the two species in the different management areas (Tukey's posthoc test: purple urchins: Caspar vs. Caspar north p=0.23; red urchins: Caspar vs. Caspar north: p=0.52).

Red abalone densities at the Frolic Cove sites (Pt. Cabrillo SMR) are higher than at the neighboring fished sites but this difference is only significant in a Tukey's posthoc pairwise comparison between Frolic Cove and Caspar and not between Frolic Cove and the Caspar North site (p=0.001 and p=0.11, respectively). As these examples show, there are significant differences in the invertebrate densities inside and outside of Pt. Cabrillo SMR but there is no clear pattern in pairwise comparison when the two neighboring sites are considered. This suggests that the differences are not the early results of protection but rather the result of variability in species densities based on pre-existing conditions at these sites indicating that further monitoring of these sites is required to detect MPA effects.

Table 3. Results of ANOVA comparing invertebrate densities among the three sites at Pt. Cabrillo SMR (Casper North, Caspar and Frolic Cove). Data were square-root transformed.

Species	DF	F	P
bat star	**2**	**5.83**	**0.007**
red abalone	**2**	**7.52**	**0.002**
California sea cucumber	2	2.18	0.129
anemone	**2**	**3.32**	**0.048**
purple urchin	**2**	**5.15**	**0.011**
red urchin	**2**	**13.21**	**0.000**

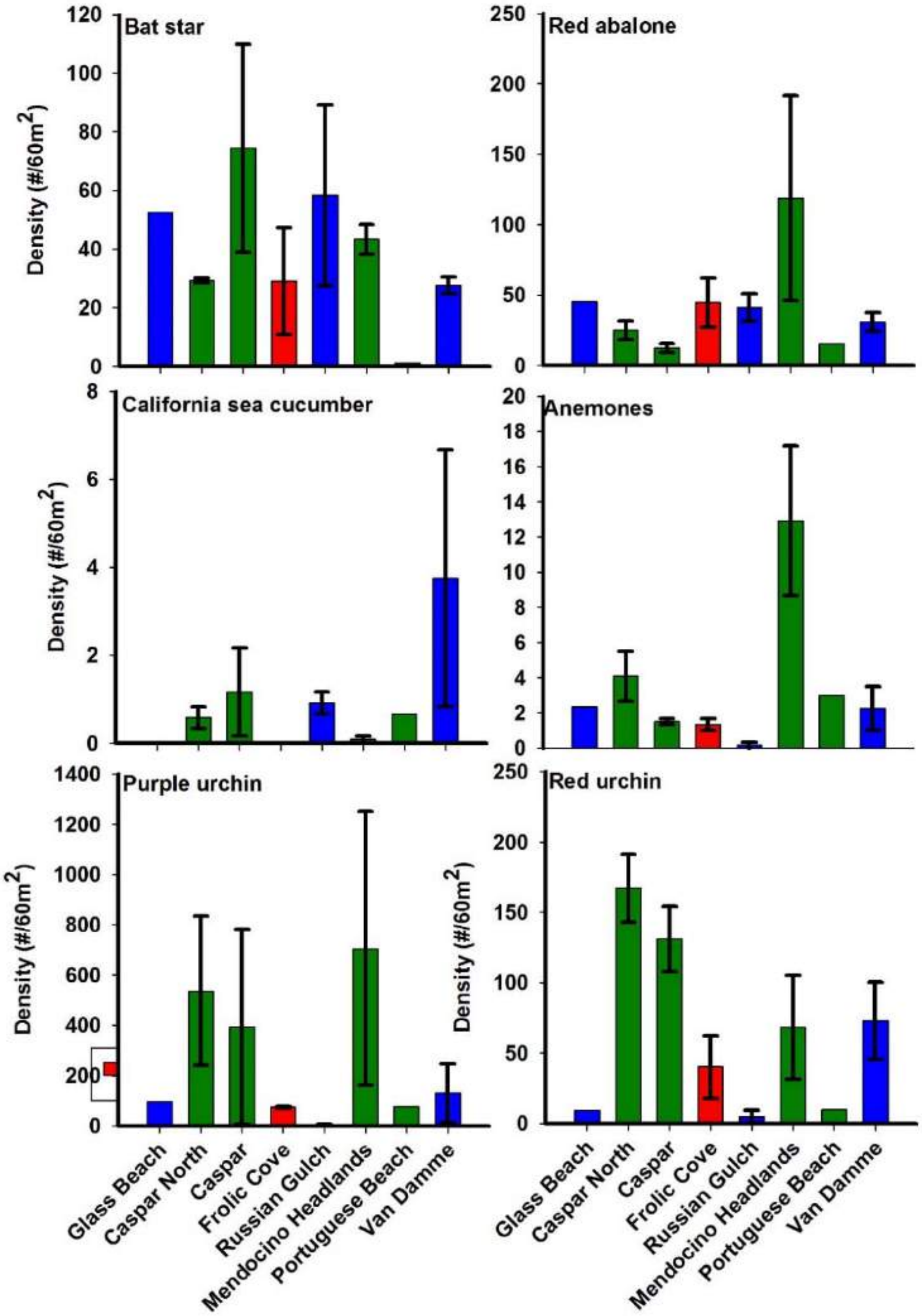


Figure 17. Invertebrate densities at the RCCA study sites during the baseline period. Data from 2014 and 2015 are pooled and error bars show the SE between years. Sites are ordered from north to south. Bars are colored according to the protection level of the sites. Red – SMR, blue – SMCA, green – outside of MPA.

Community Structure

All indicator species combined

To identify distinct kelp forest communities in the study region we used a cluster analysis in PRIMER v.6. We applied a SIMPROF test (α = 0.05) to the data but excluded YOYs from the analyses as their abundance varies greatly over time and among seasons. When all of RCCA's indicator species are considered, the NCSR sites are structured into five distinct communities (Figure 18). The two exposed northern sites, Glass Beach and Frolic Cove, are significantly different from all other sites but not from each other. Similarly, the two sites in Casper Cove (Casper and Casper North) are not significantly different from each other but are significantly different from all other NCSR sites. Mendocino Headlands has a community that is significantly different from the communities found in any of the other sites but is more similar to the four northern most sites (described above) than the other sites. Similarly, Van Damme is significantly different from all other sites, while Portuguese Beach and Russian Gulch, though not significantly different from each other, differ from all other sites and have the least similarity to all other communities analyzed.

The species that drive these community relationships were identified in a SIMPER analysis on the weighted and square root transformed data (Appendix D). The differences in densities of purple and red urchins, blue rockfish and the understory kelp *Pterygophora* strongly determine the relatedness among rocky reef communities. Van Damme's separation from the other sites is in large part driven by the presence of giant kelp at this site which is not found at any of the other study sites in the NCSR. Mendocino Headlands has a very high abundance of purple urchins separating its community from those communities observed at the other sites. Mendocino Headlands also has a large population of red abalone which distinguishes it from the four sites to the north. When fish, invertebrate, and algae assemblages are considered separately the relatedness between sites is less discernable. While the fish assemblages did present significant differences between sites, no significant differences among sites were observed when examining the invertebrate or algal assemblages separately (see below).

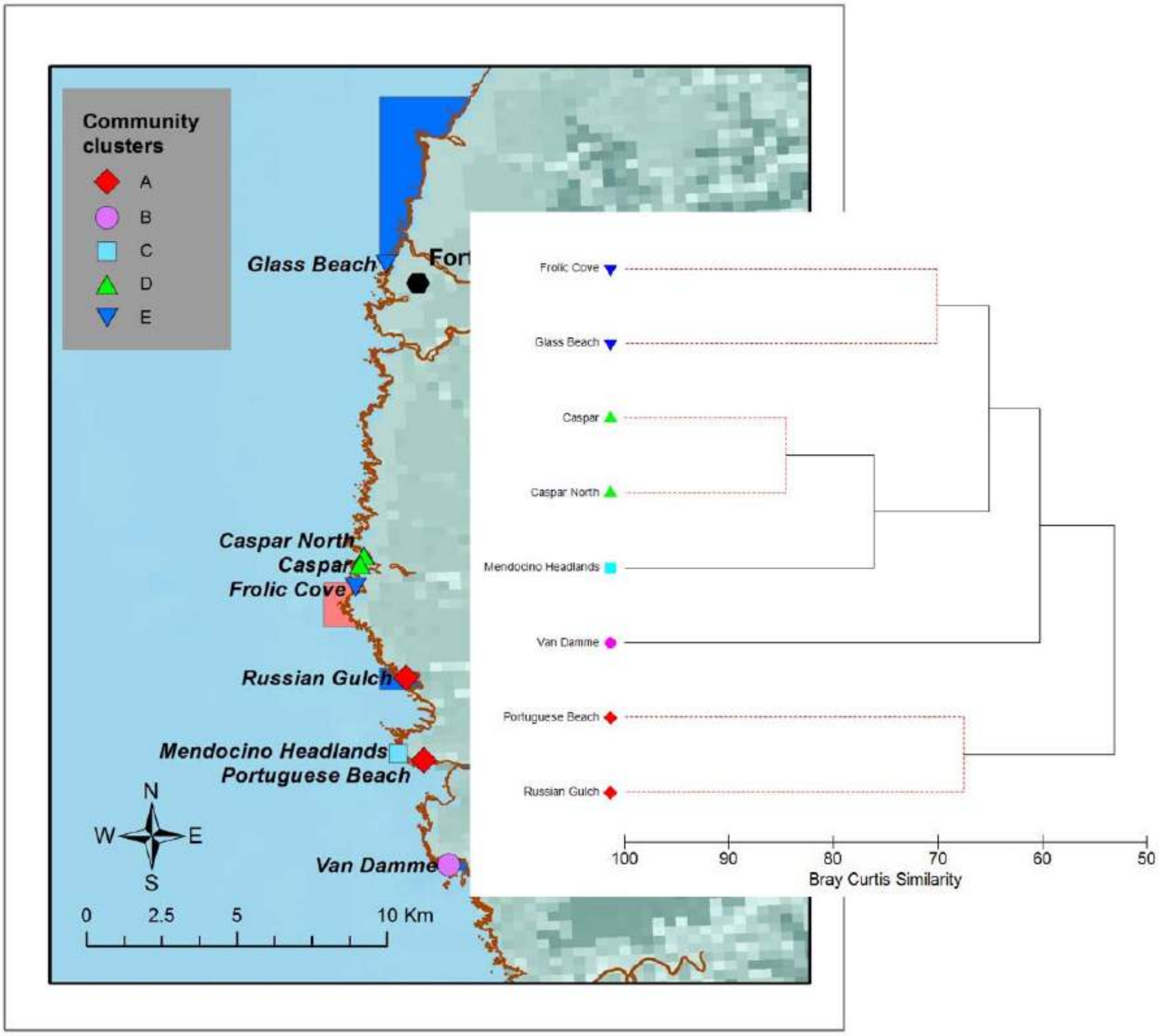


Figure 18. Map shows RCCA sites found within the NCSR. Blue boxes indicate SMCAs while red boxes indicate SMR. The dendrogram shows results of a cluster analysis of NCSR sites using all indicator species (fish, invertebrates and algae). SIMPROF tests were used to determine significant differences among communities at the site and are indicated by different symbols. Red dashed lines in dendrogram show related sites (i.e. no significant differences; α = 0.05).

Fish assemblages

To identify distinct fish assemblages, we used the same approach as described above (see all indicator species combined). Using a cluster analysis, we identified a geographic structure with two distinct assemblages, one at the northern sites (Casper North, Casper, Frolic Cove, and Mendocino Headlands) and a different assemblage at the southern sites (Russian Gulch, Portuguese Beach, and Van Damme) (Figure 19). The northern most site, Glass Beach, although more closely related to the northern sites is statistically different from all other NCSR sites analyzed. The groupings identified in the cluster analysis are supported by the multi-dimensional scaling analysis (MDS). The MDS plot indicates that the separation of fish assemblages is not only geographic in nature but correlates with the exposure of sites to the predominant north western swells in the region. If sites are classified by their exposure to these swells, the exposed northern sites group together and their fish assemblages clearly separate from the more protected sites in the south (Figure 20). Where the two assemblages come together, they overlap, and the more exposed Mendocino Headland fish assemblage groups with the northern sites which have similar exposure, whereas Russian Gulch groups with the protected sites to the south. The Frolic Cove site in the Pt. Cabrillo SMR is an exception as its fish assemblage groups with the nearby sites despite its greater protection from the predominate swells in the region.

Overall, the most abundant species of fish in the region during the baseline period are blue and black rockfish, kelp greenling and striped surfperch (Figure 21). These species also drive the differences between the fish assemblages. Together they explain 67.5% of the differences between the two assemblages (see SIMPER analysis; Appendix D). All four species are more abundant at the northern, exposed sites than at the southern, protected sites. Further, rockfish are much less abundant at the southern sites and the assemblages shift toward surfperch and hexagrammid dominated assemblages relative to the northern sites. Overall, the southern sites' fish assemblages are much less diverse than the sites to the north. At Portuguese Beach, less than half the number of species were observed when compared to the rest of the NCSR sites. The most species rich site was Caspar North with 14 of RCCA's indicator species recorded during the baseline period (Figure 19).

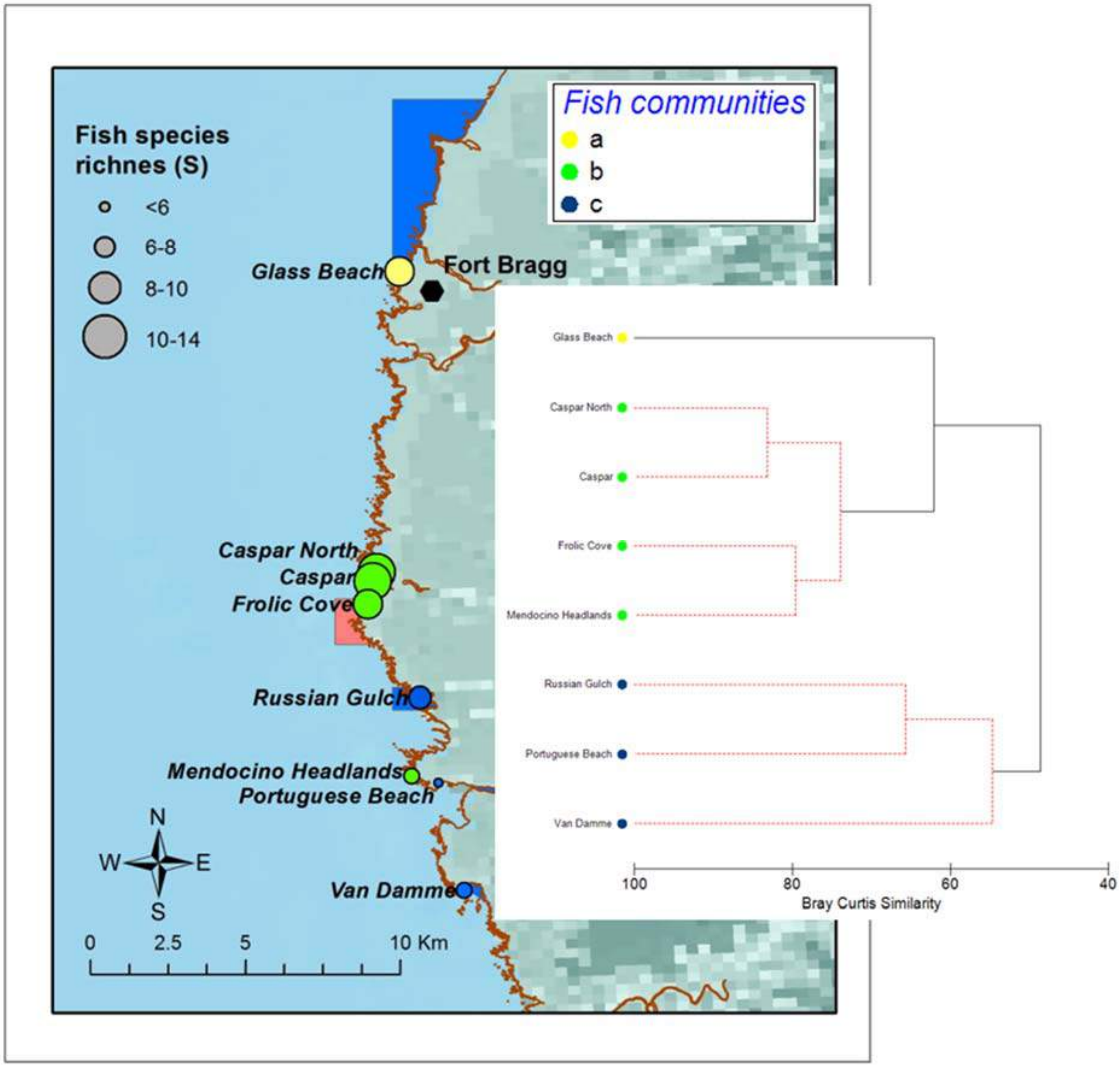


Figure 19. Map shows RCCA sites within the NCSR. Blue boxes encompass SMCAs while red boxes indicate SMR areas. Size of circles indicates the fish species richness at the sites. Inserted dendrogram shows results of a cluster analysis of the fish assemblages found in all NCSR sites. SIMPROF tests were used to determine significant differences among site assemblages and are indicated by different colors. Red dashed lines in dendrogram show related sites (i.e. no significant differences; α = 0.05).

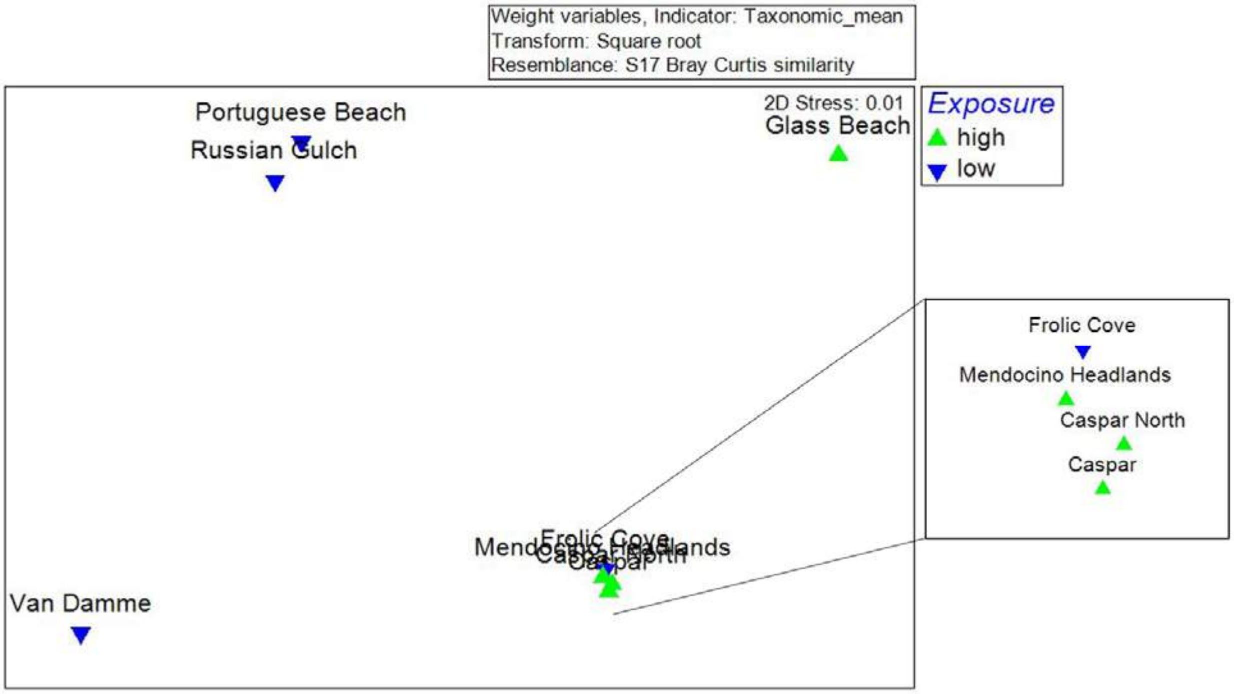


Figure 20. MDS ordination plot of communities using Bray-Curtis similarity based on the square-root transformed fish taxa. Exposure of sites to predominant swells is indicated by symbol color.

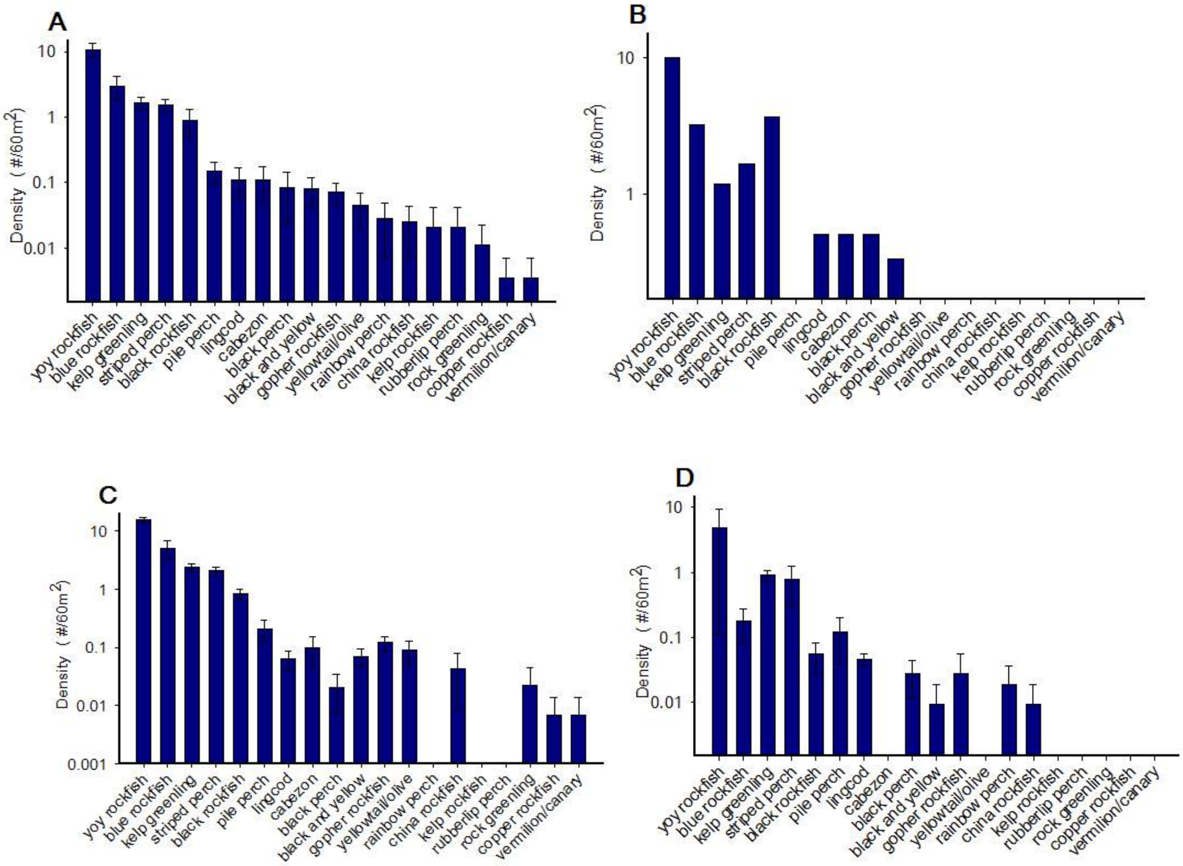


Figure 21. Fish densities during baseline period. A. species densities across all sites. B. species densities at Glass Beach. C. species densities at northern sites. D. species densities at southern sites. Error bars are ±SE between years (Glass Beach was only served 2015).

Invertebrate assemblages

Using a SIMPROF test (see all indicator species combined), no significant differences were found among the invertebrate assemblages at the NCSR sites (Figure 22). Overall, purple and red sea urchins were the most abundant species found in the NCSR followed by red abalone (Figure 23). It is important to note that no sunflower stars were found during the baseline monitoring period at any of the NCSR sites. This species had been present at these sites in the past and its absence in the region is a result of the recent sea star wasting disease (see below).

For fish assemblages in the NCSR, species richness was greater at the northern sites, but species richness for invertebrate communities was lowest at the northern sites and greatest at the southern sites (Figure 22). Mendocino Headlands had the greatest invertebrate species richness with 14 of RCCA's indicator species present (Figure 18). Glass Beach had the lowest number of invertebrate species present during the baseline period (Figure 18). Whereas the fish communities at the sites with low species richness consisted of different subsets of species, the invertebrate communities with low richness consist of the most common species found in the region such as urchins, red abalone and bat stars. The dominance in the invertebrate communities of sea urchins is a recent development in the NCSR and their abundance during the baseline years has been unprecedented, having community-wide effects (see long-term population trends below).

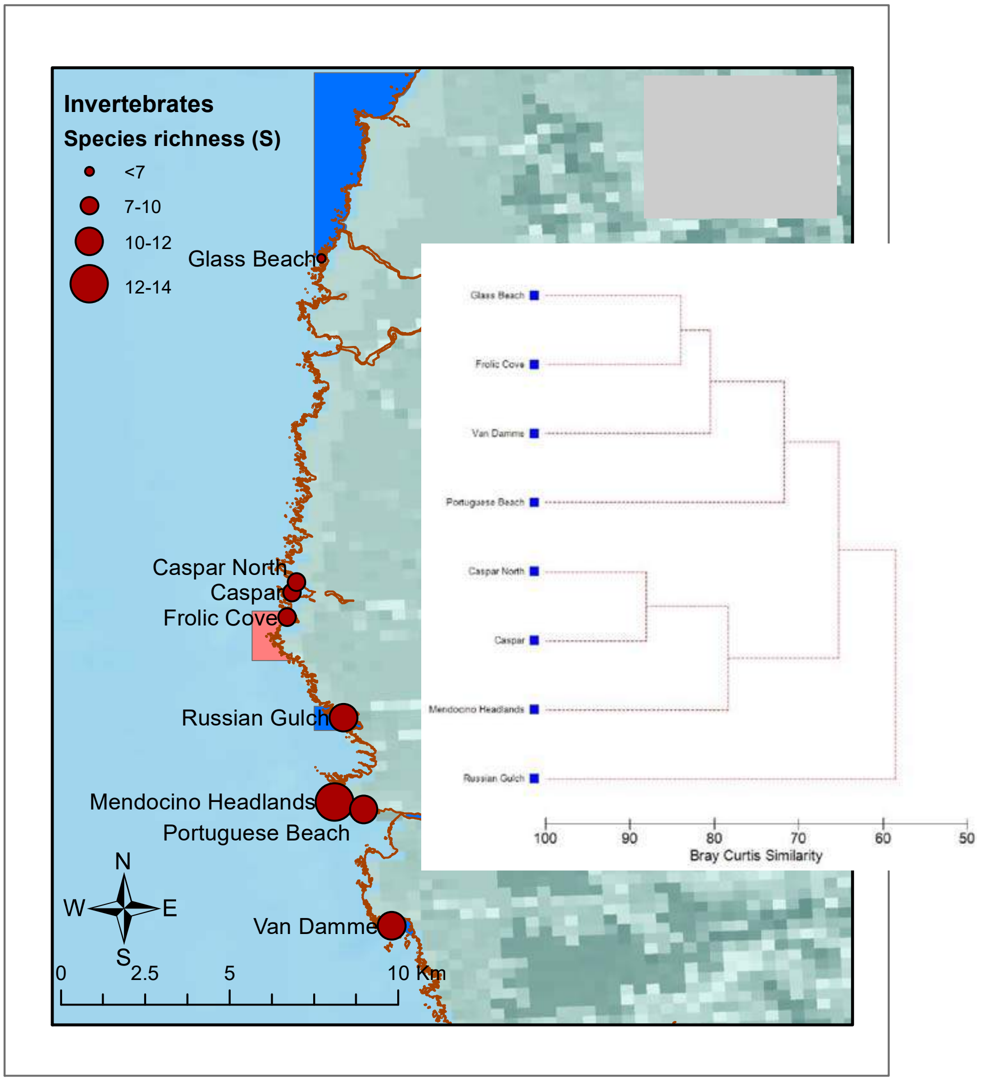


Figure 22. Map shows RCCA sites found within the NCSR. Blue boxes encompass SMCAs while red boxes indicate SMR areas. Inserted dendrogram shows results of a cluster analysis of the invertebrate assemblages found in all NCSR sites. SIMPROF tests were used to determine significant differences among site assemblages and are indicated by different symbols. Red dashed lines in dendrogram show related sites (i.e. no significant differences; α = 0.05).

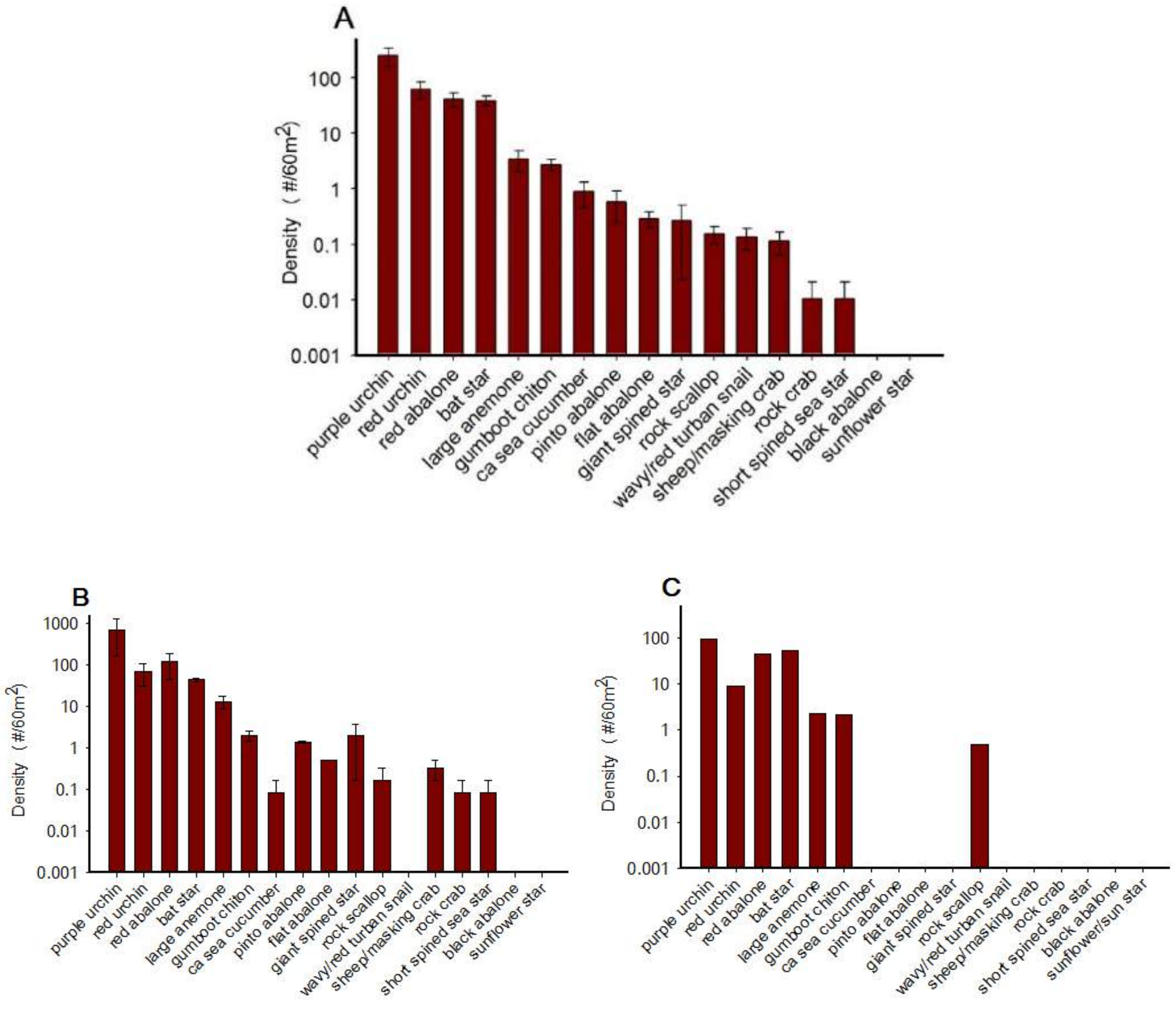


Figure 23. Invertebrate densities during baseline period (2014-2015) A) across all sites. B) at Mendocino Headlands (greatest species richness) and C) at Glass Beach for 2015 only (lowest species richness). Error bars ±SE.

Algae assemblage

All of RCCA indicator algal species experienced a massive decline at the sites in Mendocino County just prior or during the baseline years. During the baseline period, bull kelp was almost completely absent from the survey sites and *Pterygophora* was declining (Figure 33, *Nereocystis* and *Pterygophora*). *Laminaria* which had been present at low densities at the long-term sites in the past, was either not present or observed infrequently during the baseline surveys (see long-term population trends below).

Long-term trends of algae surveyed using uniform point contact methods show a different pattern (Figure 24). These surveys recorded the relative abundance of taxonomic groups that form the sublayer of algae below the canopies of bull kelp and understory kelps. The abundance of the three dominant taxonomic groups: crustose coralline, red and brown algae, seem fairly stable in their percent cover prior to 2014 at the long-term sites. In 2014 and 2015, as the canopy forming species declined in abundance, we detected an increase in the percent cover of crustose coralline and a subsequent decline in the percent cover of foliose brown and red algae. As of 2015, brown algae were basically absent from these sites, and in 2016, red algae had declined to very low levels of percent cover as well. The decline of folios algae subsequent to the loss of the canopy forming species is likely due to the increased grazing pressure of the abundant urchins at these sites.

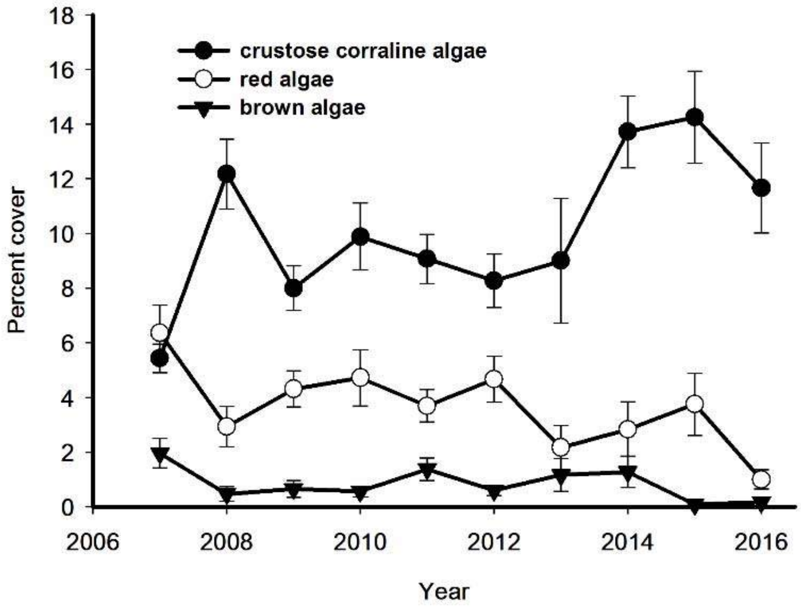


Figure 24. Percent cover of taxonomic groups of algae recorded during UPC surveys at the long-term sites in the study region.

Physical characteristics

RCCA uses eight variables to characterize the substrate and relief of its rocky reef sites (Figure 25). Bedrock was the dominate reef substrate at all sites ranging from 92% at Portuguese Beach to 46% at Russian Gulch and sandy habitat was relatively rare being less than 12% at any site and absent from Portuguese Beach. Medium relief (10 cm-1 m) was the most commonly recorded relief category at all sites, ranging from a high of 74% to a low of 56%. Low relief (<10 cm) was uncommon or absent at most sites (0.0%-9.7%) with the exception of Van Damme and Russian Gulch which had less relief and less bedrock habitat compared to the other sites.

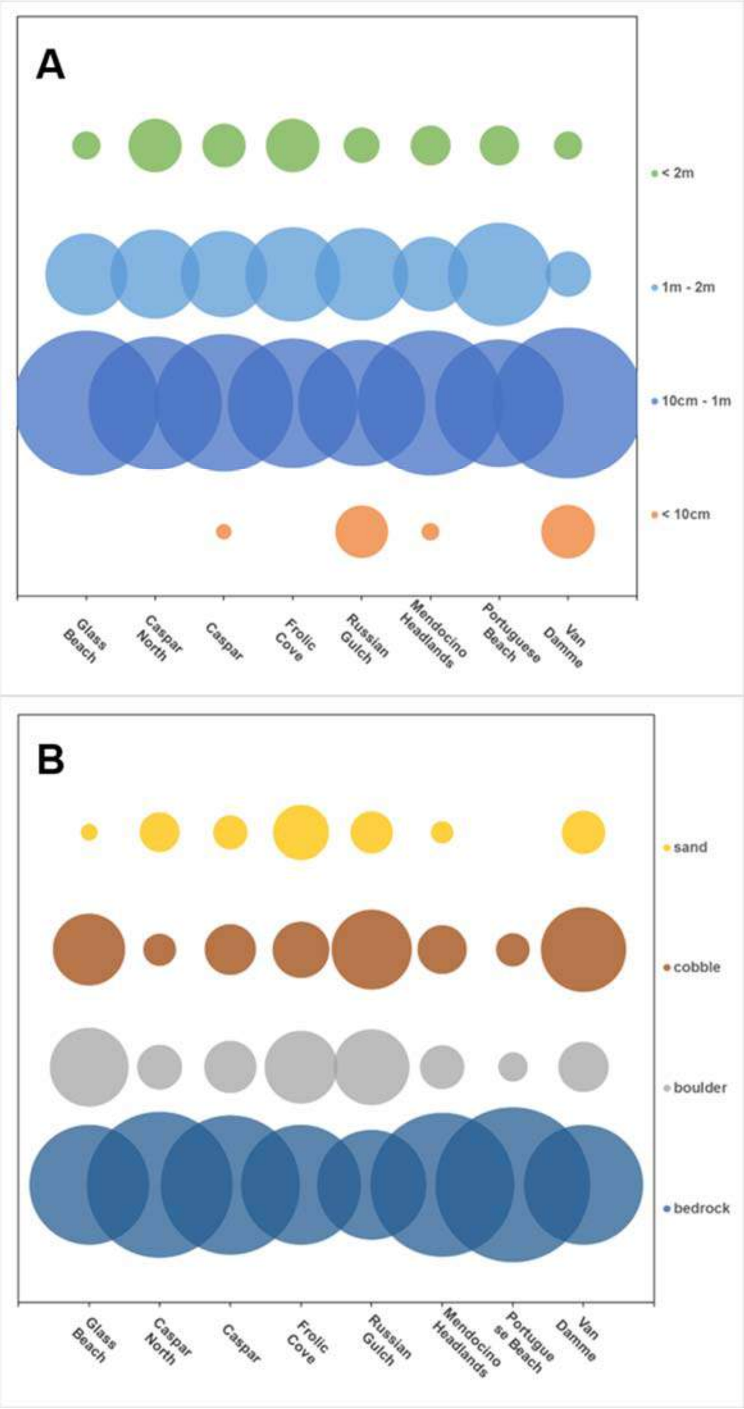


Figure 25. Physical characteristics for NCSR sites observed during baseline period (2014-2015) including A) relief of habitat and B) substrate types. Bubble size represents the relative percentages of the environmental variables at the sites. Percentages are reported in Appendix C for each site.

Fish Sizes

Size frequency distribution of the four most abundant fish species in the region were generated. For the two most abundant rockfish species, blue and black rockfish, very few individuals were above the size of first maturity (Figure 26 a & d). For blue rockfish, the median size of individuals was 8 cm during the baseline period. This represents a population of juvenile fish which is consistent with the recruitment of rockfish we observed during the baseline years. The other two abundant species, kelp greenling and striped surfperch, have a wider distribution of sizes with more mature individuals present at the RCCA sites (Figure 26 b & c). Fish size frequency distributions of these four abundant species are reported for each site in Appendix E. Below, we have selected the sites inside and outside of the Point Cabrillo SMR to highlight some of the baseline findings with respect to fish sizes.

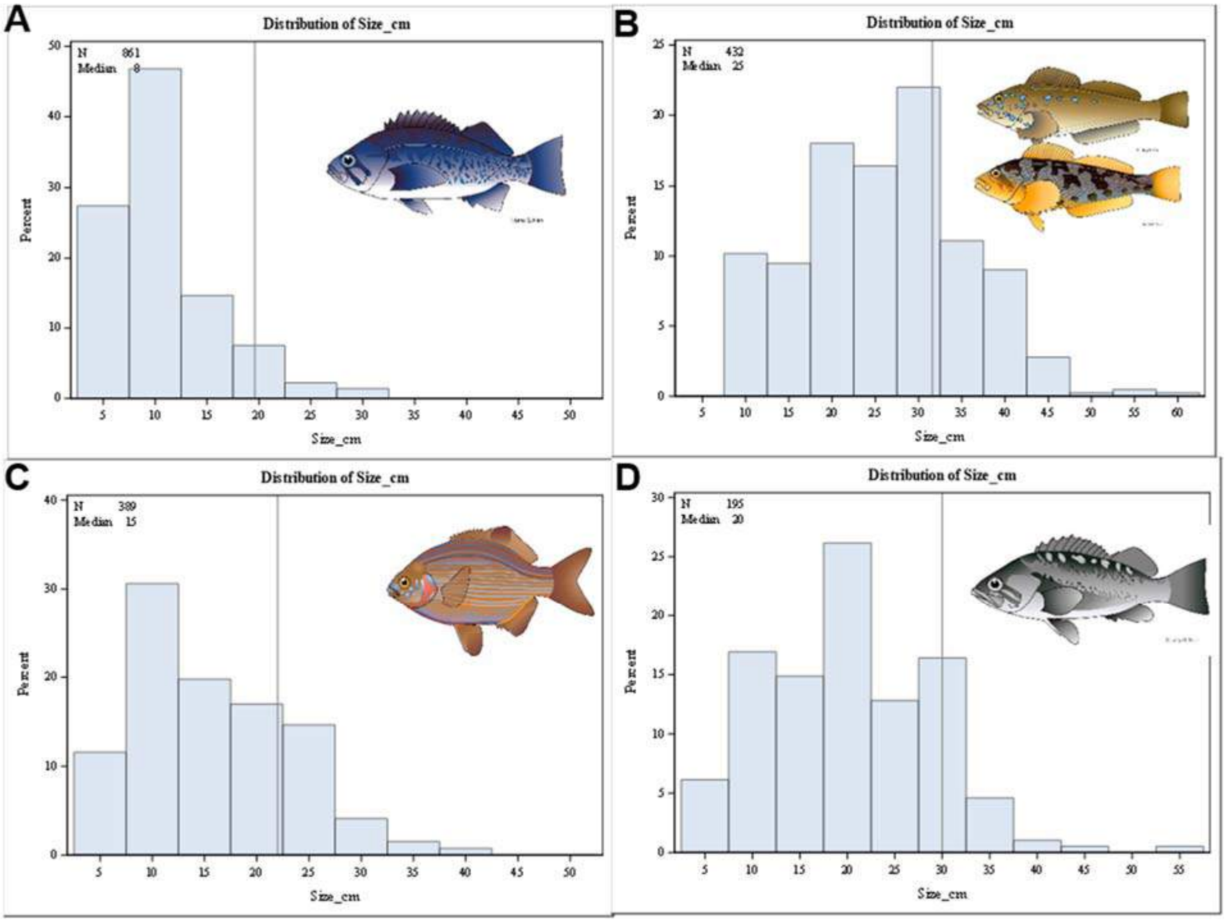


Figure 26. Frequency distribution of fish sizes (cm) for A) Blue Rockfish, B) Kelp Greenling, C) Striped Surfperch and D) Black Rockfish across all sites in the NCSR. Grey lines indicate the size at first maturity for each species.

Fish sizes inside and outside of Point Cabrillo SMR

RCCA has surveyed three sites inside and outside of the Point Cabrillo SMR. The Frolic Cove site is located in the new Pt. Cabrillo SMR, whereas the Caspar and Caspar North sites are located outside of the SMR in areas open to fishing. Kelp greenling inside and outside of the SMR show a size distribution with a substantial number of mature individuals but the size frequency distributions at the three sites indicate a shift to larger and mature individual inside the reserve when compared to the two sites open to fishing

(Figure 27). On average kelp greenling inside the SMR are larger than at the two sites outside (ANOVA: $F_{(2,212)}$=8.369, p<0.001). A planned contrast among the two fished sites vs. the protected site in the SMR shows a significant difference in kelp greenling size with individuals on average being larger inside the MPA (mean=27.0 cm, SE=0.92) than at the two outside sites (mean=24.7 cm SE=0.58) ($F_{(1,212)}$=10.097, p=0.002). Similarly, for striped surfperch, a larger percentage of mature individuals is found in the MPA compared to the outside and individuals in the MPA are on average larger than outside of the MPA (ANOVA: $F_{(2,195)}$=12.382, p<0.001; Figure 27). A planned contrast between the two sites outside of the MPA compared to the Frolic Cove site shows a significant difference in fish sizes with striped surfperch being larger inside the MPA (mean=15.7 cm, SE=0.92) than outside of the MPA (mean=13.8 cm, SE=0.42) ($F_{(1,195)}$=20.267, p<0.001). Black rockfish were also significantly larger inside the MPA compared to the outside sites (ANOVA: $F_{(2,87)}$=3.981, p=0.02; Figure 28). A planned contrast between the two sites outside of the MPA compared to the Frolic Cove site shows a significant difference in fish sizes with black rockfish being larger inside the MPA (mean=23.5 cm, SE=1.3) than outside of the MPA (mean=20.0 cm, SE=0.86) ($F_{(1,87)}$=7.234, p=0.009). Blue rockfish, at all three sites, were very small on average and very few mature individuals were seen (Figure 28). This is similar to what we have seen across the region, and any variability in size among the three sites is likely due to variability in recruitment as the majority of individuals are of size class that are either young-of-the-year or at most one year old. We did not test for differences in the sizes of blue rockfish among the sites.

Changes in the size distribution of fish species are the first responses expected when a population is protected from fishing (Lester et al. 2009, Starr et al. 2015). However, how long after protection we would expect an increase in average size or a shift in the size frequency distribution depends on the species intrinsic growth parameters as well as its habitat use. Slow-growing, long-lived species are slower to respond than faster growing species (Starr et al. 2015). Further, we would expect an MPA effect on size to arise sooner in species with limited movement ranges because individuals are more likely to stay within the MPA boundaries. Kelp greenling and striped surfperch both exhibit very limited movement ranges and their home ranges are on much smaller scales than the size of the Pt. Cabrillo SMR (Freiwald 2012). Both species are also relatively fast-growing and short-lived. Black rockfish, on the other hand, are long-lived and move over large distances. The fact that we see larger individuals of species with such different life history characteristic and habitat use suggest there might be several factors that could explain the presence of larger individuals within the MPA. Protection might play a role (as suggested by the resident, fast growing species), but habitat differences could also play an important role with larger individuals preferring the Frolic Cove habitat even if they are not resident in the MPA (black rockfish).

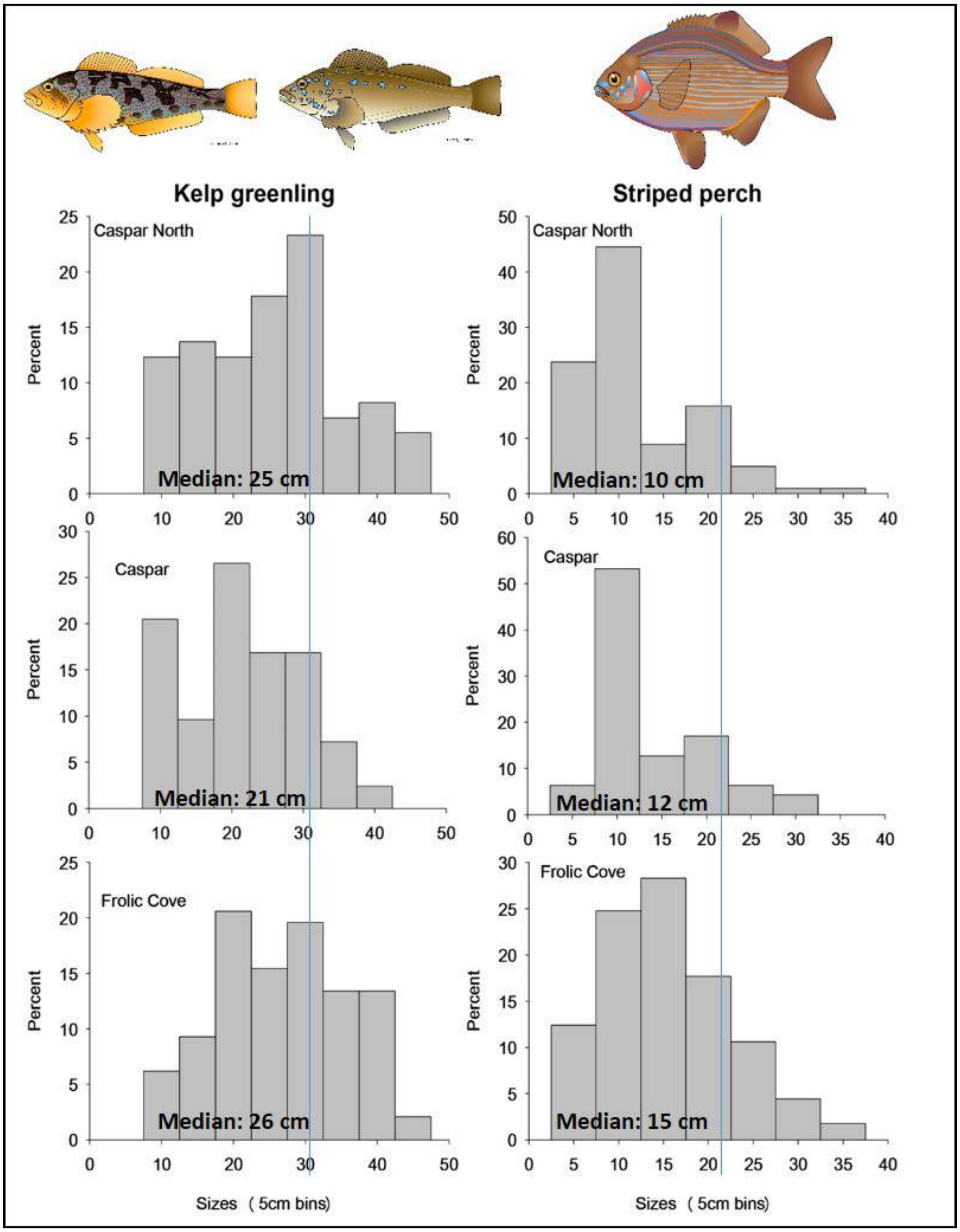


Figure 27. Size frequencies distribution of kelp greenling and striped surfperch inside and outside of Pt. Cabrillo SMR. Caspar North and Caspar are sites located outside of the SMR and Frolic Cove is located inside the Pt. Cabrillo SMR. Median size is shown for each site, and the blue lines indicate size of maturity for each species.

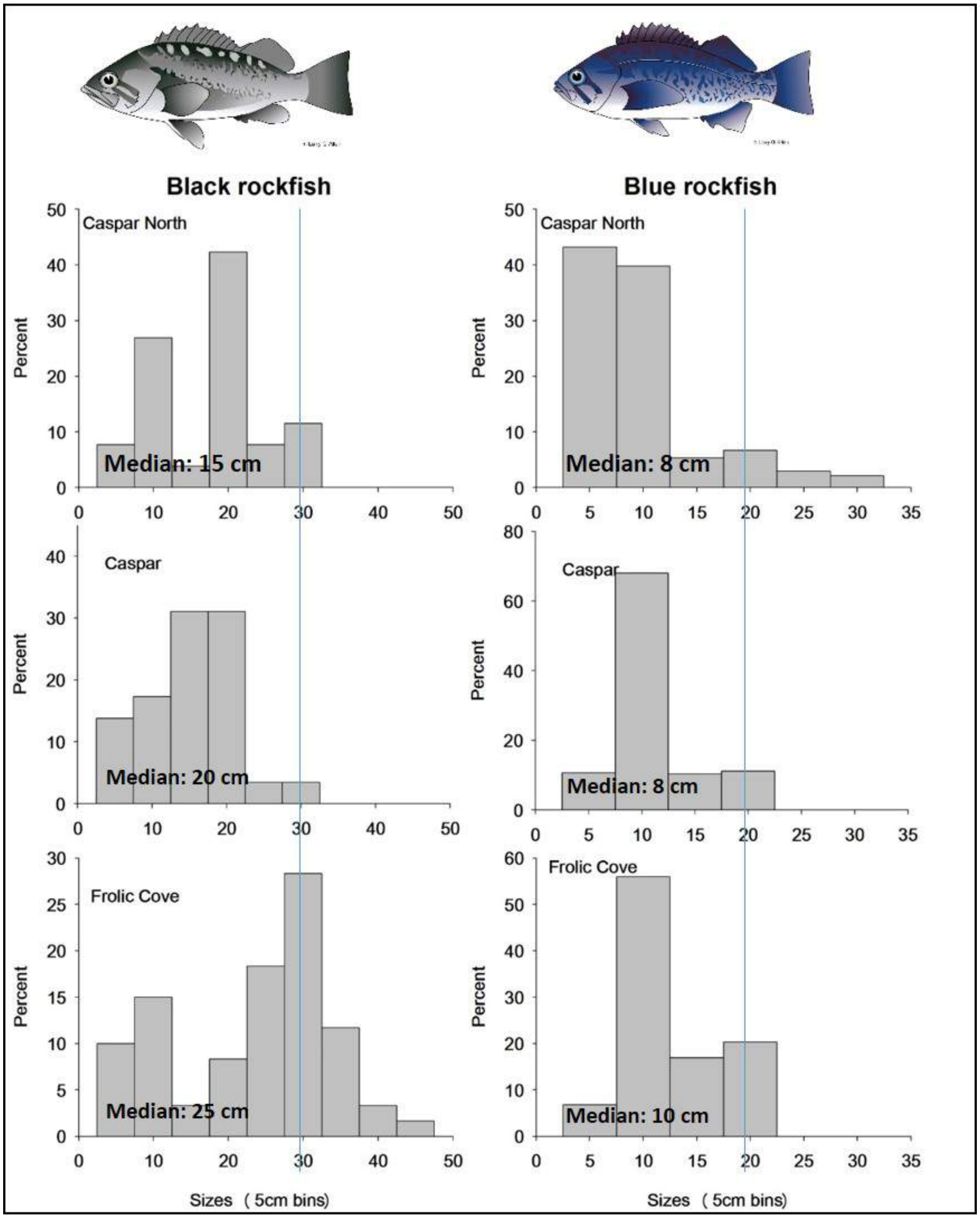


Figure 28. Size frequency distribution of black rockfish and blue rockfish. Inside and outside of Pt. Cabrillo SMR. Caspar North and Caspar are sites located outside of the SMR and Frolic Cove is located inside the Pt. Cabrillo SMR. Median size is shown for each site, and the blue lines indicate size of maturity for each species.

Fish Biomass

Fish biomass was calculated based on the sizes recorded by RCCA and length-weight relationships reported in the literature. Biomass was summarized for all fish species, combined, and averaged across the two baseline years (2014-2015). Overall, fish biomass was greatest at the Frolic Cove site in the Pt. Cabrillo SMR (Figure 29). Despite having low species richness, this site supports a high biomass of fish compared to the other NCSR sites. The densities of abundant fish species at the Frolic Cove site are not necessarily greater than at other sites (Figure 16). Interestingly, some of the relatively abundant species such as kelp greenling, striped perch and black rockfish are larger at the Frolic Cove site when compared to its neighboring sites. The higher biomass seems to be the result of this increased size of the abundant species in the reserve. Unfortunately, with no data collected prior to the establishment of the MPA, it is difficult to say if this is an early effect of protection of the site. The two sites, Van Damme and Russian Gulch, which have a relatively greater amount of low relief rock and sand compared to other areas studied, had the lowest fish biomass (Figure 29). Both of these sites are protected in SMCAs, but the take of fish and invertebrates is allowed at these sites.

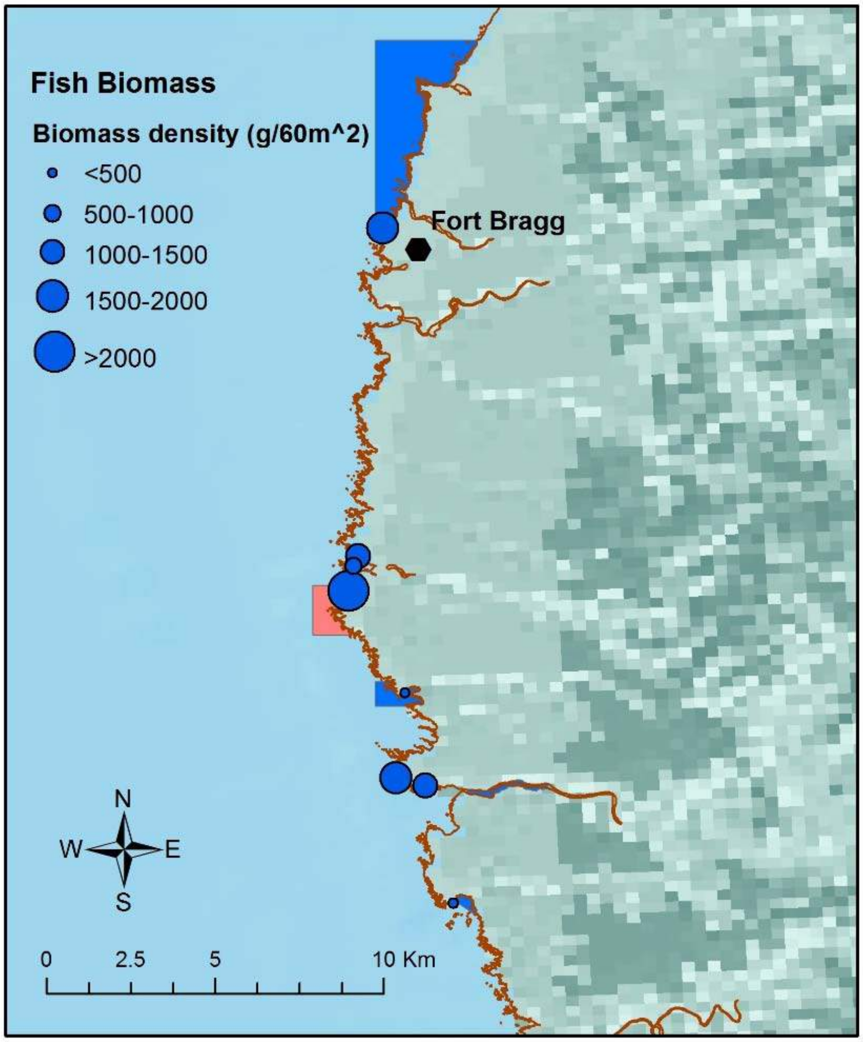


Figure 29. Biomass of all fish species combined at the NCSR studies sites observed during the baseline period (2014-2015).

Abalone Size Frequency Distributions

In Mendocino County, red abalone is the most important recreationally fished rocky reef species. They were also recorded as one of the most abundant invertebrates along the north coast during RCCA surveys. Red abalone are the one invertebrate species that RCCA not only counts, but also measures during surveys. Prior to 2016, Reef Check measured abalone to the nearest centimeter. The protocol was changed in 2016, and now red abalone are measured to the nearest millimeter using specially designed calipers for all individuals that are emergent so that an accurate measurement can be taken. The protocol change was implemented to insure that RCCA data are compatible with the red abalone data collected by the CDFW.

During the baseline period (2014-2015), the size frequency distributions of the red abalone populations at the study sites had a mode at or just above the legal size of take, with the exception of the Caspar site where few individuals were measured (Figure 30). When the mean size of red abalone is compared between the site inside the Point Cabrillo SMR (Frolic Cove) and its two neighboring sites outside of the SMR where abalone take is allowed, they are significantly different (ANOVA: $F_{(2,803)}=40.36$, $p<0.001$). A Tukey's posthoc test determined that the largest abalone are found at Caspar North (mean=18.37 cm, SE=0.334) and are significantly larger than those recorded in Frolic Cove (mean=16.79 cm, SE=0.233) ($p<0.001$). Abalone at Caspar (mean=13.57 cm, SE=0.334) were significantly smaller than at the two other sites ($p<0.001$, $p<0.001$, respectively). This suggests that these size differences are not the result of the protection in the SMR but rather pre-existing differences between these three sites.

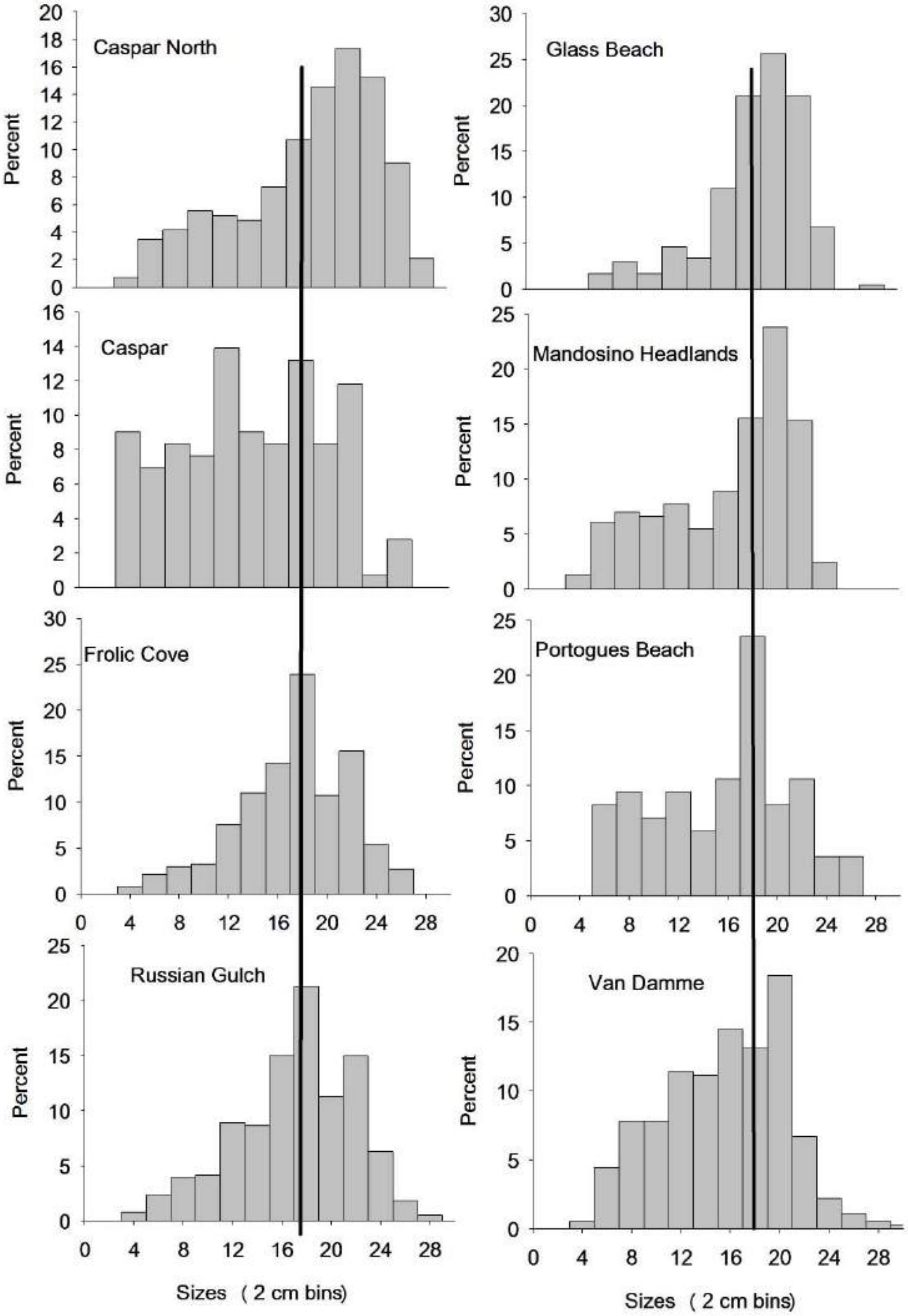


Figure 30. Size distribution (cm) of red abalone at all sites in the NCSR recorded during the baseline period (2014-2015). Black lines indicate size (7 inches) at which it is legal to take red abalone.

Long-term Population Trends

Since 2007, Reef Check California has monitored several long-term sites in the NCSR. Surveys at these sites were conducted by RCCA citizen scientists on an annual basis. In order to put baseline characterization results into a longer-term context, we have analyzed the trends in the population densities of six abundant fish species with different life histories and exploitation levels at these sites. We also show trends of six invertebrate species and the three dominant algal species counted during RCCA surveys. The selected species are listed as indicators in the monitoring metrics for the rocky reef and kelp forest ecosystem in the North Coast Monitoring Plan. These species were chosen specifically as they were abundant in the NCSR and their distribution ranges throughout the other MLPA study regions (Freiwald and Wehrenberg 2013, Freiwald and Wisniewski 2015, California Ocean Science Trust and California Department of Fish and Wildlife February 2013). For example, blue rockfish are abundant in the NCSR and present in the other regions as well. Similarly, we chose the sunflower star because of its ecological importance and historic presence in this and other study regions. The sunflower star has gone through a recent population decline and is now absent from all RCCA sites throughout California. The two urchin species chosen for the NCSR are also present throughout California, and red urchins are economically important in the NCSR and other regions. Red abalone were selected because they are the target of an important recreational fishery.

Based on their ecological and economic importance, their abundance in the study region and in references to the metrics identified in the NCSR Monitoring Plan, we have selected the following species for analysis of their population trends over time (from 2007 to 2016) at sites that RCCA has monitored prior to the baseline monitoring program:

Fish:

- Blue rockfish
- Black rockfish
- Kelp greenling
- Striped perch
- Lingcod
- Cabezon

Invertebrates:

- Red abalone
- Red urchin
- Purple urchin
- Sunflower star
- Giant spined star
- Bat Star

Algae:

- Bull kelp
- *Pterygophora*
- *Laminaria*

Choosing abundant species as indicators is crucial to achieving reliable population density estimates with the survey methods employed by RCCA and other subtidal monitoring programs in the NCSR. Several rockfish species were listed in the monitoring plan in addition to the above-mentioned species, but the RCCA data reveal many of these to be uncommon in the region and, therefore, may not work as indicators of ecosystem changes in the future. We used a regression approach to identify temporal trends in the densities of these species at each of the three long-term sites (Van Damme, Portuguese Beach, Mendocino Headlands). Data were square-root transformed for these analyses.

Fish

The long-term trends at the three RCCA monitoring sites for the six selected fish species revealed different patterns of changes in abundance over the last decade. Fish densities, especially for rockfish species, were relatively low at these three southern sites for which long-term data is available compared to the sites further north (Figure 16). Black and blue rockfish densities have been low at these sites over the long-term monitoring period and their population densities vary from year to year at the three sites (Figure 31). The regression analysis did not show any significant trends in either rockfish species over the long-term monitoring period, but blue rockfish appear to be more abundant during the baseline period than in the past (Table 4). This increase in density seems to be driven by recent recruitment as demonstrated by the small sizes of blue rockfish observed during the baseline years (Figure 26).

Kelp greenling densities at the long-term sites seem to be stable over time and similar to the region-wide densities seen during the baseline years (Figure 31). Their densities were greatest at Van Damme in the past, but the population at this site experienced a significant decline, and by 2016, densities at this site were similar to the other baseline monitoring sites (Table 4). Striped surfperch densities were low at the long-term sites in 2010/11 (Figure 31). The high variability in the density of this species at the Mendocino Headlands site and the very low R^2 value (r^2= 0.08) suggest that the significant trend identified for this species at this site might be a result of variability rather than a true increase in its density (Table 4). Lingcod and cabezon had much lower densities than the other species at all three long-term sites. Cabezon experienced a significant increase at Van Damme during the baseline years (Table 4) and both species' densities at the long-term sites were similar to the average densities across all sites during the baseline years (Figure 31).

Overall, these three long-term sites allow us to compare long-term species trends to the results of the baseline monitoring period. For most species/site combinations, we did not identify any significant trends in the densities of the species studied, suggesting that the baseline characterization is a valid representation of those species'. It also suggests that the recent oceanographic events such as the “warm blob” and subsequent El Niño event (Figure 5), and the associated changes in the kelp forest ecosystem (Figure 32 & Figure 33), did not affect the densities of the fish populations in the NCSR up to this point.

Table 4. Results of regression analyses of density trends of selected fish species at the three long-term study sites.

Site	Species	DF	F	P
Mendocino Headlands	black rockfish	1	1.47	0.231
Mendocino Headlands	blue rockfish	1	1.29	0.261
Mendocino Headlands	cabezon	1	2.54	0.117
Mendocino Headlands	kelp greenling	1	0.06	0.813
Mendocino Headlands	lingcod	1	0.20	0.659
Mendocino Headlands	**striped perch**	**1**	**4.54**	**0.038**
Portuguese Beach	black rockfish	1	1.98	0.162
Portuguese Beach	blue rockfish	1	0.92	0.339
Portuguese Beach	cabezon	1	1.65	0.202
Portuguese Beach	kelp greenling	1	2.80	0.097
Portuguese Beach	lingcod	1	0.00	1.000
Portuguese Beach	striped perch	1	1.79	0.184
Van Damme	black rockfish	1	0.10	0.753
Van Damme	blue rockfish	1	0.14	0.704
Van Damme	**cabezon**	**1**	**4.11**	**0.044**
Van Damme	**kelp greenling**	**1**	**5.46**	**0.021**
Van Damme	lingcod	1	0.12	0.731
Van Damme	striped perch	1	0.24	0.628

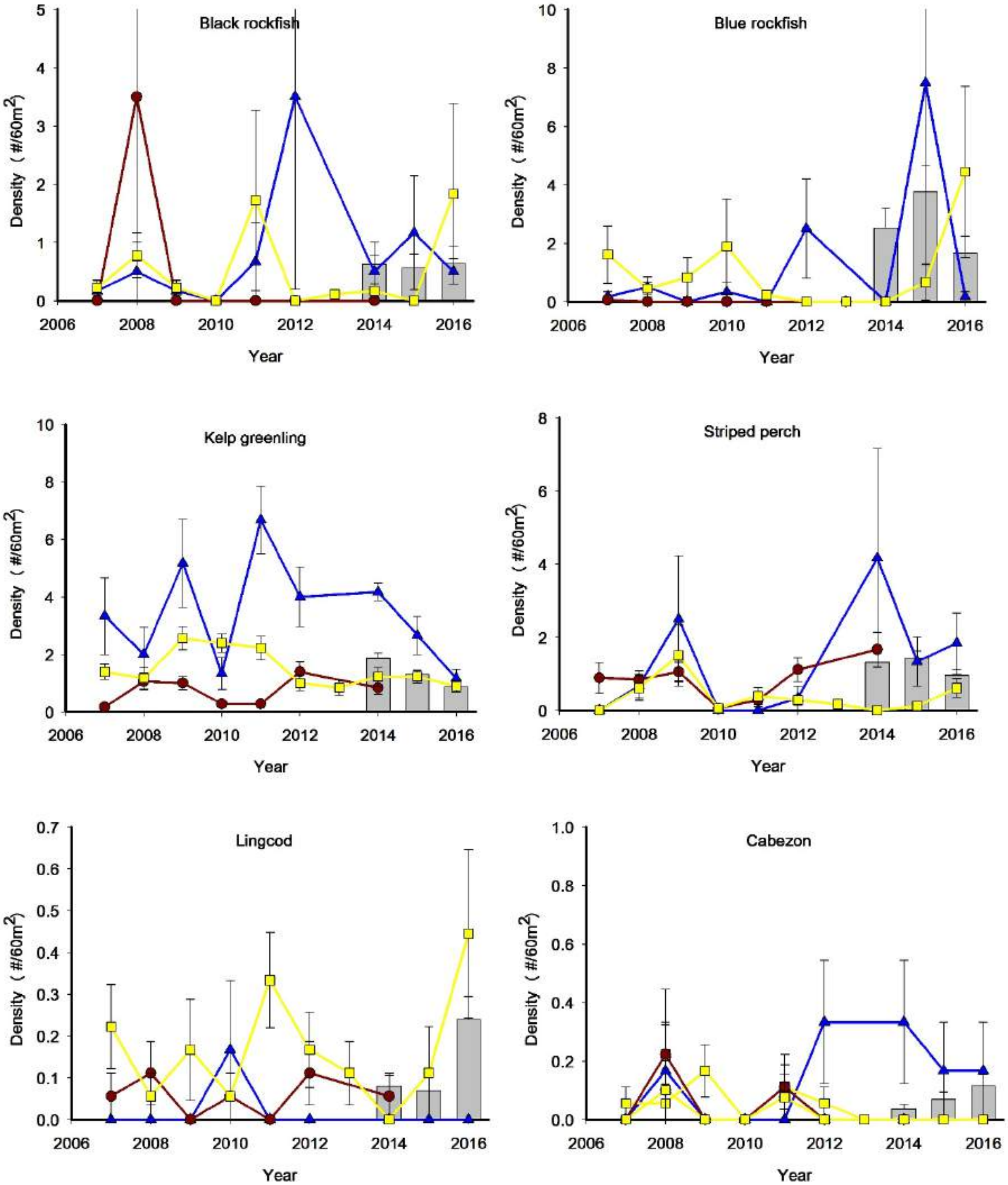


Figure 31. Density of selected fish species for all three sites sampled throughout the long-term monitoring period (2007-2016). Blue triangles – Mendocino Headlands, red circles – Portuguese Beach, yellow squares – Van Damme. Grey bars indicate mean density across all eight sites monitored during the baseline monitoring period. Error bars are ±SE.

Invertebrates

The long-term trends for the six selected invertebrate species indicate massive shifts in species densities during the last three years when compared to the years prior to the baseline period (Figure 32). The two important predatory sea star species, sunflower stars and giant spined stars (*Pisaster giganteus*), were essentially absent from the monitoring sites during the baseline years but had been abundant at the long-term sites prior to the onset of the sea star wasting disease in 2013 (Figure 32).

In the NCSR, the densities of sunflower stars were some of the highest densities observed for this species when compared to other MLPA regions in California (Figure 7). The significant decline of this species (Table 5) has eliminated one of the main predators, the sunflower star, of sea urchins in this region where other invertivores, such as predatory fish that feed on macro-invertebrates, are rare (Moitoza and Phillips 1979, Carr and Reed 2016).

Subsequent to the loss of the sea star species from the kelp forest, purple and red urchin populations exploded with their densities increasing from a few individuals per transect prior to 2014 to hundreds by 2016 (Figure 32). Red abalone are the other dominant herbivore in the north coast kelp forests and are likely to be affected by the massive increased in urchin populations and the subsequent declines in kelp densities (Figure 33). While abalone densities seem to be declining since 2014 (Figure 32), the regression analyses did not show any significant trends in red abalone densities at the three long-term sites (Table 5).

Bat stars have been affected by the sea star wasting disease California-wide. In the NCSR region, their densities show a decline in the years after 2014 (Figure 32) but their population trends at the long-term sites are not significantly negative (Table 5). This result is similar to what we have observed in other regions along the California coast where bat stars were affected by the wasting disease, but their populations have not declined as dramatically as other species of sea stars have.

The documentation of the massive changes in the invertebrate community was only possible due to the pre-existing data from the three long-term monitoring sites in the study region. Without long-term data, these changes would not have been evident from the baseline monitoring period as the changes, especially the decline of the sea star populations, occurred immediately before the implementation of the baseline monitoring program. Worth noting is that one sunflower star was recorded during an RCCA survey at the Casper North sites during the 2016 survey. This was one of only two sunflowers stars recorded that year during all RCCA surveys statewide.

Table 5. Results of regression analyses of density trends in invertebrate species at the three long-term study sites. Note: Portuguese Beach was not surveyed in 2015/16 when the dramatic changes in species densities were observed at the other sites. This could explain the non-significant results at this site.

Site	Species	DF	F	P
Mendocino Headlands	**sunflower star**	**1**	**15.66**	**0.000**
Mendocino Headlands	**giant spined star**	**1**	**14.42**	**0.000**
Mendocino Headlands	**purple urchin**	**1**	**92.10**	**0.000**
Mendocino Headlands	**red urchin**	**1**	**15.91**	**0.000**
Mendocino Headlands	red abalone	1	0.22	0.642
Mendocino Headlands	bat star	1	0.33	0.567
Portuguese Beach	**sunflower star**	**1**	**6.20**	**0.016**
Portuguese Beach	giant spined star	1	2.14	0.150
Portuguese Beach	**purple urchin**	**1**	**11.72**	**0.001**
Portuguese Beach	red urchin	1	0.28	0.599
Portuguese Beach	red abalone	1	0.25	0.616
Portuguese Beach	bat star	1	1.34	0.256
Van Damme	**sunflower star**	**1**	**9.52**	**0.003**
Van Damme	**giant spined star**	**1**	**28.78**	**0.000**
Van Damme	**purple urchin**	**1**	**34.39**	**0.000**
Van Damme	**red urchin**	**1**	**17.41**	**0.000**
Van Damme	red abalone	1	0.43	0.515
Van Damme	bat star	1	2.69	0.105

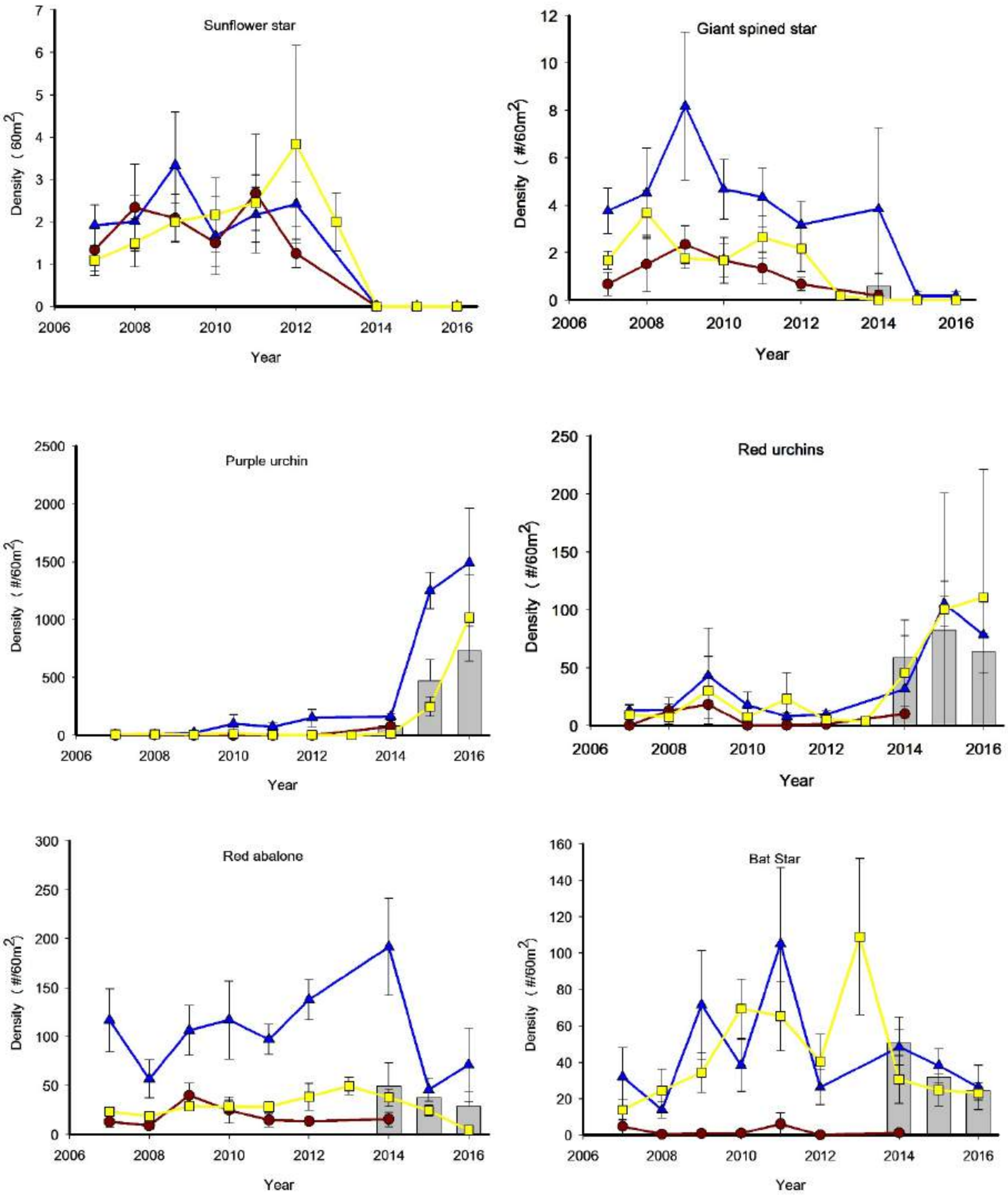


Figure 32. Density of selected invertebrate species for all three sites sampled throughout the long-term monitoring period (2007-2016). Blue triangles – Mendocino Headlands, red circles – Portuguese Beach, yellow squares – Van Damme. Grey bars indicate mean density of selected invertebrate species across all eight sites established during the baseline monitoring period. Error bars are ±SE.

Algae

As observed in the invertebrate populations, RCCA long-term monitoring efforts captured the massive changes in the kelp populations at the NCSR sites over the last three years (2014-2016). All three common species of kelp declined and were almost absent from all NCSR sites by 2016. All three species showed significant declines at the long-term sites (Table 6). While bull kelp densities have been variable throughout the long-term monitoring period, that species was basically absent from all monitoring sites by 2015 (Figure 33). The decline of the bull kelp population was immediately followed by a decline of the understory kelp, *Pterygophora*, which was only present in very low numbers by 2016. *Laminaria* had been present at low densities at all three sites prior to the baseline monitoring but its densities declined further. While the decline in the bull kelp populations appears to have started before urchin densities increased, and might have initially been caused by the unusually warm water conditions, the urchin's population explosion and the subsequent grazing pressure in the urchin barrens at the sites certainly has contributed to its continued absence, even as water temperatures returned to being more similar to the long-term average in 2016.

Overall, RCCA's long-term data from these three sites have documented the change in the rocky reef communities that has led to a shift from kelp dominated reefs prior to the baseline period to urchin barrens. How this will affect other species, including red abalone and fish, remains to be seen. Without annual long-term monitoring of the rocky reef communities, we would not be able to identify and track changes such as the ones noted above. RCCA's ongoing monitoring has demonstrated how oceanographic events and sudden disease outbreaks can have massive consequences for the reef communities and can lead to rapid changes in kelp forest ecosystems.

Table 6. Results of regression analyses of density trends in kelp species at the three long-term study sites.

Site	Species	DF	F	P
Mendocino Headlands	**bull kelp**	**1**	**10.99**	**0.001**
Mendocino Headlands	***Laminaria***	**1**	**7.32**	**0.009**
Mendocino Headlands	***Pterygophora***	**1**	**12.72**	**0.001**
Portuguese Beach	bull kelp	1	1.42	0.238
Portuguese Beach	***Laminaria***	**1**	**6.11**	**0.017**
Portuguese Beach	*Pterygophora*	1	0.74	0.394
Van Damme	**bull kelp**	**1**	**16.53**	**0.000**
Van Damme	***Laminaria***	**1**	**11.55**	**0.001**
Van Damme	*Pterygophora*	1	2.47	0.120

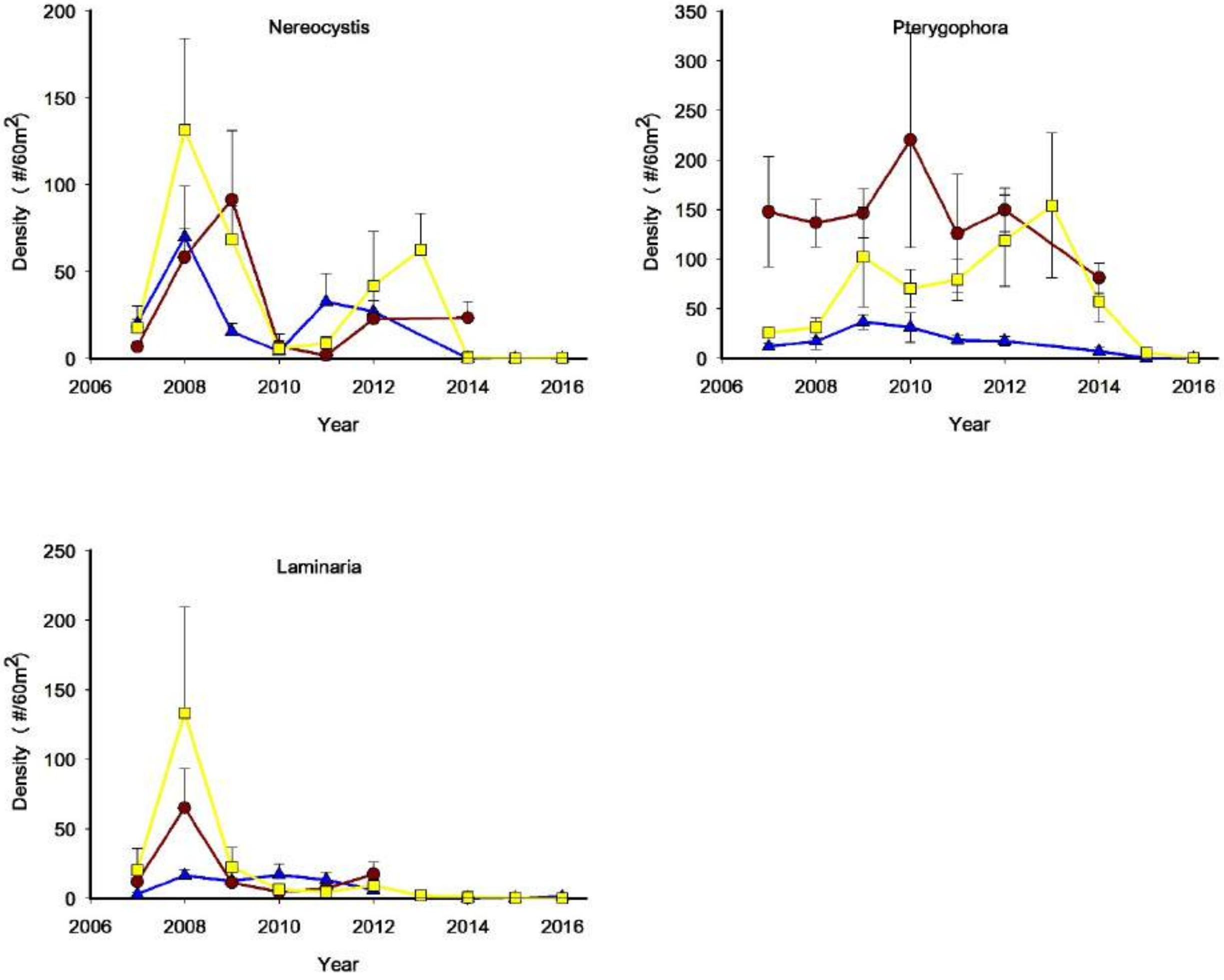


Figure 33. Density of three kelp species for all three sites sampled throughout the long-term monitoring period (2007-2016). Blue triangles – Mendocino Headlands, red circles – Portuguese Beach, yellow squares – Van Damme. Error bars are ±SE.

Capacity Building and Data Dissemination

During the baseline monitoring period, RCCA held 6 trainings in the NCSR for new volunteer citizen scientists. We also conducted 6 recertification classes for previously trained volunteers. These trainings and recertifications were conducted as community trainings for the general public and as trainings at our partner institutions, Humboldt State University (HSU) and the UC Davis' Bodega Marine Lab (BML), where we trained students and instructors during the scientific diving course. Overall, we trained and recertified 150 volunteer citizen scientists in northern California over the baseline period. Volunteers from each of these trainings and recertifications made up the NCSR survey teams. In addition to volunteers trained in the NCSR counties, volunteers from other regions in California traveled to Mendocino to participate in RCCA surveys.

Figure 34. RCCA volunteers after a successful survey.

The NCSR is much less populated than other regions in California and the pool of active scuba divers that could be recruited to Reef Check California is much smaller. Despite Mendocino County having an active free diving community, the willingness to don scuba gear and dive in cold, low visibility conditions to survey the rocky reefs is much lower than we have experienced in other areas of California. While there was much interest in the baseline monitoring effort and the role citizen scientists can play in it, initially few volunteers were willing to participate. Nevertheless, through community outreach and involvement in the local dive community, our regional manager began recruiting volunteers for the program. Over the baseline period, RCCA participated in about 20 outreach and community events in the NCSR, raising the awareness about MPAs and the ongoing monitoring activities. Additionally, our regional manager also became a key member and co-chair of the Mendocino County MPA Collaborative and participated in local and statewide Collaborative events. To broaden community involvement, we helped implement an intertidal monitoring program for the Sherwood Valley Band of Pomo which is now autonomously run by community members (without further RCCA participation). Recently, our regional manager has joined the Mendocino County Fish and Game Commission, extending our network of relationships in that area. Over the last two years, RCCA has also collaborated successfully with The Nature Conservancy on implementing an abalone monitoring protocol, adding additional surveys to our RCCA monitoring program. Overall, RCCA has built a strong presence in the local community during the baseline years and, through collaborations and additional funding streams, has built the capacity for continued long-term monitoring in the NCSR. We have already completed an additional year of monitoring in 2016 and are looking forward to continuing to monitor our sites and expand our monitoring network in 2017 and in the years to come. Without the initial investment through the baseline monitoring program, it would not have been viable for a citizen science organization such as Reef Check to build the capacity for continued long-term monitoring in a remote region such as the NCSR. Prior to the baseline program, our long-term sites were monitored by volunteers from outside the region and by HSU students. Now we involve the local community in the monitoring of their coast.

Another step to build capacity and increase the availability of monitoring data to the public and interested researchers has been to expand RCCA's public online data display and distribution system. All of the Reef Check Program data are available in an interactive interface at: http://data.reefcheck.org. Users are able to view and download data in geographic and temporal contexts and design their own graphs based on sites and species of interest to them. This system makes RCCA's data publicly available as soon as they are entered and checked for quality.

Conclusions

Ecosystem-based management and conservation approaches, such as MPAs, require large amounts of ecological data (Saarman et al. 2013). These data are needed for their implementation, for adaptive management towards their goals, and in order to evaluate their achievements or failures (White et al. 2011). Citizen scientists can help collect these data, and their involvement enables local communities to take part in the scientific-based management process of marine ecosystems (McKinley et al. 2016). RCCA has involved citizen scientists successfully in all MLPA study regions where MPAs were established in California (Gillett et al. 2012, Freiwald and Wehrenberg 2013, Ocean Science Trust and Califorina Department of Fish and Wildlife 2013, Freiwald and Wisniewski 2015). In the North Coast Study Region, RCCA started monitoring in 2007, long before the MLPA implementation of MPAs in this region. Since that time, its volunteer citizen scientists have monitored the rocky reef and kelp forest ecosystem annually at three sites. During the baseline monitoring period, RCCA expanded this monitoring to additional sites in the southern part of the NCSR. RCCA has established a full-time regional manager position in the NCSR and, through community trainings and outreach events, has grown its body of volunteer citizen scientists in this region. Now in its eleventh year of long-term data collection, RCCA has built the capacity for continued, long-term monitoring of rocky reefs and MPAs in the region.

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 (Freitag et al. 2016). An important benefit of involving the pubic (i.e. volunteers) in the monitoring of California's MPAs is that 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 (Sayce et al. 2013). RCCA's 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 (Freitag and Pfeffer 2013).

During the baseline monitoring period, the ocean conditions in the NCSR have been very unusual with much higher water temperatures compared to the mean temperatures recorded over the previous ten years (García-Reyes and Sydeman 2017). These unusual conditions are related to the widely reported 'warm blob' of water off the California coast (Peterson et al. 2015) and the following El Niño (Chavez 2016). Just prior to and during the baseline period, we have seen unprecedented changes of the rocky reef communities in the NCSR and elsewhere in California. Sea star populations were decimated by the sea star wasting disease (Hewson et al. 2014, Menge et al. 2016). Consequently, sea urchin populations have increased over 100-fold, and algae, such as the canopy forming bull kelp and understory species such as *Pterygophora*, have almost completely disappeared from many reefs. RCCA's long-term monitoring data documents these changes to the kelp ecosystem and also indicates that fish populations have not yet been affected by these changes during the baseline period. The rocky reefs in the NCSR appear very different than they did in the years prior to the baseline monitoring period. They have changed from kelp forests with serval kelp species providing three dimensional structure and food for herbivores, such as red abalone, to urchin barrens with little algae remaining.

RCCA detected significant differences in species densities and size frequency distributions inside versus outside of the Point Cabrillo SMR for fish and invertebrate species. The larger size of several of the common fish species (black rockfish, kelp greenling, striped surfperch) in the marine reserve could be an early indicator of the success of this MPA and might serve as an example of a relatively fast response to protection. Increases in fish sizes have been shown to be the first measurable MPA response after protections were implemented in other MLPA regions in California (Starr et al. 2015). These size increases will lead to greater biomass in the MPA compared to fished areas (e.g., Hamilton et al. 2010). The highest overall fish biomass recorded during the baseline surveys at any of the RCCA sites was at the Frolic Cove site in the Pt. Cabrillo SMR. Difference in species densities for fish and red abalone, on the other hand, could not be attributed to protection as we did not detect any consistent significant differences between the MPA site and the two nearby fished sites.

When considering the data reported from this baseline program in future assessments of the MPAs, it is critical to consider the massive changes that the ecosystem has experienced during the survey period. Relying only on the two years of baseline data in future evaluations of MPA performance might bias the conclusions drawn if the previous state of the ecosystem – with abundant kelps and low numbers of urchins – is not considered. For example, whether sea star populations can recover from the almost complete local extinction, remains to be seen. RCCA's long-term data from some of the sites in the NCSR serve as an example of the importance of ongoing reef and MPA monitoring and will be useful as a reference in future MPA evaluations. Without long-term data, even comprehensive snapshots of an ecosystem's state might lead to inaccurate conclusions about MPA trajectories and the state of the managed resources. Therefore, we suggest that the available ecosystem data from monitoring efforts performed prior to the baseline period should be considered in any future evaluation of ecosystems in the context of MPAs or other management measures. The MLPA baseline monitoring in all of California's regions and its integration with long-term datasets from RCCA and other monitoring programs is a positive example of how an investment in long-term ecological studies can substantially boost insights into ecosystem changes, especially given the recent extreme ocean conditions and the widespread disease outbreak (Hughes et al. 2017).

Long-term Monitoring Recommendations

The unprecedented changes in species abundances over the baseline monitoring period in the NCSR demonstrate the difficulties in predicting what species act as good indicators of ecosystem change (Reed et al. 2016). For example, sunflower stars, an important invertebrate predator (Moitoza and Phillips 1979, Carr and Reed 2016), is an ecologically important species that was absent during the baseline period, but should be included in any MPA evaluation. Similarly, reference points for sea urchin species should consider the pre-baseline densities when they are included as indicator species for MPA evaluations. Some invertebrate species have not been affected as dramatically by the recent environmental conditions and disease outback. Examples presented in this report are bat stars and the California sea cucumber. These species should be included in any MPA long-term monitoring program as they might show more stable population dynamics in light of recent or future environmental changes. Although the kelp populations have recently experienced dramatic declines and were mostly absent from monitoring sites during the baseline period, clearly they are important ecosystem components and habitat forming species, and their prior densities should be considered as reference points for MPA evaluation. In their absence, the percent cover of encrusting algae, such as crustose and articulated coralline algae, and foliose red algae may also act as important indicator species, representing the remaining algal community.

For fish species to be useful long-term indicators of MPA performance, several factors should be considered. Their ecological function (i.e. trophic level and functional group) and their economic value (i.e. exploitation level) are important considerations. Another important factor is the effort needed with which these species can be reliably sampled. Species need to exist in great enough abundances so that population density estimates can be derived with a reasonable amount of sampling effort. Rare species may be ecologically or economically important but they might not be sampled effectively with a reasonable amount of effort. RCCA surveys during the baseline period and previous years have shown that few fish species are abundant enough in the NCSR to work well for MPA evaluation given the constraints (e.g., ocean conditions, logistics, etc.) on sampling reefs in this region. Of the fish species listed in the MPA Monitoring Plan as potential indicators, blue and black rockfish, kelp greenling, and striped surfperch were most abundant and would therefore serve well as indicator species. Cabezon and lingcod are less abundant but given their ecological importance, should also be considered as indicators. Collectively, these fish species represent a large section of the trophic functions from planktivore (blue rockfish), to piscivore (black rockfish, lingcod) and invertebrate predators (kelp greenling, cabezon) with different levels of exploitation and life histories. This selection of species should be augmented with other species based on comparison of RCCA's data with the datasets from the other projects that monitored the same ecosystems further north.

RCCA's work performing the NCSR baseline monitoring has demonstrated the effectiveness of citizen science for data collection in the region's MPAs and rocky reefs. Additionally, through the involvement of volunteer divers, local communities become educated in the scientific methods and gain a deeper understanding of their local marine ecosystems than they would have without participating hands-on in the scientific monitoring of the MPAs. This is particularly valuable when resource users such as recreational or commercial fishers are involved in the monitoring. Baseline monitoring in the NCSR has shown how changing environmental conditions and sudden disease outbreaks can have large and sudden effects on the rocky reef communities. Without annual, long-term monitoring we would not have been able to detect or quantity the consequences of these unprecedented events. This serves as an example that in order to detect MPA effects and understand how ecosystems change as the result of changing ocean conditions (i.e. climate change, OAH), ocean climate oscillations (e.g., El Niño) and events such as a sudden disease outbreak or the appearance of invasive species, continued annual MPA monitoring is necessary. Citizen science programs with trained volunteers conducting standardized surveys provide a valuable contribution to helping scientists obtain the data they need to study these complex ecosystems.

Financial Report

Reef Check California budget and actual costs for NCSR baseline monitoring

Category Reimbursement	Category Budget	Total Cost to Date	Remaining Balance
Salaries	$102,284.00	$ 99,826.55	$ 2,457.45
Benefits	$ 23,676.00	$ 23,343.66	$ 332.34
Supplies	$ 10,575.00	$ 10,145.92	$ 429.08
Travel	$ 11,000.00	$ 9,167.25	$ 1,832.75
Other Costs (Contracts)	$ 9,000.00	$ 8,737.81	$ 262.19
Indirect 15%	$ 23,465.00	$ 22,683.19	$ 781.81
TOTAL	**$180,000.00**	**$173,904.38**	**$ 6,095.62**

The above budget and actual costs represents the project expenses as of the end of 2016. The budget represents the current budget after an approved budget change request and therefore differs from the original budget submitted at the beginning of the project. Most of the requested funds have been spent as intended and presented in the revised budget. The remaining balance of $6,095.62 was allocated for the preparation of the final report. We will submit a final invoice for this.

Literature Cited

Bonter, D. N. and C. B. Cooper. 2012. Data validation in citizen science: a case study from Project FeederWatch. Frontiers in Ecology and the Environment **10**:305-307.

California Ocean Science Trust and California Department of Fish and Wildlife. February 2013. State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012., California, USA.

Carr, M. and D. Reed. 2016. Shallow Rocky Reefs and Kelp Forests. Pages 311-336 *in* H. Mooney and E. Zavaleta, editors. Ecosystems of California. University of Califorina Press.

Chavez, F. 2016. What is El Niño and why is 2016 interesting? Central California Integrated Ocean Observing System.

Clark, K. R., R. N. Gorley, S. P. J, and W. R. M. 2014. Changes in marine communities: an approach to statistical analysis and interpretations, 3rd editions. PRIMER-E: Plymouth.

Clarke, K. R., Gorley, R N. 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Dickinson, J. L. and R. Bonney, editors. 2012. Citizen Science: Public Participation in envrionmental Research. Cornell University Press, Ithaca, NY.

Freitag, A., R. Meyer, and L. Whiteman. 2016. Strategies Employed by Citizen Science Programs to Increase the Credibility of Their Data. Citizen Science: Theory and Practice. **1**:2.

Freitag, A. and M. J. Pfeffer. 2013. Process, not product: investigating recommendations for improving citizen science "success". PLoS ONE **8**:e64079.

Freiwald, J. 2012. Movement of adult temperate reef fishes off the west coast of North America. Canadian Journal of Fisheries and Aquatic Sciences **69**:1362-1374.

Freiwald, J. and M. Wehrenberg. 2013. Reef Check California: North Central Coast Baseline Surveys of Shallow Rocky Reef Ecosystems. Report to California Sea Grant (Project # R/MPA-13, Grant # 09-015), Reef Check Foundation, Pacific Palisades.

Freiwald, J. and C. Wisniewski. 2015. Reef Check California: Citizen Scientist monitoring of rocky reefs and kelp forests: Creating a baseline for California's South Coast, Final Report South Coast MPA Baseline Monitoring 2011-2014. Report to California Sea Grant (Project # R/MPA-21, Grant # 10-049), Reef Check Foundation, Pacific Palisades.

Freiwald, J., C. Wisniewski, and D. Abbott. 2016. Northward range extension of the crowned sea urchin (*Centrostephanus coronatus*) to Monterey Bay, California. California Fish and Game **102**:37-40.

García-Reyes, M. and W. J. Sydeman. 2017. California Multivariate Ocean Climate Indicator (MOCI) and marine ecosystem dynamics. Ecological Indicators **72**:521-529.

Gillett, D., D. Pondella, II, J. Freiwald, K. Schiff, J. Caselle, C. Shuman, and S. Weisberg. 2012. Comparing volunteer and professionally collected monitoring data from the rocky subtidal reefs of Southern California, USA. Environmental Monitoring and Assessment **184**:3239-3257.

Hamilton, S. L., J. E. Caselle, D. P. Malone, and M. H. Carr. 2010. Incorporating biogeography into evaluations of the Channel Islands marine reserve network. Proceedings of the National Academy of Sciences **107**:18272-18277.

Hewson, I., J. B. Button, B. M. Gudenkauf, B. Miner, A. L. Newton, J. K. Gaydos, J. Wynne, C. L. Groves, G. Hendler, M. Murray, S. Fradkin, M. Breitbart, E. Fahsbender, K. D. Lafferty, A. M. Kilpatrick, C. M. Miner, P. Raimondi, L. Lahner, C. S. Friedman, S. Daniels, M. Haulena, J. Marliave, C. A. Burge, M. E. Eisenlord, and C. D. Harvell. 2014. Densovirus associated with sea-star wasting disease and mass mortality. Proc Natl Acad Sci U S A.

Hughes, B. B., R. Beas-Luna, A. K. Barner, K. Brewitt, D. R. Brumbaugh, E. B. Cerny-Chipman, S. L. Close, K. E. Coblentz, K. L. de Nesnera, S. T. Drobnitch, J. D. Figurski, B. Focht, M. Friedman, J. Freiwald, K. K. Heady, W. N. Heady, A. Hettinger, A. Johnson, K. A. Karr, B. Mahoney, M. M. Moritsch, A.-M. K. Osterback, J. Reimer, J. Robinson, T. Rohrer, J. M. Rose, M. Sabal, L. M. Segui, C. Shen, J. Sullivan, R. Zuercher, P. T. Raimondi, B. A. Menge, K. Grorud-Colvert, M. Novak, and M. H. Carr. 2017. Long-Term Studies Contribute Disproportionately to Ecology and Policy. BioScience **67**:271-281.

Leising, A. W., I. D. Schroeder, S. J. Bograd, J. Abell, R. Durazo, G. Gaxiola-Castro, E. P. Bjorkstedt, J. Field, K. Sakuma, R. R. Robertson, R. Goericke, W. T. Peterson, R. Brodeur, C. Barceló, T. D. Auth, E. A. Daly, R. M. Suryan, A. J. Gladics, J. M. Porquez, S. McClatchie, E. D. Weber, W. Watson, J. A. Santora, W. J. Sydeman, S. R. Melin, F. P. Chavez, R. T. Golightly, S. R. Schneider, J. Fisher, C. Morgan, R. Bradley, and P. Warybok. 2015. State of the California Current 2014–15: Impacts of the warm-water "Blob". STATE OF THE CALIFORNIA CURRENT CalCOFI Rep. **56**:31-68.Lester, S. E., B. S. Halpern, K. Grorud-Colvert, J. Lubchenco, B. I. Ruttenberg, S. D. Gaines, S. Airame, and R. R. Warner. 2009. Biological effects within no-take marine reserves: a global synthesis. Marine Ecology-Progress Series 384:33-46.

McKinley, D. C., A. J. Miller-Rushing, H. L. Ballard, R. Bonney, H. Brown, S. C. Cook-Patton, and M. A. Soukup. 2016. Citizen science can improve conservation science, natural resourcemanagement, and environmental protection. Biological Conservation.

Menge, B. A., E. B. Cerny-Chipman, A. Johnson, J. Sullivan, S. Gravem, and F. Chan. 2016. Sea Star Wasting Disease in the Keystone Predator *Pisaster ochraceus* in Oregon: Insights into Differential Population Impacts, Recovery, Predation Rate, and Temperature Effects from Long-Term Research. PLoS ONE **11**:e0153994.

Moitoza, D. J. and D. W. Phillips. 1979. Prey defense, predator preference, and nonrandom diet: The interactions between Pycnopodia helianthoides and two species of sea urchins. Marine Biology **53**:299-304.

Ocean Science Trust and Califorina Department of Fish and Wildlife. 2013. State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012. . California Ocean Science Trust and California Department of Fish and Wildlife, California, USA.

Peterson, W., M. Robert, and N. Bond. 2015. The warm blob – Conditions in the northeastern Pacific Ocean. PICES Press **23**.

Reed, D., L. Washburn, A. Rassweiler, R. Miller, T. Bell, and S. Harrer. 2016. Extreme warming challenges sentinel status of kelp forests as indicators of climate change. Nature Communications **7**:13757.

Saarman, E., M. Gleason, J. Ugoretz, S. Airamé, M. Carr, E. Fox, A. Frimodig, T. Mason, and J. Vasques. 2013. The role of science in supporting marine protected area network planning and design in California. Ocean & Coastal Management **74**:45-56.

Sayce, K., C. Shuman, D. Connor, A. Reisewitz, E. Pope, M. Miller-Henson, E. Poncelet, D. Monié, and B. Owens. 2013. Beyond traditional stakeholder engagement: Public participation roles in California's statewide marine protected area planning process. Ocean & Coastal Management **74**:57-66.

Schroeter, S. C., N. L. Gutierrez, M. Robinson, R. Hilborn, and P. Halmay. 2009. Moving from Data Poor to Data Rich: A Case Study of Community-Based Data Collection for the San Diego Red Sea Urchin Fishery. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science:230-243.

Starr, R. M., D. E. Wendt, C. L. Barnes, C. I. Marks, D. Malone, G. Waltz, K. T. Schmidt, J. Chiu, A. L. Launer, N. C. Hall, and N. Yochum. 2015. Variation in Responses of Fishes across Multiple Reserves within a Network of Marine Protected Areas in Temperate Waters. PLoS ONE **10**:e0118502.

Theobald, E. J., A. K. Ettinger, H. K. Burgess, L. B. DeBey, N. R. Schmidt, H. E. Froehlich, C. Wagner, J. HilleRisLambers, J. Tewksbury, M. A. Harsch, and J. K. Parrish. 2015. Global change and local solutions: Tapping the unrealized potential of citizen science for biodiversity research. Biological Conservation **181**:236-244.

Thiel, M., Miguel Angel Penna-Díaz, G. Luna-Jorquer, S. Salas, J. Sellanes, and W. Stotz. 2014. Citizen Scientists and Marine Research: Volunteer Participants, Their Contributions, and Projection for the Future. Oceanography and Marine Biology: An Annual Review **52**:257-314.

White, J. W., L. W. Botsford, M. L. Baskett, L. A. K. Barnett, R. J. Barr, and A. Hastings. 2011. Linking models with monitoring data for assessing performance of no-take marine reserves. Frontiers in Ecology and the Environment **9**:390-399.

Appendix A

Reef Check California indicator fish species

Common Name	Scientific Name	Rationale
blacksmith	*Chromis punctipinnis*	C
opaleye	*Girella nigricans*	C, E
garibaldi	*Hypsypops rubicundus*	C, SI
sargo	*Anisotremus davidsoni*	C
black perch	*Embiotoca jacksoni*	C,E
striped seaperch	*Embiotoca lateralis*	C, E
rubberlip seaperch	*Rhacochilus toxotes*	C, E
pile perch	*Rhacochilus vacca*	C, E
rainbow seaperch	*Hypsurus caryi*	C, E
CA CA sheephead*	*Semicossyphus pulcher*	C, E, EI
rock wrasse	*Halichoeres semicinctus*	C
senorita	*Oxyjulis californica*	C
kelp bass	*Paralabrax clathratus*	C, E
barred sand bass	*Paralabrax nebulifer*	E
cabezon*	*Scorpaenichthys marmoratus*	E
lingcod	*Ophiodon elongatus*	E, SI
giant sea bass†	*Stereolepis gigas*	SI
kelp greenling*	*Hexagrammos decagrammus*	E
rock greenling*	*Hexagrammos lagocephalus*	E
horn shark	*Heterodontus francisci*	EI, E
kelp rockfish*	*Sebastes atrovirens*	E
grass rockfish*	*Sebastes rastrelliger*	E
brown rockfish*	*Sebastes auriculatus*	E
gopher rockfish*	*Sebastes carnatus*	E
black and yellow*	*Sebastes chrysomelas*	E
China rockfish*	Sebastes *nebulosus*	E
yellowtail rockfish & olive	*Sebastes flavidus/Sebastes serranoides*	E
copper rockfish*	*Sebastes caurinus*	E
vermilion rockfish & canary	*Sebastes miniatus/Sebastes pinniger*	E
black rockfish*	*Sebastes melanops*	E
blue rockfish*	*Sebastes mystinus*	E
bocaccio	*Sebastes paucispinis*	E, SI
treefish*	*Sebastes serriceps*	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, **SI** = species of interest or concern (protected, endangered, overfished, etc.)

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 corrugate*	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 Actinaria	C

* Size estimated to nearest centimeter

** Anemones must be 10 cm or larger (height or width) to be recorded; gorgonians must be 10 cm or greater in height to be counted

All other organisms must be greater than 2.5 cm to be counted

† 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 (important to trophic food web), **SI** = species of interest or concern (protected, endangered, overfished, etc.)

Reef Check California indicator algae 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

Reef Check California habitat variables

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:

Relief is recorded as the distance between the lowest and the highest point of the substrate within a 1 meter by 0.5 meter box at each UPC point along the transect.

- 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

Substrate cover categories:

- None - empty substrate
- Brown Seaweed - Any type of the five large kelps that are surveyed on the seaweed transect (giant kelp, bull kelp, Pterygophora, southern sea palm and Laminaria spp.).
- Articulated Coralline Algae
- Other Brown Seaweed - Any other type of brown seaweed including *Sargassum* spp., *Undaria pinnatifida* and *Cystoseira*
- Green Algae - Any type of algae that appears very green in color.
- Red Algae - Any type of algae that appears red in color (other than articulated and crustose coralline algae).
- Crustose Coralline Algae
- Sessile Invertebrates - Includes sponges, anemones, bryozoans, gorgonians, sandcastle worms, barnacles, etc.
- Mobile Invertebrates - Includes sea stars, urchins, sea cucumbers, crabs, limpets, etc.

Seagrasses -Includes surfgrass and eelgrass.

Appendix B

Reef Check California monitoring methods

How to Participate in Reef Check California

The Reef Check California Training course is designed to provide participants with the skills required to precisely monitor shallow rocky reefs with the Reef Check California survey protocol. The training program also reviews safe diving practices learned in your SCUBA certification course, techniques of research diving, sampling design, general marine ecology, species identification and discussion about how monitoring helps achieve marine management needs. Trainings include a combination of classroom and field sessions. Following successful completion of the training, all participants will be issued a Reef Check California Certification and will be eligible to obtain a Reef Check California Specialty Certification through NAUI. Data will only be accepted by divers who have met the minimum testing standards and received accreditation from Reef Check.

No prior scientific training is required for participation. However, in order to be eligible to take this course you must meet the following course prerequisites:

- Proof of dive certification
  - Minimum of 30 logged lifetime dives
  - Minimum of 15 logged dives in California or other temperate region with water temperature below 65°F
  - Minimum of 6 dives within the last year
  - Minimum age of 16
  - Completion of liability release
  - Completed reading of Reef Check California Instruction Manual

Dive Experience

The Reef Check California protocol requires that divers successfully perform multiple tasks underwater. Tasks include hovering motionless near the seafloor (often in an upside down or horizontal position), identifying and counting target organisms and writing these observations on a slate. Multiple tasks often require extra concentration underwater and buoyancy control can easily be lost – even for experienced divers. **This course is designed for experienced divers who have mastered buoyancy and safe diving practices and are comfortable with their equipment.**

Reef Check California Survey Methods

The Reef Check California methodology is based on CRANE (Cooperative Research and Assessment of Nearshore Ecosystems) and PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans) methodologies. Despite the scientific rigor of PISCO surveys, they cover only a small fraction of California's reefs (visit www.piscoweb.org for more information). CRANE was a joint research effort led by the Department of Fish and Wildlife that surveyed 88 sites between Monterey Bay and San Diego, including the Channel Islands. Unfortunately, these sites were all surveyed only once in 2004 and only portions of the sites have been surveyed since. Even with this tremendous effort, a comprehensive picture of California's rocky reefs is not available due to the gaps in coverage and lack of replication. Through your regular efforts, we can make a difference in areas where government resources fall short!

You will collect many different types of surface and underwater data during your Reef Check California survey. All underwater surveys are based on the transects discussed in Chapter 4. All the datasheets you will use to complete a survey are found in Appendix B. You will be given these sheets on underwater paper for your training and surveys.

Survey Overview

A standard Reef Check California survey will include:

- **Site Description** (1 per site). Anecdotal, observational, historical, geographical and other data should be recorded on the Site Description Form. These data are extremely important when we interpret correlations in Reef Check California survey results. It is very important to describe the physical setting of the site and its position in relation to obvious human influences on the Site Description Form. This assures that data comparisons will be made between similar reef settings (see Chapter 6).

- **Fish Transects** (35 species, 18 transects each survey – 6 core transects and 12 fish-only transects). Divers search for and record the 35 target fish species observed along a transect 30 meters long, 2 meters wide and 2 meters high.

- **Invertebrate Transects** (30 species, 1 order (Actiniaria - anemones) - 6 transects each survey). Using the same 6 core transects as the fish transects, divers search for and record the target invertebrate species along the transect (30 x 2 meters). Note that these transects do not have a height associated with them; all target invertebrates are found only on the bottom.

- **Seaweed Transects** (8 species, 1 genus comprising several species, 6 fixed transects each survey). Target algae species within the 2 m swath along the core transects as well as invasive species that are noted as present or absent anywhere on the site.

- **Substrate Uniform Point Contact transects (UPC)** (6 transects each survey). The same core transects as the fish, invertebrate and seaweed transects are used, but this time, points are sampled at each 1 m interval along the tape. At each point, three types of information will be collected to determine reef substrate composition, organisms that are covering the reef and the rugosity (variation of vertical relief) of the reef.

- **Urchin Size Frequency Survey** (1 per site in fall only). This survey is not associated with a transect but should occur in the immediate vicinity of the core transects.

In total, there are 36 transects at each site: 6 core transects, each consisting of a fish, invertebrate, seaweed and UPC along the same transect tape; and then 12 fish only transects. Urchin surveys are not conducted on transect lines.

The transects should be grouped on the reef as inshore (closer to shore) and offshore (further from shore). Three core transects and 6 fish-only transects should be placed in each reef zone (inshore and offshore). Each transect should follow a predetermined compass heading and a designated depth contour. Transects can be laid one after another on small reefs, however, the transect start and end points **must** be separated by a minimum of a **5 m gap**. There should also be a minimum 5 meter spacing between transects (i.e., all transects should have spacing of 5m on all sides). These 5 meter gaps are necessary to ensure independence between samples (replicates). Due to logistics and safety, reef habitats deeper than **18 m (~60 feet)** will not be sampled. Zones were created to help allocate samples across an entire site providing a representative sample. Restrictive depth categorization for each zone were not used due to the variable topography of California's rocky reefs and logistical feasibility of sampling along fixed depth zones at multiple sites (Schroeder et al., 2002; J. Caselle, personal comm.).

In many cases, it will not be possible to follow a consistent depth contour for multiple transects. This is permissible as long as the transects are separated into outer and inner zones. There may even be some instances where an outer transect is shallower than an inner transect. This is why it is important to note the start and end depth of each transect on your datasheet. **The depth along any individual transect must not vary by more than 4 m (~12 feet) or cover more than 10 continuous meters of sand.** More details on sand in chapter 6.

Visibility must be at least 3 meters to conduct fish surveys. More details on checking visibility in chapter 5.

To keep track of the various transects, a specific numbering scheme must be used for all transects. Core transects shall be numbered 1 – 6 with the outer transects numbered first as 1 -3 (deeper dive first) and the inshore core transects numbered 4 – 6. Fish-only transects shall be numbered 7 – 18 with the offshore fish only transects numbered 7 – 12 (deeper dive first) and the inshore fish only transects numbered 13 – 18 (Figure 5).

Sites should be targeted to be surveyed a minimum of one time per year, preferably twice with a survey in spring and fall. Unless you have a large team, it is not likely you will be able to complete the Reef Check California survey in one day of diving. It is perfectly acceptable to spread the diving out over several days, although we require that all transects be completed within a 4 week time period to minimize temporal variation associated with that survey.

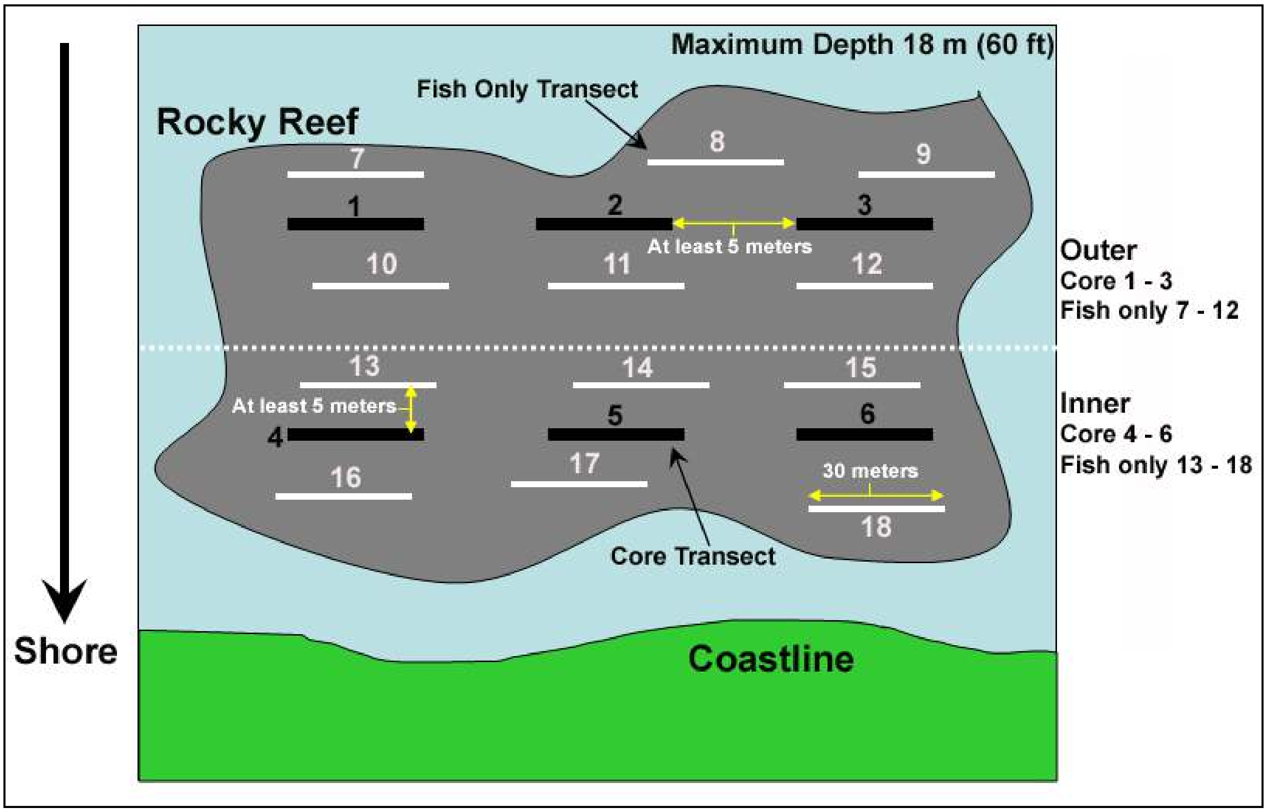


Figure 1. Diagram of transects over a rocky reef. All teams should aim to complete six core transects, which are marked in bold (3 in each zone), plus an additional twelve random fish only transects, which are marked in white (6 in each zone). All transects are 30 meters in length.

Site Selection

Site selection is a critical factor in the success of your surveys. The ultimate goal of Reef Check California is to monitor rocky subtidal communities twice per year along the entire mainland and island coasts. Initially, priority will be given to monitoring sites inside and on the periphery of planned or existing MPAs and at sites recommended by CDFW. Monitoring sites will be selected based on a variety of factors including, but not limited to, logistics, accessibility and presence of volunteer teams. In addition to the criteria listed above, teams are encouraged to adopt their “favorite” dive site as a monitoring location.

For the purposes of Reef Check California, **a site is defined as 250 linear meters of coastline unless distinguished by distinct geological features** (e.g., a bay). When selecting sites it is helpful to first map the area of interest. This will help you to identify the best places to deploy your transects. Due to the importance of long-term monitoring, preference should be given to sites that teams anticipate they can revisit year after year.

With all site selection, however, it is important to remember that a survey is only a sample of the rocky reef environment. The site selected for the survey should be representative of the reef area of interest. For purposes of standardization, surveys of steep walls (drop-offs), pinnacles, and reefs predominantly located in caves or beneath overhangs should be avoided.

Target Species

The Reef Check California protocol was designed to assess the health of rocky reefs and is quite different from many other monitoring protocols. Reef Check California focuses on the abundance of local marine organisms that not only best reflect the condition of the ecosystem, but are easily recognizable. Before selecting the species list, a thorough literature review was conducted in order to determine which species are currently monitored by the numerous existing sampling programs and the criteria the groups used to select their target species (Burcham, 2004; CDFG, 2004b; Carr et al., 2003; Schroder et al., 2002; Davis et al., 1997). In addition, an analysis of the REEF volunteer database (www.reef.org) provided insight into the relative frequency of species encountered by recreational divers in the Monterey/Carmel region (J. Wolfe, personal comm.).

The Reef Check California shallow subtidal species list was compiled using the following criteria:

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

For example, the garibaldi was selected because it is commonly observed in Southern California and it is a species of special interest or concern due to its protected status and designation as California's state marine fish. The red urchin, on the other hand, was selected because it is a commercially fished species and is an ecologically important species. Cryptic species are not included because they cannot be surveyed adequately by visual techniques alone (Stephens et al., 2006).

The Reef Check California Protocol survey includes 30 invertebrate species and 1 invertebrate order; 35 fish species; 8 algal species and 1 algal genus (Tables 1 - 3). There are several important points to keep in mind as you learn the taxa:

- Fishes will be recorded to the nearest centimeter and differentiated as juveniles, males and females where appropriate.

- Size estimates will be made of all abalones to the nearest centimeter. If you cannot physically measure an abalone but can clearly identify the species, instead of recording the size in centimeters (e.g. “17”) on your datasheet you will record “X” to denote no size was obtained.
- All juvenile or “young-of-the-year” (YOY) rockfish shall be recorded as YOY on your datasheet. They are not sized since YOYs are <10cm.
- Certain species that are difficult to tell apart, like the yellowtail and olive rockfishes, are grouped into a single category. Note: although this will decrease the resolution of the data that is collected, it will increase the precision of counts by minimizing observer error.
- All invertebrates and seaweeds have minimum size requirements. These are described later and noted on all data sheets.
- **DO NOT GUESS!** Bad data are much worse than no data. If you are surveying and are not sure of identification of a species, make notes in the comments section of your datasheet or on your slate and discuss it with your team after the dive. If appropriate (i.e. you have the required license and have a high probability of returning the organism unharmed) and in an area that does not have restrictions prohibiting take, you can gently bring back sessile invertebrates or algae for ID confirmation after you complete your survey. Be sure to replace anything you take by returning it as close as possible to the location from where it was removed.

Reef Check California will not have separate target species lists for different geographic regions in California. Although we recognize the distinct biological breaks along California’s coast and associated differing compositions of species, separate species lists would limit the ability of the monitoring program to detect subtle geographic range shifts in target species. In addition, a single species list permits volunteers trained in any part of California to participate in surveys along the entire coast.

A NOTE ON SAFETY!

Diver safety is our number one priority. Reef Check surveys should NOT be undertaken when weather or sea conditions are unsafe or if a diver does not feel well. In particular, teams should **NEVER** plan any dives that will require **decompression**. Any diver who is not comfortable diving for any reason should **NOT** participate in the diving aspects of the survey.

Invertebrate Transects

Reef Check California Invertebrate Species

Unlike fish, most invertebrates are relatively sedentary (they don’t move very much), allowing for careful examination of their features. Some invertebrates will be camouflaged, and thus, difficult to notice, which means that you must know what you are looking for in order to sample well.

The Reef Check California invertebrate species are listed in Table 1 and pictures can be found in Appendix C. More detailed descriptions can be found in the accompanying training materials. Please note the specific measurement requirements for each species and the rationale for its selection.

Table 1. 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 corrugate*	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 Actinaria	C

* Size estimated to nearest centimeter

** Anemones must be 10 cm or larger (height or width) to be recorded; gorgonians must be 10 cm or greater in height to be counted

All other organisms must be greater than 2.5 cm to be counted

† 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 (important to trophic food web), **SI** = species of interest or concern (protected, endangered, overfished, etc.)

Invertebrate Transect
Individuals of the RCCA invertebrate species list are recorded along a two meters wide (1 meter on either side of the transect line) and 30 meters long transect. Therefore, the total survey area is 30 meters x 2 meters = 60 square meters for each transect. Flashlights are required on the invertebrate surveys to look in cracks and crevices (standardized for all surveys). Flashlights should also be used to verify urchin species, red urchins (*Strongylocentrotus franciscanus*), which can be a dark red, vs. crowned urchins (*Centrostephanus coronatus*), which have a bright blue ring at the base of each spine (Figure 12). Flashlights are also necessary for identifying abalone species.

If you should encounter a large abundance of a particular species, you may subsample. You can stop counting once you have counted 50 individuals of that species ONLY if you record on your datasheet the distance you have traveled along the transect. If, for example, you counted the fiftieth bat star at 10 meters along the transect, you would stop counting and write 50 in the total column and 10 in the distance column. Pay special attention to record the distance traveled when working backwards along the transect line. For example, if you were working backwards along the transect line and recorded 50 bat stars in the first 5 meters, you would record 5 m, not 25 m (which would be your location on the transect line). Only seaweed and invertebrates are subsampled. Fishes are NOT subsampled.

It is important to note that all invertebrates have a minimum size requirement of < 2.5 cm except large anemones and gorgonians, which have a minimum size of 10 cm. Shell lengths of all abalones should be recorded to the nearest centimeter. If you can't physically measure an abalone record "X" on your datasheet in the appropriate species row. In addition, **due to their endangered statuses, white and black abalones should be recorded if they are observed anywhere during the survey (on or off of transect).** If you believe you see one do as much of the following as possible: check for confirmation from your buddy; record whether or not it is on transect; take a photo including the holes, shell and epipodium; and mark the location with a float so GPS coordinates can be taken from the surface.

It is imperative that your sampling is non-invasive. While it is extremely important to look in cracks and under overhangs to search for hidden species such as lobster, it is also important not to move any of the organisms during a survey. Invertebrate surveying is generally most easily performed when the diver adopts a face down, feet up position no more than 3 feet off the bottom.

Starting and ending times should be recorded on the datasheet in the appropriate location. There is no time limit for invertebrate transect; however, they should be performed with a 10 min goal in mind. A note should be made of any rarely sighted animals such as giant octopus, sharks and bat rays. They should be recorded at the bottom of the datasheet under "Comments." See Figure 7 for an example on how to record data on the invertebrate datasheet.

The importance of white and black abalone

On 29 May 2001, the National Marine Fisheries Service (NMFS) listed the white abalone as a federally endangered species under the U.S. Endangered Species Act, making it the first marine invertebrate to be listed. Despite the fact that part of the white abalone fishery has been closed since 1977, densities have continued to fall. Current population estimates indicate that white abalone have declined by as much as 99% since the 1970s (CDFG, 2004). Black abalone became listed as a federally endangered species by NMFS on 13 February 2009. These abalone were harvested early in CA history and commercial harvesting peaked in the 1970s. Much of the loss since the 1980s has been attributed to the disease withering syndrome. The commercial and recreational fisheries closed in 1993 (NOAA, 2004).

Seaweed Transect

Reef Check California Seaweed Species

The Reef Check California seaweed species are listed in Table 2 and pictures can be found in Appendix C. More detailed descriptions can be found in the accompanying training materials. Please note the **specific height requirements for each species** and the rationale for its selection. It is also important to pay special attention to four species of invasive seaweed (*Undaria pinnatifida, Caulerpa taxifolia, Sargassum filicinum* and *S. muticum*). These species should be recorded as present if they are seen anywhere during a survey. If you detect either *Undaria pinnatifida, Caulerpa taxifolia* it is important to document your finding by either taking a picture (above or below water) or taking a sample and sending it to Reef Check Headquarters for identification. **If a sample is removed, be certain not to spread the invasive species.**

Table 2. Species and rationale of Reef Check California indicator 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

Seaweed Transect

Seaweeds, also known as marine algae, are attached directly to the substrate and will be sampled using the same 30 m x 2 m transect that was utilized during the invertebrate transect. Note that four species of invasive algae are observed as “present” or “absent” anywhere near the survey site (on or off transect). All non-invasive species have a minimum height requirement, which can be found on the datasheet. In addition, the number of stipes (“stems”) of giant kelp per individual holdfast is recorded. Counting kelp stipes should be done 1m off the bottom and can be easily accomplished by running one’s fingers through the kelp stipes counting as you go (Figure 6). For very dense kelp, it may be necessary to count the number of stipes that fit in one “handful” and then count “handfuls” to estimate the total number of stipes per kelp. The seaweed species list and specifics for measurement are listed in Table 2.

Again, subsampling methods will be employed when performing seaweed counts. Once 50 individuals of a species have been counted, record the number and the distance on your data sheet. **Of special note - when subsampling giant kelp, stop counting at 50 individual plants (holdfasts) not 50 stipes.** Starting and ending times should be recorded on the datasheet in the appropriate location. There is no time limit for seaweed transects; however, they should be done with a 10 min goal in mind. See Figure 7 for an example on how to record data on the seaweed datasheet.

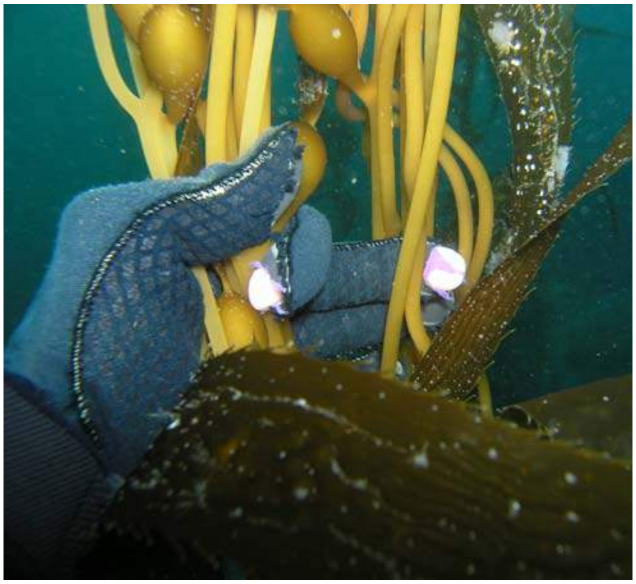
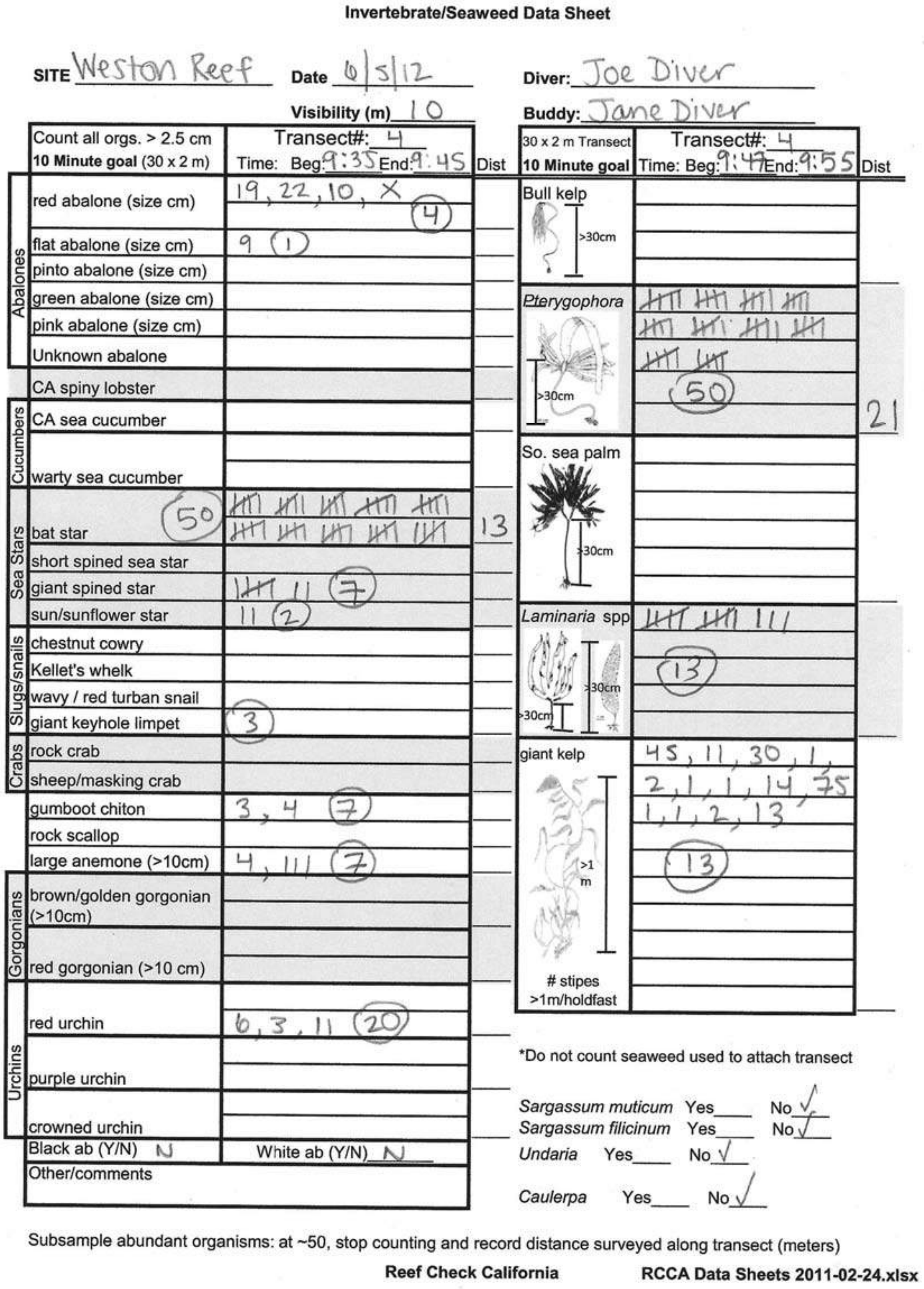


Figure 2. Using fingers to count kelp stipes at 1m off the bottom (Photo: C. Shuman).



Invertebrate/Seaweed Data Sheet

SITE Weston Reef **Date** 6/5/12 **Diver:** Joe Diver

Visibility (m) 10 **Buddy:** Jane Diver

	Count all orgs. > 2.5 cm **10 Minute goal** (30 x 2 m)	Transect#: 4 Time: Beg: 9:35 End: 9:45	Dist
Abalones	red abalone (size cm)	19, 22, 10, X ④	
Abalones	flat abalone (size cm)	9 ①	
Abalones	pinto abalone (size cm)		
Abalones	green abalone (size cm)		
Abalones	pink abalone (size cm)		
Abalones	Unknown abalone		
	CA spiny lobster		
Cucumbers	CA sea cucumber		
Cucumbers	warty sea cucumber		
Sea Stars	bat star ㊿	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	13
Sea Stars	short spined sea star		
Sea Stars	giant spined star	𝍸 II ⑦	
Sea Stars	sun/sunflower star	II ②	
Slugs/snails	chestnut cowry		
Slugs/snails	Kellet's whelk		
Slugs/snails	wavy / red turban snail		
Slugs/snails	giant keyhole limpet	③	
Crabs	rock crab		
Crabs	sheep/masking crab		
	gumboot chiton	3, 4 ⑦	
	rock scallop		
	large anemone (>10cm)	4, III ⑦	
Gorgonians	brown/golden gorgonian (>10cm)		
Gorgonians	red gorgonian (>10 cm)		
Urchins	red urchin	6, 3, 11 ⑳	
Urchins	purple urchin		
Urchins	crowned urchin		
	Black ab (Y/N) N	White ab (Y/N) N	
	Other/comments		

30 x 2 m Transect **10 Minute goal**	Transect#: 4 Time: Beg: 9:47 End: 9:55	Dist
Bull kelp >30cm		
Pterygophora >30cm	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 ㊿	21
So. sea palm >30cm		
Laminaria spp >30cm >30cm	𝍸 𝍸 III ⑬	
giant kelp >1 m # stipes >1m/holdfast	45, 11, 30, 1, 2, 1, 1, 14, 75 1, 1, 2, 13 ⑬	

*Do not count seaweed used to attach transect

Sargassum muticum Yes____ No ✓

Sargassum filicinum Yes____ No ✓

Undaria Yes____ No ✓

Caulerpa Yes____ No ✓

Subsample abundant organisms: at ~50, stop counting and record distance surveyed along transect (meters)

Reef Check California **RCCA Data Sheets 2011-02-24.xlsx**

Figure 3. Example datasheet demonstrating how to record invertebrate and seaweed data during a RCCA survey.

Uniform Point Contact (UPC) Transect

The Uniform Point Contact Survey (UPC) involves collecting three types of data at points spaced in 1 meter intervals along the transect line. The data collected at each point are: 1) substrate type, 2) type of organisms covering the substrate and 3) rugosity or relief. There is a space for each point sample on the UPC datasheet (Appendix B). Record the category codes in the appropriate spaces on the datasheet. Upon completion of the dive, tally up the number of each of the codes in the space provided on your sheet. Check to ensure that substrate, cover and rugosity each total 30 points. There is no time limit for a UPC transect.

Substrate

There are many cases when the substrate type may be ambiguous and you will have to do your best to make an unbiased assessment. Please use the following guidelines to identify substrate types. Note that these may differ from other definitions with which you are already familiar.

Substrate type will be recorded as:

S - Sand/Silt/Clay (< 0.5 cm)

C - Cobble (rock and shell debris, 0.5 cm – 15 cm)

B - Boulder (> 15 cm – 1m diameter)

R - Reef (> 1m diameter)

O - Other (metal, other man-made material etc.)

Cover

Bottom cover will be determined by recording what is directly under each 1 meter point along the transect line. Ten categories will be used to record what percentage of the bottom is occupied by certain individuals. Mobile invertebrates (urchins, sea cucumbers, sea stars, etc.) should be recorded as MI. Invertebrates that cannot change location (sponges, tunicates, scallops, barnacles, etc) should be recorded as SI (Sessile Invertebrates). There are 6 categories of algae that can be covering the bottom (see below for codes). When in doubt about which color the algae is use your flash light. Please note that there are two categories for brown seaweed, Brown Seaweed (B) and Other Brown Seaweed (OB). Category B is used to describe only the five kelps that are counted during an algae transect. The OB category describes any other brown seaweed, including the brown invasives, *Undaria pinnatifida* and *Sargassum* spp. If the point falls upon any part of the alga (blade, stipe, holdfast) it should be recorded. This rule applies to all algae except category B (Brown), which should only be recorded if the point falls directly on its holdfast. Non-attached algae, or drift algae, should be moved when encountered to determine what is below. When long blades of algae are encountered it is important to determine if they are attached to the reef (accomplished by giving a gentle tug). If they are attached they will be counted and if they are not attached they will not be counted. Low profile, fuzz-like growth that you cannot physically grab and remove from the substrate should be disregarded and you should record the dominant feature below it. If the fuzz-like growth is significant enough to grab a piece from the substrate and the color can be determined, record it in the appropriate seaweed category. If the point falls on an empty shell it should be moved to record what is beneath it.

Cover will be recorded as:

N – None.

B – Brown Seaweed. Any type of the five large kelps that are surveyed on the seaweed transect (giant kelp, bull kelp, Pterygophora, southern sea palm and Laminaria spp.).

AC - Articulated Coralline Algae (Figure 8).

OB – Other Brown Seaweed. Any other type of brown seaweed including *Sargassum* spp., *Undaria pinnatifida* and *Cystoseira* (Figure 9).

G – Green Algae. Any type of algae that appears very green in color.

R – Red Algae. Any type of algae that appears red in color (other than articulated and crustose coralline algae).

CC - Crustose Coralline Algae. Only if there are no other organisms present above it (Figure 10).

SI - Sessile Invertebrates. Includes sponges, anemones, bryozoans, gorgonians, sand castle worms, barnacles, etc. (Figure 11).

MI- Mobile Invertebrates. Includes sea stars, urchins, sea cucumbers, crabs, limpets, etc (Figure 12, Figure 13).

SG- Seagrasses. Includes surfgrass and eelgrass.

Figure 4. Different types of articulated coralline algae. The keyhole limpet and purple urchin burrowed in the rock would be recorded as mobile invertebrates (Photos: C. Shuman).

Figure 5. Examples of Other Brown algae (OB) (Photos: D. Richards, M. Schwalbach, and K. A. Miller).

Figure 6. Crustose coralline algae
(Photo: C.Wisniewski)

Figure 7. The sponges (top left), bryozoans (top right) and anemone (bottom right) are examples of sessile invertebrates. Although some anemones have the ability

to slowly move locations, we will be considering the anemones that we encounter as sessile (Photos: C. Wisniewski)

Figure 8. Urchins are examples of mobile invertebrates. Flashlights help to distinguish between red urchins (left) and crowned urchins (right) which both can look black in color. Red urchins reflect back a red color and crowned urchins have a bright blue ring at the base of the spines. (Photos: C. Wisniewski)

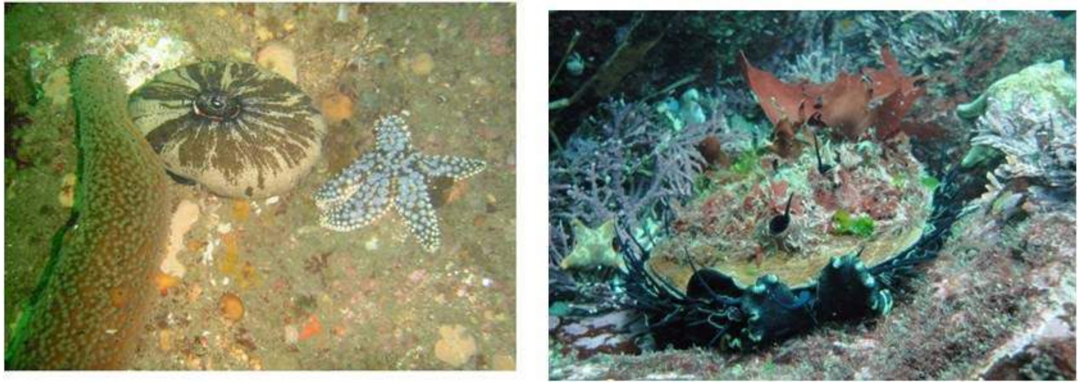


Figure 9. The sea cucumber, keyhole limpet, sea star (left photo) and red abalone (right picture) are examples of mobile invertebrates (Photos: L. Fink and M. Wehrenberg).

Rugosity

Rugosity (vertical relief) will be estimated by determining the greatest vertical relief that exists within a 1 meter by 0.5 meter imaginary box along the tape. The measured section will extend 0.5 m in front of each point and 0.5 m to either side of the tape. The height is estimated as the difference in height between the highest and lowest points within the imaginary 1 m x 0.5 m box in front of you (Figure 14). Four categories will be used to record vertical relief estimates:

Category 0: 0 – 10 cm
Category 1: > 10 cm – 1 m
Category 2: > 1m – 2 m
Category 3: > 2 m

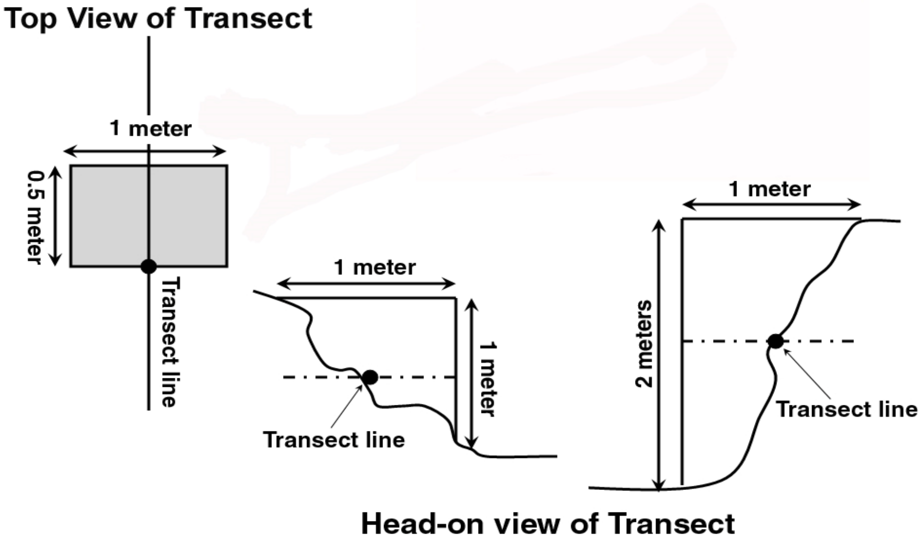


Figure 10. Physical relief is measured as the greatest vertical relief within a 1-meter wide section across the tape and .5-meter section in front of each point

Fish Transect

Reef Check California Fish Species

While the prospect of learning the 35 fish species listed in Table 3 may appear daunting, you will be surprised that with a bit of practice you will soon be a fish identification expert. Underwater fish identification will be eased by considering the following factors: habitat, behavior, size, shape, color and markings.

- **Habitat** - Is the species swimming in the mid-water or hiding under or on a rock? At what depth did you see it?

- **Behavior** - Is the fish schooling or is it alone? Does it immediately swim away when it sees you?

- **Size and shape** - There are several areas on which to focus: the body, mouth, fin shape, color and markings.

- **Body** - Does the fish have a heavy body and large lips? If so, it is probably a rockfish or a sea bass. Does it look eel-like or have an elongated body? If so, it is probably a kelp greenling or lingcod.

- **Mouth** - By looking at the mouth type and shape, you can often determine the food source (e.g., senorita and CA sheephead).

- **Fin shape** - Examine the tail and dorsal fins of the species of interest. Are they rounded, straight, forked or joined?

- **Color** - Remember that color varies dramatically and is influenced by conditions, especially light levels. The most reliable places to look for colors are the fins. The vermilion rockfish, for example, has dark edges on its fins. It is important to remember that for some species there can be significant variation between males and females (e.g., kelp greenling and CA sheephead) and between different life phases – juvenile and adult (e.g., CA sheephead, garibaldi and rockfish).

- **Markings** - Generally more distinctive than colors, markings are the bedrock of any ecologist's fish identification skill set. Pay special attention to stripes (horizontal), bars (vertical) or bands for identifying sea perch and sargo. For identifying yellowtail rockfish, olive rockfish and juvenile garibaldi, on the other hand, it is best to look for spots or blotches. Finally, fine lines or speckles along body are important to consider when identifying striped sea perch and blacksmith.

All Reef Check California fish species are pictured in Appendix C. Additional information can also be found on your flash cards that were included in your supplemental training materials.

Table 3. Species, measurement criteria and rationale of Reef Check California indicator fish species.

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 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*	Juv, 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*	*Sebastes chrysomelas*	<15, 15-30, >30	E
China rockfish*	Sebastes *nebulosus*	<15, 15-30, >30	E
yellowtail rockfish & olive	*Sebastes flavidus/Sebastes serranoides*	<15, 15-30, >30	E
copper rockfish*	*Sebastes caurinus*	<15, 15-30, >30	E
vermilion rockfish & canary	*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 (important to trophic food web), **SI** = species of interest or concern (protected, endangered, overfished, etc.)

SPECIAL NOTE: In addition to the species listed above RCCA also counts "young-of-the-year" (YOY) rockfishes (Figure 15). Another name for these newly born rockfishes is "recruits." Rockfishes have pelagic larvae that are released from the females in the kelp forest and then drift offshore on the currents until they eventually are return into nearshore waters and "recruit" back to the kelp forest to grow into adults. The timing of the release of larvae and the duration of their pelagic stage varies by species. Generally juveniles are released in the early spring to fall and are in the pelagic stage from 1- 6 months depending on the species (Love e al. 2002). It is difficult for even the most highly trained scientists to differentiate YOY rockfish species when they are < 10 cm. As an RCCA certified diver you will be asked to identify small individuals (greater than 2.5 cm) that clearly have a rockfish body shape but with coloration and/or markings that differ from adults and record them as YOY on your datasheet. Even if you can identify YOYs to species do not record them under the respective species but as the YOYs on your datasheet.

©Lonhart

©Ben Troxell

©Tom Laidig

Lonhart / SIMoN NOAA.

Figure 11 Various young-of-the-year (YOY) rockfish species.

In addition to the species descriptions found in the supplemental training materials and in Appendix C, we recommend investing in a quality fish identification guide. Some of our favorites include:

Gotshall, D. W. 2001. Pacific Inshore Fishes, Fourth Edition (Revised). Sea Challengers, Monterey, California.
Allen, L.G., D. J. Pondella II, and M. H. Horn (eds) 2006. The Ecology of Marine Fishes. California and Adjacent Waters. University of California Press, Berkeley, California.
Eschmeyer, W. N. and E. S. Herald. 1983. A Field Guide to Pacific Coast Fishes North America (A Peterson Field Guide). Houghton Mifflin Co, Boston / New York.
Humann, P. 1996. Coastal Fish Identification Guide: California to Alaska. New World Publications, Jacksonville, Florida.
Love, M. S., M. Yoklavich, and L. Thorsteinson 2002. The Rockfishes of the Northeast Pacific. University of California Press, Berkeley, California.
Love, M. 1996. Probably more than you want to know about the fishes of the Pacific coast. Really Big Press, Santa Barbara, California.

Visibility check
You must measure visibility to ensure you have the > 3 m visibility required to survey fish. To perform a visibility check, your buddy stays stationary, holds the free end of tape in one hand (preferably wearing a black glove) and displays their other hand away from their body with their five fingers spread wide. You take the reel end of the tape and swim out until you can no longer make out the individual fingers on your buddy's hand. Then, reel in just slightly so you can clearly see each finger. Record on the datasheet the furthest distance from your buddy at which you can clearly make out each individual finger. If when you enter the water it is obvious that you have > 3 m visibility, then the visibility measurement should be done after you complete your assigned transects. If you have any doubt about the visibility perform the measurement prior to starting the survey and then make sure to move at least 5 m before beginning your transect.

Fish are surveyed along a 30 m transect in an area 2 m across the transect tape and 2 m off the bottom (30 x 2 x 2 m = 120 m3). We require that fish are surveyed while the transect is being deployed in order to minimize disturbance to fish and potential bias to counts. The maximum water column height above the transect to record fish is restricted to 2 m. RCCA divers will swim the fish survey as a buddy team. However, **ONLY** the diver deploying the transect (primary) will be conducting the fish survey count. The diver that is not deploying the transect tape (secondary) shall be responsible for:

- Staying well behind the bubble stream of the first diver and out of that diver's field of vision
- Maintaining close enough contact to assist in an emergency
- Evaluating the survey technique (e.g. speed, ensuring the diver is looking in all crevices as well as surveying the midwater, direction, etc.)

The secondary diver is a crucial part of the quality control program for Reef Check and should make notes on their data board to give feedback to the primary diver on the surface when reviewing the datasheets after the dive.

The first and last things to do during a fish survey are record starting and ending times and depths. When recording fish, swim at an approximate speed of 3 - 6 meters per minute. Flashlights are required on the fish survey, but you must be diligent to only use your flashlight to look in holes and then turn it off, as the light can be an attractant to fish. During your swim, you must observe fish in the water column < 2 m above the substrate and stop to examine the substrate to search for sedentary, solitary and hidden species. Be sure to look in cracks and crevices, but not so much that it takes more than 10 minutes to complete the survey. The time is to be used as a guide to help define your search pattern. Simple flat habitats should be surveyed quicker than highly complex habitats. Finally, remember to never count fish that come from behind you or individuals that you see on subsequent transects that you may have "missed". Divers will also size and record the presence of giant black sea bass (*Stereolepis gigas*) seen anywhere during the survey (on or off transect), though it should be recorded in the comments whether or not it was seen on transect.

Each 30 meter transect should take from 5 to 10 minutes to complete.

For many divers it is helpful to think of your survey as a series of moving windows. Try to maintain a uniform size of your window by using landmarks and by taking mental snapshots of mobile shoaling species in your window. It is helpful to consistently look ahead but not too far ahead (~ 3 m). Remember that your window is constantly moving forward.

If you run into a large school of fish here are some tips to counting:

- Count by twos.
- Estimate an arbitrary portion of school and then the total number by judging how many of those “portions” comprise the school.

The most important part of your survey is that estimates are consistent between different surveys, sites and observers.

Sizing Fish

Before discussing how to size fish underwater, we must have a picture of what we are measuring. For the purposes of Reef Check California, we will be measuring total length, which is simply the total length of a fish from the mouth to the tip of the tail (Figure 16).

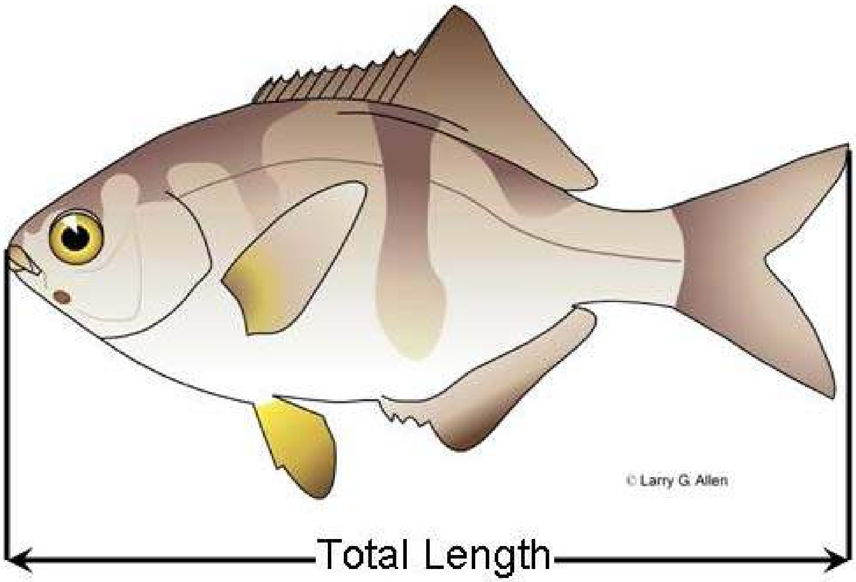


Figure 12. Total length of fish, in this case a pile perch, is measured from mouth to tip of tail (Illustration © Larry G. Allen).

During a RCCA fish transect you will be sizing individual fish to the nearest centimeter. Once you have identified the species of an individual, you will estimate its size. Estimating sizes of moving fish underwater requires much practice and is probably one of the most difficult things you will be tasked with during a survey. Nevertheless, after initial practice, size estimates should become very accurate (see aids to sizing below). The goal is to estimate the size of each individual to the nearest centimeter, but often this can be challenging, especially if schools of fish are present. In this case, it is possible to bracket the size of a group of fish and write down the largest and smallest size and the number of individuals in the group. For example, if a school of 10 blue rockfish is present and the largest fish is 15 cm and the smallest is 9 cm, you would record: 10 blue rockfish 9-15 cm (for details on how to record this on the datasheet, see section: Recording Fish Transect Data). Young-of-the-year rockfish (YOYs) are not sized but their number is recorded under “YOY” on your datasheet.

Quite possibly the single most difficult problem in estimating size underwater is to compensate for the magnifying effect of water. Objects appear to be closer and larger underwater. This phenomenon, known as Snell's Law of Refraction, is caused by the refraction of light moving from one medium (water) to another (air inside your mask), and the differing speed of light in the varying media. The amount of refraction (i.e., magnification) is affected by depth, available light, turbidity, the distance of the object to your mask faceplate and even the distance of your faceplate to your eye. As a general rule, however, objects appear 33% larger (which is 4/3 magnification) or 25% closer.

There are several specific factors that contribute to an **underestimation of fish size**:

- Low light

- Poor visibility
- Dull body color
- Objects in foreground
- Deep-bodied or “fat” fish. Pay special attention to species with abnormal proportions of length to height (e.g., garibaldi or black sea perch).

Conversely, there are several specific factors that lead to an **overestimation of fish size**:

- Bright light
- Good visibility
- Bright body color
- Objects in background
- Skinny or elongate fish. Pay special attention to species with abnormal proportions of length to height (e.g., lingcod or senorita).

Aids to sizing

Fortunately, there are several tricks you can use to improve your sizing estimates. The most straightforward is to **measure the span of your hand**. Armed with this information you will be able to begin to develop an idea of size underwater. Another trick is to put easy-to-read marks on your **data slate**. This will give you an idea of exact sizes underwater. Further, you can employ a technique called **bracketing** to help you practice. Bracketing works as follows: you identify a fish sitting on a rock and estimate its size while noting the features on the rock at the head and tail of the fish. You then approach the rock, and (if the fish swims away) measure the distance between the features on the rock/substrate.

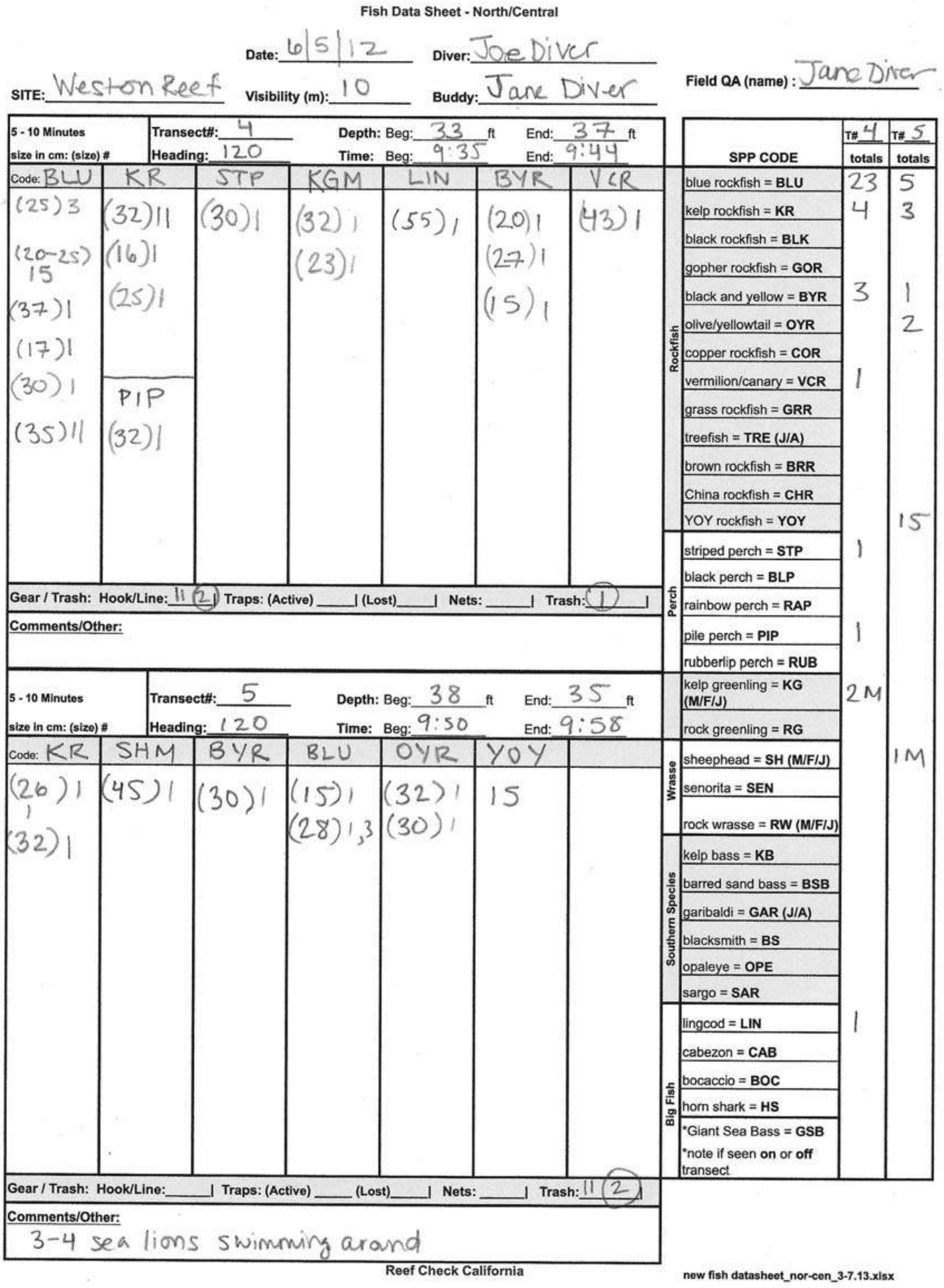
Another helpful practice is to estimate the size of non-moving objects or organisms (e.g., sea stars, sea cucumbers) then approach them and measure their size with your slate. After you measure, note if your estimate was below or above the measured size and adjust your estimation before you repeat this process. Doing this before every fish transect on your way to the transect start location will greatly increase your ability to estimate fish sizes accurately.

Recording Fish Transect Data

When counting and sizing fish on transect it is important to record and tally data in a standardized way. With each species seen on transect you record the species code in the grey “code” box on the datasheet. The code for each species can be found in the column on the right. Under the code record the size to the nearest centimeter of each fish seen, putting parentheses around the size estimate. If you ever see additional fish of the same size of that particular species you can put tick marks (III) or the actual number seen (3) next to the recorded size. If you see only one fish of a particular size you must put one tick mark next to the size. If it is not possible to record individual sizes of fishes in a large school, record the size range of the group of fish in parentheses and the number of individuals in that group next to it. There are seven columns on the datasheet for recording individual species during a fish transect. If you find more than seven species on a transect you can split a column by drawing a horizontal line (see Figure 17 for an examples of how to record fish data).

Once you have finished the survey and you are out of the water you must tally up your datasheet. Count the total numbers of individuals of each species and record them in the “transect total” column on the far right of the datasheet. This is also the time to check to make sure that you wrote the correct species codes in the code boxes and to ensure that all sizes and numbers are legible and clear.

Once you have completed your datasheet in this way have it reviewed by another team member and discuss any observations that seem uncommon or unusual to you. Have the reviewer write his/her name in the ‘Field QA’ field on top of the datasheet after all issues have been discussed and resolved.



Fish Data Sheet - North/Central

Date: 6/5/12
Diver: Joe Diver
SITE: Weston Reef
Visibility (m): 10
Buddy: Jane Diver
Field QA (name) : Jane Diver

5 - 10 Minutes
size in cm: (size) #
Transect#: 4
Heading: 120
Depth: Beg: 33 **ft** **End:** 37 **ft**
Time: Beg: 9:35 **End:** 9:44

Code: BLU	KR	STP	KGM	LIN	BYR	VCR
(25)3	(32)11	(30)1	(32)1	(55)1	(20)1	(43)1
(20-25) 15	(16)1		(23)1		(27)1	
(37)1	(25)1				(15)1	
(17)1						
(30)1	PIP					
(35)11	(32)1					

Gear / Trash: Hook/Line: 11 ② | **Traps: (Active)** ____ | **(Lost)**____ | **Nets:** ____ | **Trash:** ①

Comments/Other:

5 - 10 Minutes
size in cm: (size) #
Transect#: 5
Heading: 120
Depth: Beg: 38 **ft** **End:** 35 **ft**
Time: Beg: 9:50 **End:** 9:58

Code: KR	SHM	BYR	BLU	OYR	YOY	
(26)1	(45)1	(30)1	(15)1	(32)1	15	
(32)1			(28)1,3	(30)1		

Gear / Trash: Hook/Line:____ | **Traps: (Active)** ____ **(Lost)**____ | **Nets:** ____ | **Trash:** 11 ②

Comments/Other:
3-4 sea lions swimming arand

	SPP CODE	T# 4 totals	T# 5 totals
Rockfish	blue rockfish = **BLU**	23	5
	kelp rockfish = **KR**	4	3
	black rockfish = **BLK**		
	gopher rockfish = **GOR**		
	black and yellow = **BYR**	3	1
	olive/yellowtail = **OYR**		2
	copper rockfish = **COR**		
	vermilion/canary = **VCR**	1	
	grass rockfish = **GRR**		
	treefish = **TRE (J/A)**		
	brown rockfish = **BRR**		
	China rockfish = **CHR**		
	YOY rockfish = **YOY**		15
Perch	striped perch = **STP**	1	
	black perch = **BLP**		
	rainbow perch = **RAP**		
	pile perch = **PIP**	1	
	rubberlip perch = **RUB**		
	kelp greenling = **KG (M/F/J)**	2M	
	rock greenling = **RG**		
Wrasse	sheephead = **SH (M/F/J)**		1M
	senorita = **SEN**		
	rock wrasse = **RW (M/F/J)**		
Southern Species	kelp bass = **KB**		
	barred sand bass = **BSB**		
	garibaldi = **GAR (J/A)**		
	blacksmith = **BS**		
	opaleye = **OPE**		
	sargo = **SAR**		
Big Fish	lingcod = **LIN**	1	
	cabezon = **CAB**		
	bocaccio = **BOC**		
	horn shark = **HS**		
	*Giant Sea Bass = **GSB** *note if seen **on** or **off** transect		

Reef Check California

new fish datasheet_nor-cen_3-7.13.xlsx

Figure 13. Example datasheet, demonstrating how to record fish data during a RCCA survey.

Fishing Gear and Trash Observations

In order to record the amount of marine debris and lost or active fishing gear on rocky reefs, we will count any fishing gear and debris that falls within our 2 meter swath on all fish transects (18 transects). If any part of this gear or trash is within your swath (e.g. the edge of a lobster trap or a piece of monofilament line), it will be counted. Fishing gear that is attached to fish that are recorded on transect (e.g. hook in mouth, trailing line) will also be recorded. Fishing gear and other objects will be broken down into four categories:

Hook and line (recreational fishing tackle) - includes hooks, lures, bobbers, sinkers, fishing rods and fishing line, etc. This category also encompasses boat anchors, anchor line, spear fishing gear, including spears, tips and guns (if gear is recorded it should be noted in the comments section what was found).
Traps - includes both abandoned (recorded as 'lost') and active (recorded as 'active') traps. Broken and deteriorated traps (i.e., parts of traps) will also be counted. Lobster hoop nets will fall into this category since they serve the same purpose as a trap.
Nets - includes full nets or pieces of net material.
Trash - includes anything manmade that was lost or tossed into the ocean and that doesn't fall into one of the fishing gear categories such as plastics, bottles, cans, metal, ropes, etc. (if trash is recorded it should be noted in the comments section what was found).
Each item from the above categories that is encountered on a fish transect will be recorded on the fish data sheet as a tick mark in its respective category (Figure 17). After the dive once you have tallied your fish counts you can tally and circle the total number of each fishing gear and trash observation.

Urchin Size Frequency Survey

Where a sufficient number of urchins are present, 100 individuals of both red and purple urchins should be sized using calipers (Figure 18). **This can be done anywhere at the site and is not associated with a transect. Urchin surveys are performed once per year, during the fall survey only).** It is important that you get a representative sample of the urchins at the site and not just count those that are accessible and of a particular size. You may need to gently clear small plots to ensure you don't double count and to ensure you measure ALL of the first 100 urchins you encounter. If you begin an urchin survey but are not able to count 100 urchins of each species by the end of the dive make sure to turn in your data anyway.

Figure 14. Figure 15. Urchin sizing with calipers (Photo: N. Fash, www.fashpics.com).

The Forum and Scheduling a Survey

Once you are certified as a Reef Check California diver, you can take part in surveys throughout California. The Reef Check website is the primary tool for you to connect with your fellow divers. The Reef Check California Online Forum (http://forum.reefcheck.org) has been designed to allow you to sign up for as well as schedule survey dives and sort out survey logistics. Each thread in the Forum should pertain to a specific proposed survey location and date. The RCCA Certified Diver Forum is split into two sub-Forums: Nor/Cen California and Southern California. These allow you to quickly focus in on upcoming events in your region. During your course you will automatically be directed to register for the Forum and sign up to receive a weekly digest showing recent posts. You can modify your profile settings by selecting User Control Panel. You can modify your digest settings by selecting Digests. You can unsubscribe to the Forum by sending an email with "UNSUBSCRIBE FORUM" in the subject line to rcinfo@reefcheck.org.

- The naming convention for each thread should contain the survey region, site name and date (e.g., Monterey – Breakwater, 10/1/08). You will receive an update from the survey organizer on the Forum about conditions so it is important you check the Forum thread for updates after you are sign up. You will not receive updates to your personal email in most cases. Your Regional Program Manager and Volunteer Coordinator will assist you with overall dive planning. The website allows you to recruit fellow divers to help complete the survey.
- RCCA staff does NOT need to be present for you to conduct a survey though someone must be acting as data captain and will be in charge of overseeing the survey and data collection.

Data Captain

When a survey is being proposed and posted on the Forum it is essential to designate a team leader, also known as the data captain. This individual will coordinate with the Regional RCCA Staff. The Data Captain is responsible for:

- Logistics (checking weather conditions, parking permits, etc.)
- Making sure the team has sufficient blank datasheets to complete a survey
- Team survey assignments, including transect locations
- Collection and review of datasheets after each dive
- Ensuring all data are entered into the online database and the original datasheets are submitted to the Regional Program Manager

- Data Captain's usually have 1 year of survey experience before filling this role. There are numerous planning resources available for the Data Captain that can be obtained by contacting your regional RCCA staff.

Each Diver is Responsible for Their Own Safety!

Every diver must take full responsibility for their own safety at all times, including the decision whether or not to dive. The data captain does not assume responsibility for safety on the survey. Each diver assumes individual responsibility for their own safety at all times.

Site Description Form

The data entered on the Site Description Form helps put the survey data into context – it is therefore essential in helping us interpret what we see underwater. **The Site Description Form (Appendix B) should be started before the survey begins and completed immediately following the dives on the first day of the survey.**

Record the location of your site on the Site Description Form using the following methods:

- Global Positioning System (GPS) – preferred
- Maps or nautical charts
- GIS software such as Google Earth (www.earth.google.com). Google Maps can also generate lat/long coordinates.

Basic Information

Site Name: If you are the first team to survey a location, use the common name used for the site and if there is not one, you can name the site anything you like. Otherwise, you must use the name that was formally given to the site. If you are unsure, please contact the Regional Program Manager to determine if you are the first team to survey a site.

County, City/Island: Please be as descriptive as necessary. If you are located on an island, please record the island name as the city. If the island has a city on it record the city name, island name (Avalon, Santa Catalina).

Latitude/Longitude: Record the coordinates in decimal degrees. Remember, latitude is measured as north and south and longitude is measured as east and west. All surveys in California should be north latitude and west longitude, at least for the next couple million years.

Date: For each survey spanning more than 1 day to complete, record the date you started the first transect and the date the final transect was completed. Each survey should be completed within a **four week** time span from the first to the last transect.

Weather: Indicate the general weather conditions that prevailed over the sampling period. If the surveys were conducted over multiple days, record the weather condition that was most representative of average conditions.

Temperature: Temperature is an important component of any survey. Please record the temperature on the surface and in the water during each survey. Record the 10 m temperature at the end of the first transect at that depth and record the 5 m temperature at the end of the safety stop. A conversion calculator is provided in NED to convert the temperature you record from Fahrenheit to Celsius. If the surveys were conducted over multiple days, use a representative water temperature for the survey period (e.g. an average).

Distance and Depth: The approximate distance from shore and average depth of the site should be recorded in meters. While distance and depth can be extremely variable for a given site, please do your best to estimate a distance and depth that accurately characterizes the reef you are surveying.

Exposure and Storms: When analyzing data, it is important for us to ensure we are comparing reefs of similar types to each other. As you can imagine, highly exposed reefs are likely to exhibit different physical and biological characteristics than fully sheltered reefs. Record whether the site you are surveying is always sheltered, sometimes sheltered or exposed. An example of a reef that is sometimes sheltered would be one that is only exposed to swells and/or storms a certain time of year (i.e. exposed to winter swells out of the north, but sheltered from summer swells out of the south). Recent storms provide additional insight into recent physical disturbances that may have affected your survey site. **Recent is defined as within the previous 4 weeks** and is a storm that was accompanied by significant wind, waves and/or rain.

Transects completed: Ideally, all transects should be completed for each survey and all errors corrected by repeated surveys. If for some reason your team is unable to complete all the required transects or there are errors in the data that could not be corrected, than they should be noted here.

IMPORTANT: Please record the name of the team member who submitted the data (usually the team leader/data captain), the name of the team member who checked the data and list the names and of all team members. **Team members should be indicated by their full name (*e.g.*, John Diver).** Also please be consistent with first name usage (*e.g.*, use full legal name, no nicknames - Bill Golden should be William Golden). **It is extremely important that team member names are recorded and entered consistently and correctly. If not, the names will not match the names of certified divers in our database or you will not be able to enter the data in NED.**

Before You Jump in the Water

Prepare all necessary equipment

Prepare and distribute all equipment used during a Reef Check survey as follows:

GPS or nautical chart: to mark position of survey.

Transect Lines: we recommend using a 30 m fiberglass measuring tape with a hand crank. We also recommend that you wrap a piece of stiff wire around the free end to secure it to kelp or rocks and add small pieces of tape around the transect tape at each meter mark to make the points easier to find during the UPC surveys (Figure 19).

Slates/Underwater Paper: we require that teams use pre-printed underwater paper and the sandwich-type PVC slates.

Pencils: to record data on underwater paper (graphite, golf or plastic pencils work best).

Permanent markers: for labeling slates and equipment.

Buoys: to mark beginning and end of transect line (safety sausages work best though they can be made from empty plastic bottles).

All required gear for safe diving.

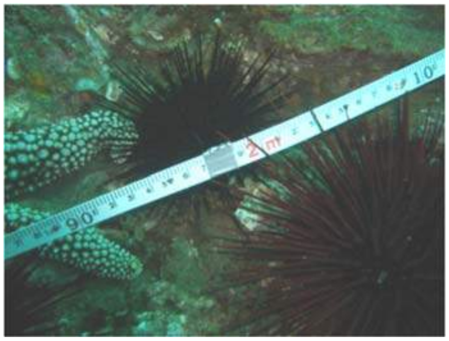


Figure 16 One-meter intervals marked with tape on transect line. This practice is especially important when the transect tape does not have meters marked on both sides (Photo: G. Hodgson).

Prepare datasheets

It is important to complete the Site Description Form including the Global Positioning System (GPS) coordinates of your survey site **prior** to beginning the survey. Record the names of the team leader/data captain and team members as well as the date and site name on the site description sheet.

Prepare the datasheets and ensure that you have sufficient slates and underwater paper for all team members. The number of slates and sheets will depend on the number of people in your team. Datasheets should be allocated prior to the dive and every member should have a datasheet to complete his or her portion of the survey.

It is imperative that you fill out ALL of the descriptive fields on your datasheet:

- Date
- Site name
- Transect number
- Depth start and stop for each transect
- Diver and Buddy names
- Transect start and end times. **All** surveys should be performed anytime 2 hours after sunrise through 2 hours before sunset. If you are using your dive timer instead of a watch, indicate the approximate time of day the transect took place on your datasheet after you surface (see Appendix B).
- Visibility – the distance where one can no longer clearly count your buddy's fingers on an open hand held away from the body (3m visibility is required to conduct fish surveys).

Assign team members to survey tasks

There are many acceptable ways to divide up the survey tasks depending on the skills of the team members and team size. Not all team members will be qualified to complete all types of surveys. Some team members will feel more comfortable recording fish or invertebrates and others will just want to serve as buddies. Because each team will be different, the data collection strategy should be adjusted to match the ability and experience of the team. The best quality data will be obtained by having an experienced team leader/data captain assign tasks appropriate for each team member. The team leader /data captain must ensure that every team member understands their assignment and is capable of performing out properly. We recommend pairing up experienced Reef Checkers with those with less experience.

Team leaders assign survey tasks to buddy pairs, including transect numbers, potential location, predetermined depth ranges and compass headings.

Each team member must record on their datasheet, as well as notify the team leader, when reliability of data from a transect are in question. When this occurs, the Regional Manager will review the data and consult with the survey team to ensure the validity of the data before including them in the database.

Deploying the Transects

Core Transects

For each of the six core transects (3 inshore and 3 offshore) you will conduct 4 different surveys:

1. Fish
2. Invertebrate

3. Seaweed
4. UPC

Given that you will perform multiple surveys on these transects, we recommend you secure the end of the transect with a wire, a clip or small weight to ensure the transect end does not become free before all the surveys are completed (Figure 20).

Be sure to deploy the transect parallel to the selected depth contour. Please note that it is extremely easy to bias the direction of your transect towards features or fish. Maintaining the pre-assigned compass heading helps minimize bias. If you are deploying a transect on a pre-determined bearing and encounter > 10 m of sand, alter your bearing to get back on to rocky reef substrate. If you do not pass any kelp and/or rocky substrate (bedrock or boulders) coming up through the sand in < 10 m, void the transect and redeploy once you have found the reef again. On the other hand, if you encounter algae emerging from the sand frequently this suggests you are surveying rocky reef habitat that has been recently covered with sand and you should continue your transect according to your heading. If you encounter a very large boulder or anything greater than 4 m tall, alter your course and contour around the object at the average depth of your transect. After going around the object, continue back onto your predetermined heading. If the object you encounter does not cause you a > 4 m depth change, simply stay on bearing and go over the top of it. The fish transect survey window should always be 0 – 2 m off the bottom unless the transect is along a wall in which case the height should be 2 m above the transect line. Although you will be surveying up to 2 m off the bottom you should be located towards the bottom of the survey window remembering to look up frequently to survey midwater species. Should you encounter a large crack or crevice beneath your transect that is too small to swim into, count all organisms within the crack that are also within the 2 m wide swath around the tape. If it is a large enough crevice to swim through and does not change depth more than 4 m, you can follow the contour according to your heading, staying close to the seafloor. Be sure to count only fish found up to 2 m off the bottom. If the transect is placed under an overhanging ledge, do not count the organisms on the underside or on top of the ledge. Be sure that your deepest transect is no deeper than 18 meters (60 ft).

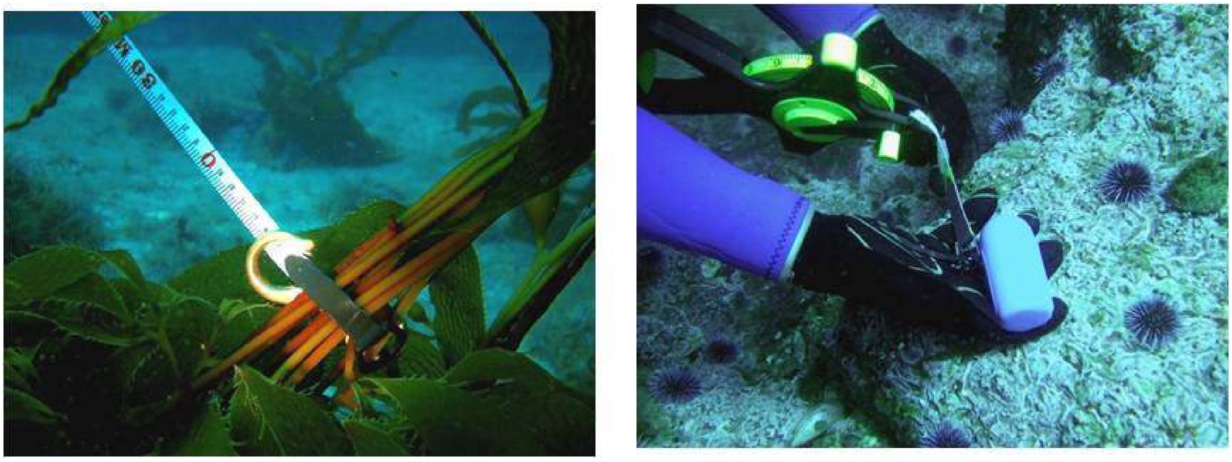
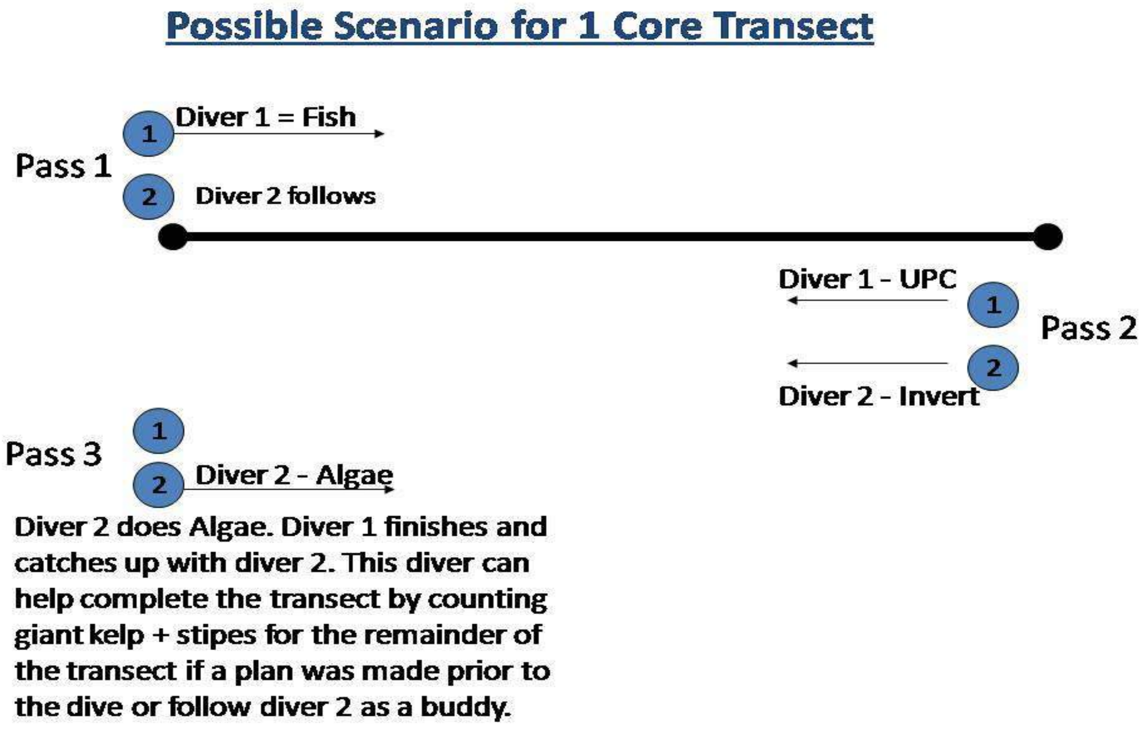


Figure 17. . Two ways of anchoring core transect : either with a clip or with a two pound weight (Photos: N. Flash, www.flashpics.com).

Although there are many acceptable ways for a buddy pair to allocate the tasks to complete a core transect, one of the most common ways used by our divers is shown below. REMEMBER safety is the number one concern when discussing allocation of tasks during a survey and completing the survey underwater. Discuss in detail which tasks will be done by each diver and make sure all proposed actions fall well within safe diving standards of both divers in the buddy team.



Diver 2 does Algae. Diver 1 finishes and catches up with diver 2. This diver can help complete the transect by counting giant kelp + stipes for the remainder of the transect if a plan was made prior to the dive or follow diver 2 as a buddy.

Deploying Fish Transects

The core fish transects and all fish only transects will be 30 m in length and will survey an area 2 meters wide by 2 meters high along the transect. Each transect will begin by a buddy pair swimming to their assigned section of the site area. They reach a predetermined depth range at which the transect is deployed at a fixed heading. Ideally, starting points will be randomly selected in an area where you have thirty meters of contiguous rocky reef. It is important that the fish only transects do not overlap and care must be taken to not double count fish that may be following the surveyors.

Twelve gauge copper wire or alligator clips are recommended for temporarily anchoring the end of the transect to a rock or bunch of kelp stipes (Figure 21). This provides enough “hold” to keep the end of the transect affixed for the duration of the survey but allows you to free the end by gently tugging on the transect line. You can then wind up the tape and continue on with the next transect. Caution must be used to not damage any delicate organisms or the transect line with this method.

Figure 18 Twelve gauge wire and alligator clip anchoring Fish Only Transects (Photos: N. Fash, www.fashpics.com and G. Hodgson).

Buddy Pairs

Because fish are easily perturbed, the fish transect is the first survey conducted. Reef Check California divers will swim the fish surveys as a buddy team. However, **ONLY** the diver laying out the transect (primary) will be conducting the fish survey count.

The primary diver shouldn't be much more that a slate's length off the bottom (~35 cm) and the backup diver should be directly above and behind the primary diver's bubble stream. It may be helpful for the backup (secondary) diver to gently touch the primary diver's tank to maintain proper positioning (Figure 22). The backup diver should **NEVER** be in front of the bubble stream of the first diver and in no way interfere with the primary diver's field of vision.

The diver not laying out the transect tape (secondary) shall be responsible for:

- Staying well behind the bubble stream of the primary diver and out of his/her field of vision
- Maintaining close enough contact to assist in an emergency
- Evaluating the survey technique (e.g., speed, direction, depth, search pattern, etc.)

The secondary diver is a crucial part of the quality control program for Reef Check California. He/She should make notes on their slate to give feedback to the primary diver on the surface when reviewing datasheets after the dive.

Figure 19. Divers showing the proper positioning for fish transects. The primary diver is responsible for laying the transect and denoting the survey area while staying close to the bottom. The backup diver is just above the primary diver and just behind the bubble stream (Photo: B. Field).

For the seaweed transects only, teams can elect to split up the species being counted – one buddy would count giant kelp plants and stipes while the other buddy would count all the other seaweed species. After the dive, the buddy team would reconcile their data sheets so all the seaweed data is on one sheet and the other sheet is voided. Or, one person can choose to perform the entire seaweed count on their own. DIVERS ARE NOT ALLOWED TO EACH COUNT ONE SIDE OF THE TRANSECT. When splitting a seaweed survey, divers must pay special attention to ensure subsampling is not done incorrectly.

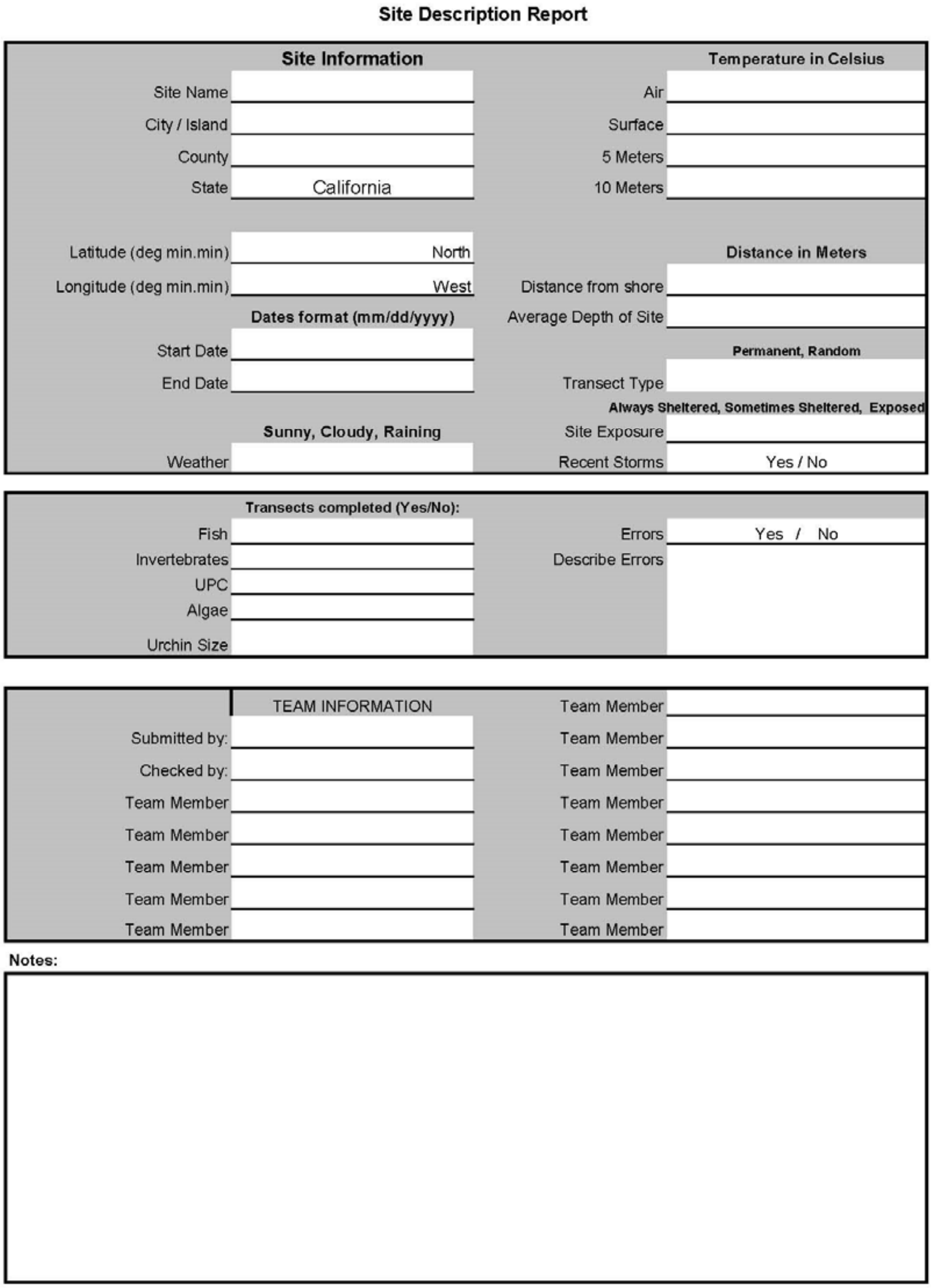
For invertebrate and UPC transects, one diver **must perform an entire transect individually** – i.e. there is no splitting those counts. An easy method for staying together on the line is to have one buddy do the invertebrate survey while the other follows completing the UPC survey.

Care and Maintenance of Research Equipment: Research equipment is no different than the rest of your gear. Before each dive, be sure it is in working order and rinse it off with fresh water after every dive.

Recording Data and Ensuring Quality

You are becoming part of a unique and dedicated group of individuals. Once you are certified as a Reef Check California diver you will have become a citizen-scientist. The most important things you do as a citizen-scientist is to collect and record data. We have talked about the potential biases that we mitigate through training, practice and standardization and you will be entrusted with the quality of the data you collect. The quality of the data is the foundation of the RCCA program and must be ensured from start to finish. It is your responsibility to not only record accurate data but to record data in a way that ensures that it is entered in the database correctly. Therefore, data has to me recorded in a legible fashion so that other can enter it into the database. It is good practice to have someone else at the survey read your datasheet to insure that all entries are clear and unambiguous.

Datasheets
Site Description Form



Site Description Report

Site Information

Site Name
City / Island
County
State California

Latitude (deg min.min) North
Longitude (deg min.min) West

Dates format (mm/dd/yyyy)

Start Date
End Date

Sunny, Cloudy, Raining

Weather

Temperature in Celsius

Air
Surface
5 Meters
10 Meters

Distance in Meters

Distance from shore
Average Depth of Site

Permanent, Random

Transect Type

Always Sheltered, Sometimes Sheltered, Exposed

Site Exposure
Recent Storms Yes / No

Transects completed (Yes/No):

Fish
Invertebrates
UPC
Algae
Urchin Size

Errors Yes / No
Describe Errors

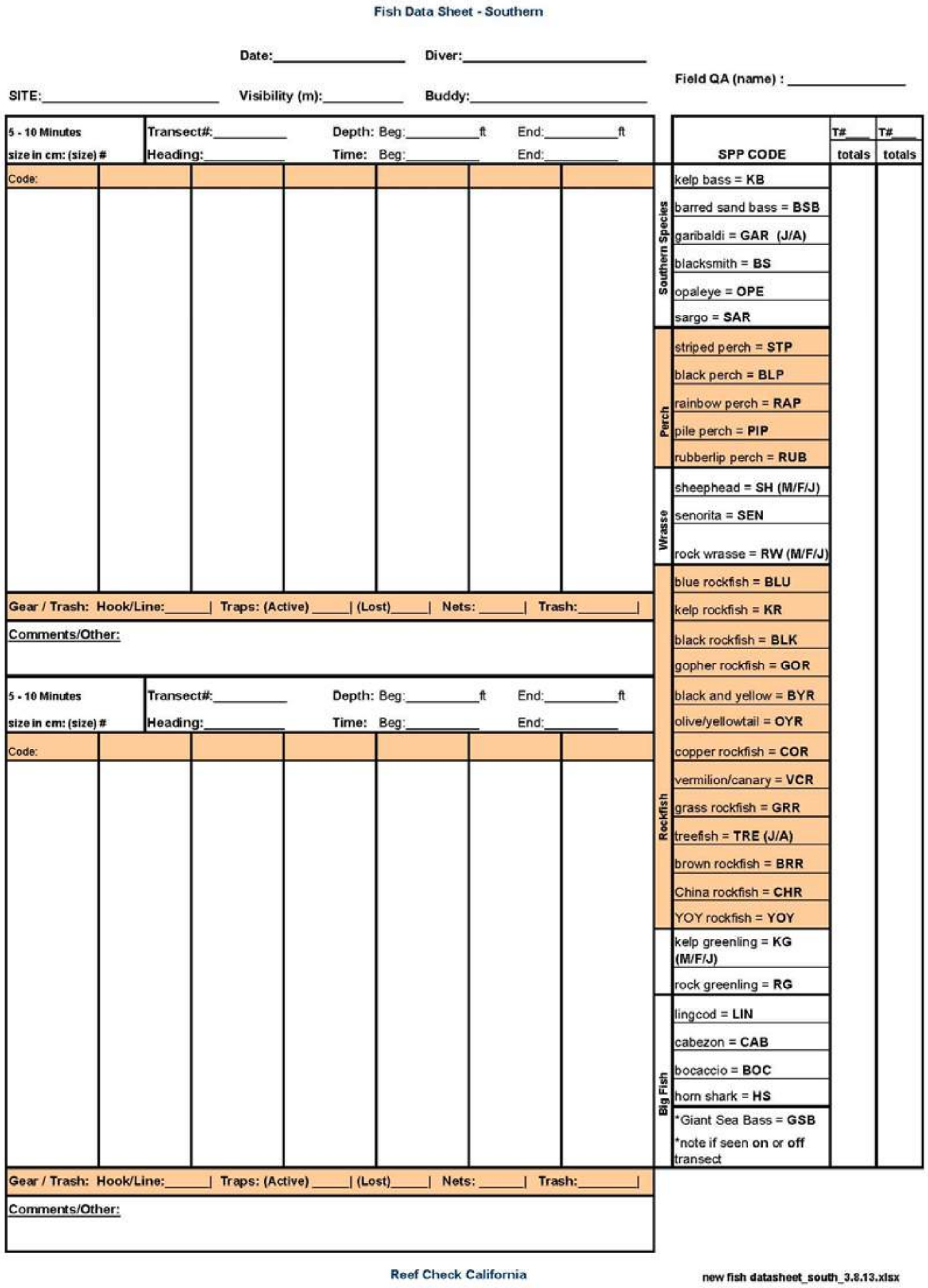
TEAM INFORMATION

Submitted by:
Checked by:
Team Member
Team Member
Team Member
Team Member
Team Member

Team Member
Team Member
Team Member
Team Member
Team Member
Team Member
Team Member
Team Member

Notes:

Fish Datasheet-Southern



Fish Data Sheet - Southern

Date:________________ **Diver:**____________________

Field QA (name) : ______________

SITE:____________________ **Visibility (m):**__________ **Buddy:**____________________

5 - 10 Minutes **Transect#:**__________ **Depth:** Beg:__________ft End:__________ft

size in cm: (size) # **Heading:**__________ **Time:** Beg:__________ End:__________

Code:

Gear / Trash: Hook/Line:______| **Traps: (Active)** _____| **(Lost)**_____| **Nets:** ______| **Trash:**________|

Comments/Other:

5 - 10 Minutes **Transect#:**__________ **Depth:** Beg:__________ft End:__________ft

size in cm: (size) # **Heading:**__________ **Time:** Beg:__________ End:__________

Code:

Gear / Trash: Hook/Line:______| **Traps: (Active)** _____| **(Lost)**_____| **Nets:** ______| **Trash:**________|

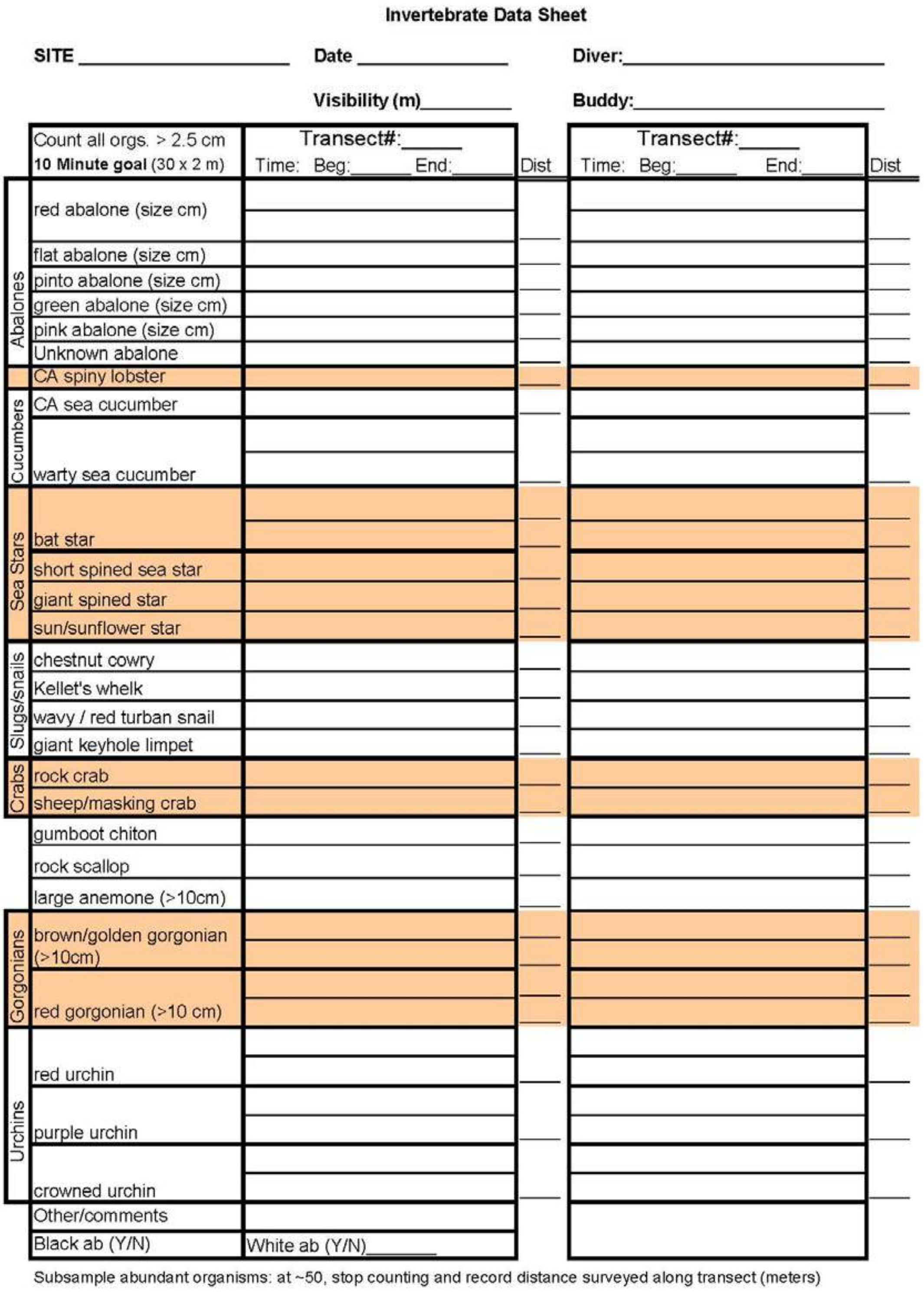
Comments/Other:

	SPP CODE	T#____ totals	T#____ totals
Southern Species	kelp bass = **KB**		
	barred sand bass = **BSB**		
	garibaldi = **GAR (J/A)**		
	blacksmith = **BS**		
	opaleye = **OPE**		
	sargo = **SAR**		
Perch	striped perch = **STP**		
	black perch = **BLP**		
	rainbow perch = **RAP**		
	pile perch = **PIP**		
	rubberlip perch = **RUB**		
Wrasse	sheephead = **SH (M/F/J)**		
	senorita = **SEN**		
	rock wrasse = **RW (M/F/J)**		
Rockfish	blue rockfish = **BLU**		
	kelp rockfish = **KR**		
	black rockfish = **BLK**		
	gopher rockfish = **GOR**		
	black and yellow = **BYR**		
	olive/yellowtail = **OYR**		
	copper rockfish = **COR**		
	vermilion/canary = **VCR**		
	grass rockfish = **GRR**		
	treefish = **TRE (J/A)**		
	brown rockfish = **BRR**		
	China rockfish = **CHR**		
	YOY rockfish = **YOY**		
	kelp greenling = **KG (M/F/J)**		
	rock greenling = **RG**		
Big Fish	lingcod = **LIN**		
	cabezon = **CAB**		
	bocaccio = **BOC**		
	horn shark = **HS**		
	*Giant Sea Bass = **GSB** *note if seen **on** or **off** transect		

Reef Check California

new fish datasheet_south_3.8.13.xlsx

Invertebrate Datasheet



Invertebrate Data Sheet

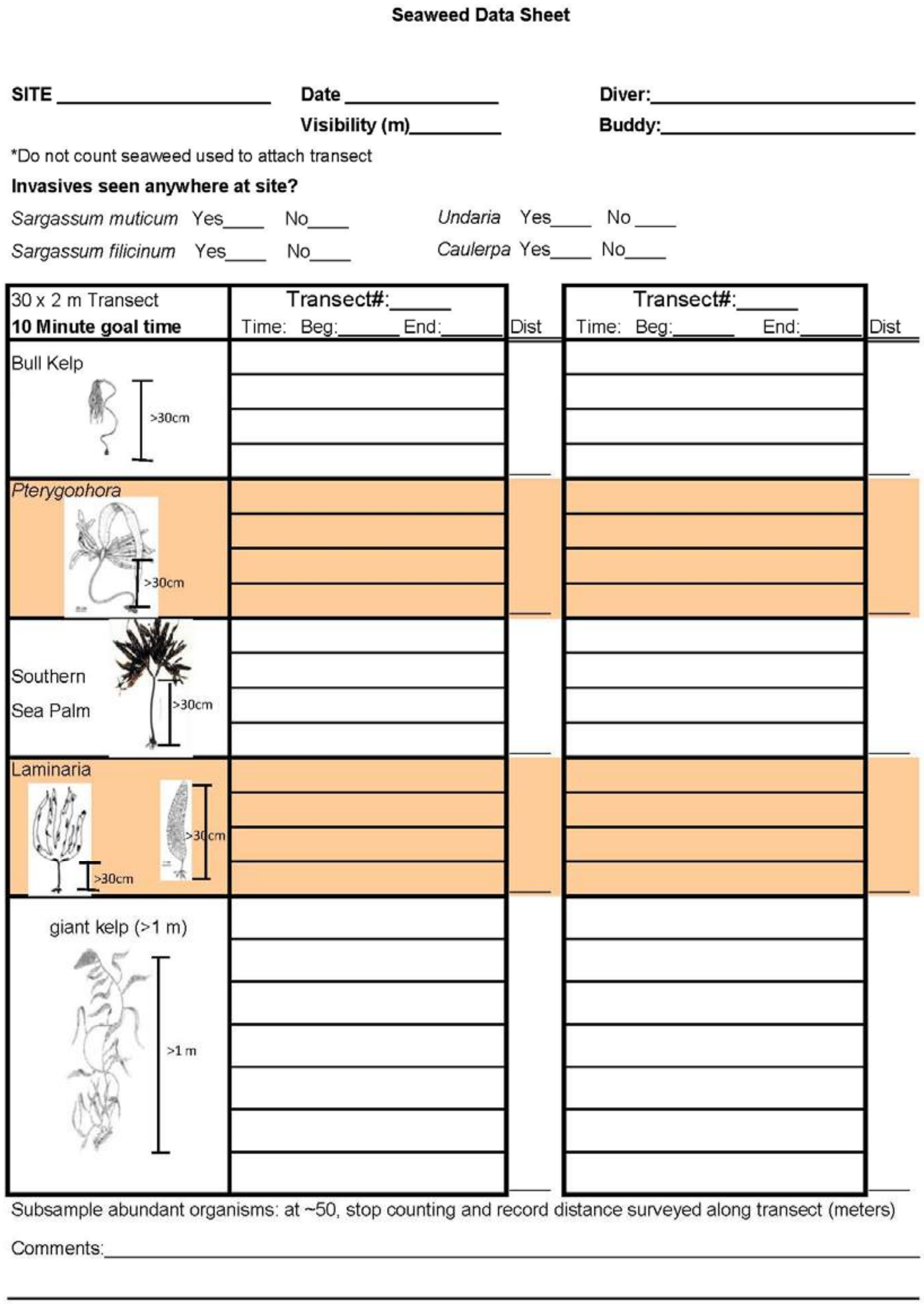
SITE ____________________ **Date** _____________ **Diver:**________________________

Visibility (m)________ **Buddy:**________________________

	Count all orgs. > 2.5 cm **10 Minute goal** (30 x 2 m)	Transect#:_____ Time: Beg:______ End:______	Dist	Transect#:_____ Time: Beg:______ End:______	Dist
Abalones	red abalone (size cm)		____		____
	flat abalone (size cm)		____		____
	pinto abalone (size cm)		____		____
	green abalone (size cm)		____		____
	pink abalone (size cm)		____		____
	Unknown abalone		____		____
	CA spiny lobster		____		____
Cucumbers	CA sea cucumber		____		____
	warty sea cucumber		____		____
Sea Stars	bat star		____		____
	short spined sea star		____		____
	giant spined star		____		____
	sun/sunflower star		____		____
Slugs/snails	chestnut cowry		____		____
	Kellet's whelk		____		____
	wavy / red turban snail		____		____
	giant keyhole limpet		____		____
Crabs	rock crab		____		____
	sheep/masking crab		____		____
	gumboot chiton		____		____
	rock scallop		____		____
	large anemone (>10cm)		____		____
Gorgonians	brown/golden gorgonian (>10cm)		____		____
	red gorgonian (>10 cm)		____		____
Urchins	red urchin		____		____
	purple urchin		____		____
	crowned urchin		____		____
	Other/comments				
	Black ab (Y/N)	White ab (Y/N)________			

Subsample abundant organisms: at ~50, stop counting and record distance surveyed along transect (meters)

Seaweed Datasheet



Seaweed Data Sheet

SITE ____________________ **Date** _____________ **Diver:**________________________

Visibility (m)________ **Buddy:**________________________

*Do not count seaweed used to attach transect

Invasives seen anywhere at site?

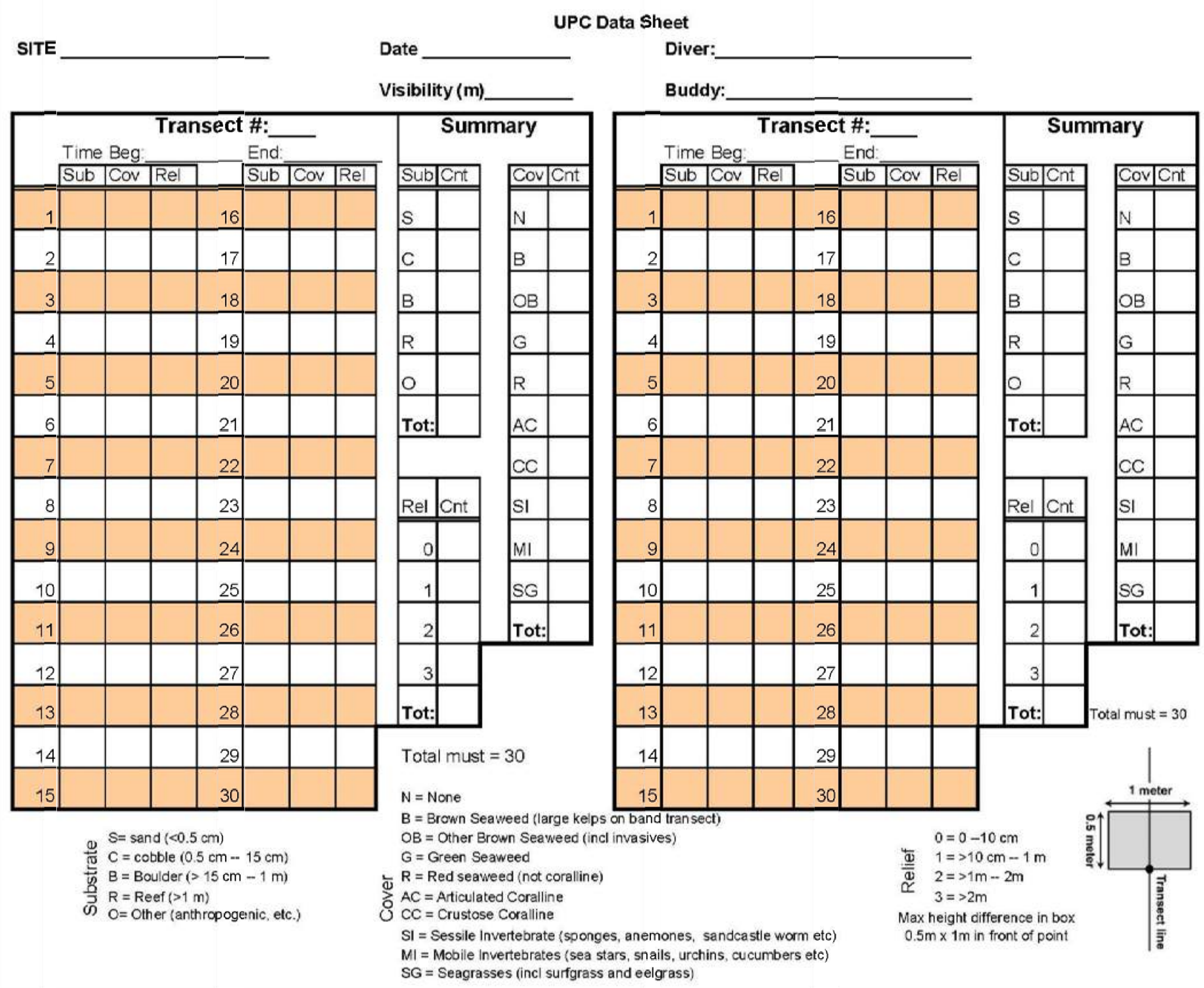
Sargassum muticum Yes____ No____ *Undaria* Yes____ No ____

Sargassum filicinum Yes____ No____ *Caulerpa* Yes____ No____

30 x 2 m Transect **10 Minute goal time**	Transect#:_____ Time: Beg:______ End:______	Dist	Transect#:_____ Time: Beg:______ End:______	Dist
Bull Kelp >30cm				
Pterygophora >30cm				
Southern Sea Palm >30cm				
Laminaria >30cm >30cm				
giant kelp (>1 m) >1 m				

Subsample abundant organisms: at ~50, stop counting and record distance surveyed along transect (meters)

Comments:____



UPC Data Sheet

SITE ____________________

Date ______________

Visibility (m)________

Diver:_____________________

Buddy:_____________________

Transect #:____

Time Beg:__________ End:__________

	Sub	Cov	Rel		Sub	Cov	Rel
1				16			
2				17			
3				18			
4				19			
5				20			
6				21			
7				22			
8				23			
9				24			
10				25			
11				26			
12				27			
13				28			
14				29			
15				30			

Summary

Sub	Cnt
S	
C	
B	
R	
O	
Tot:	

Rel	Cnt
0	
1	
2	
3	
Tot:	

Cov	Cnt
N	
B	
OB	
G	
R	
AC	
CC	
SI	
MI	
SG	
Tot:	

Total must = 30

Transect #:____

Time Beg:__________ End:__________

	Sub	Cov	Rel		Sub	Cov	Rel
1				16			
2				17			
3				18			
4				19			
5				20			
6				21			
7				22			
8				23			
9				24			
10				25			
11				26			
12				27			
13				28			
14				29			
15				30			

Summary

Sub	Cnt
S	
C	
B	
R	
O	
Tot:	

Rel	Cnt
0	
1	
2	
3	
Tot:	

Cov	Cnt
N	
B	
OB	
G	
R	
AC	
CC	
SI	
MI	
SG	
Tot:	

Total must = 30

Substrate
S= sand (<0.5 cm)
C = cobble (0.5 cm -- 15 cm)
B = Boulder (> 15 cm -- 1 m)
R = Reef (>1 m)
O= Other (anthropogenic, etc.)

Cover
N = None
B = Brown Seaweed (large kelps on band transect)
OB = Other Brown Seaweed (incl invasives)
G = Green Seaweed
R = Red seaweed (not coralline)
AC = Articulated Coralline
CC = Crustose Coralline
SI = Sessile Invertebrate (sponges, anemones, sandcastle worm etc)
MI = Mobile Invertebrates (sea stars, snails, urchins, cucumbers etc)
SG = Seagrasses (incl surfgrass and eelgrass)

Relief
0 = 0 --10 cm
1 = >10 cm -- 1 m
2 = >1m -- 2m
3 = >2m
Max height difference in box
0.5m x 1m in front of point

Urchin Size Frequency Datasheet

SITE ____________________ **Date** __________ **Diver:**_________________________

Depth:_____________ **Visibility (m)**________ **Buddy:**________________________

~100 of each species Time: Beg:______ End:_______

Purple urchin test diameter (cm)		**Total**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Red urchin test diameter (cm)		**Total**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
>16		

Comments: ____________________

____

____

* _________________________________

Appendix C

Summary of species densities at RCCA's NCSR sites

Glass Beach

Physical characteristics and primary substrate cover at Glass Beach site (2014)

Average depth	7.71 meters	Depth range 5.48-9.45 meters

Substrate type	Percentage
Bedrock	55.00%
Boulders	23.89%
Cobble	20.00%
Sand	1.11%
Other	0.00%

Relief	Percentage
0-10cm	0.00%
10 cm-1meter	73.89%
1-2meter	23.33%
>2 meters	2.78%

Substrate Cover	Percentage
Articulated coralline	22.78%
Brown seaweed	1.67%
Crustose coralline	25.00%
Green seaweed	0.00%
Mobile invertebrates	3.33%
None	17.78%
Other brown seaweed	0.00%
Red seaweed	14.44%
Sessile invertebrates	15.00%

Algae Density (60 m^2) for Glass Beach site (2014)

Common Name	Scientific Name	Mean Density	Standard Error
Pterygophora	*Pterygophora Californica*	6.33	
Bull kelp	*Nereocustis luetkeana*	0.00	
Laminaria	*Laminaria Spp*	1.33	
Giant kelp	*Macrocystis pyrifera*	0.00	
Giant kelp stipes	*Macrocystis pyrifera*	0.00	
Southern sea palm	*Eisenia arborea*	0.00	

Invertebrate Density (60 m^2) for Glass Beach site (2014)

Common Name	Scientific Name	Mean Density	Standard Error
Purple urchin	*Strongylocentrotus purpuratus*	96.62	
Red urchin	*Strongylocentrotus Franciscanus*	9.17	
Red abalone	*Haliotis rufescens*	45.36	
Flat abalone	*Haliotis wallensis*	0.00	
Pinto abalone	*Haliotis kantschatkana*	0.00	
Bat star	*Patiria miniata*	52.61	
Giant spine star	*Pisaster giganteus*	0.00	
Short spine star	*Pisaster brevispinus*	0.00	
Sun/sunflower star	*Solaster spp./ Pycnopodia spp.*	0.00	
Large anemone	*Anemone Spp*	2.33	
Gumboot chiton	*Cryptochiton stelleri*	2.17	
Rock scallop	*Crassedoma giganteum*	0.00	
wavy/red turban snail	*Lithopoma Undosum*	0.00	
Rock crab	*Cancer Spp.*	0.00	
Sheep/masking crab	*Loxorhynchus spp.*	0.00	
CA sea cucumber	*Parastichopus californicus*	0.00	
warty sea cucumber	*Parastichopus parvimensis*	0.00	
CA spiny lobster	*Panulirus interruptus*	0.00	
Green abalone	*Haliotis fulgens*	0.00	
Pink abalone	*Haliotis corrugata*	0.00	
Chestnut cowry	*Cyoraes soadicea*	0.00	
Kellet's whelk	*Kelletia kelletii*	0.00	
Giant keyhole limpet	*Megathura crenulata*	0.00	
Brown/golden gorgonian	*Muricea fruticosa, M. californica*	0.00	
Red gorgonian	*Leophogorgia chilensis*	0.00	

Fish Density (60 m^2) for Glass Beach site (2014)

Common Name	Scientific Name	Mean Density	Standard Error
Black rockfish	*Sebastes melanops*	3.67	
Black and yellow rockfish	*Sebastes chrysomelas*	0.33	
Blue rockfish	*Sebastes mystinus*	3.17	
Brown rockfish	*Sebastes auriculatus*	0.00	
China rockfish	*Sebastes nebulosus*	0.00	
Copper rockfish	*Sebastes caurinus*	0.00	
Gopher rockfish	*Sebastes carnatus*	0.00	
Grass rockfish	*Sebastes rastrelliger*	0.00	
Kelp rockfish	*Sebastes atrovirens*	0.17	
Vermillion/Canary rockfish	*Sebastes miniatus*	0.00	
Yellowtail/Olive rockfish	*Sebastes serranoides*	0.00	
YOY rockfish	*Sebastes spp.*	10.00	
Black perch	*Embiotoca Jacksoni*	0.00	
Pile perch	*Rhacochilus vacca*	0.00	
Rainbow perch	*Hypsurus caryi*	0.17	
Rubberlip perch	*Rhacochilus toxotes*	0.17	
Striped perch	*Embiotoca lateralis*	1.67	
Kelp greenling	*Hexagrammos decagrammus*	1.17	
Lingcod	*Ophiodon elongatus*	0.00	
Cabezon	*Scorpaenichthys marmoratus*	0.50	
Rock greenling	*Hexagrammos lagocephalus*	0.00	
Barred sand bass	*Paralabrax nebulifer*	0.00	
Blacksmith	*Chromis punctipinnis*	0.00	
Bocaccio	*Sebastes paucispinis*	0.00	
Garibaldi	*Hypsypops rubicundus*	0.00	
Horn shark	*Heterodontus francisci*	0.00	
Kelp bass	*Paralabrax clathratus*	0.00	
Opaleye	*Girella nigricans*	0.00	
Rock wrasse	*Halichoeres semicinctus*	0.00	
Sargo	*Anisotermus davidsoni*	0.00	
Senorita	*Oxyjulis californica*	0.00	
CA sheephead	*Semicossyphus pulcher*	0.00	
Treefish	*Sebastes serriceps*	0.00	

Caspar North

Physical characteristics and primary substrate cover at Caspar North site (2014-2015)

Average depth	10.36 meters	Depth range 6.10 – 12.80 meters

Substrate type	Percentage
Bedrock	81.94%
Boulders	7.78%
Cobble	4.17%
Sand	6.11%
Other	0.00%

Relief	Percentage
0-10cm	0.00%
10 cm-1meter	62%
1-2meter	28%
>2 meters	10%

Substrate Cover	Percentage
Articulated coralline	8.06%
Brown seaweed	0.00%
Crustose coralline	50.28%
Green seaweed	0.00%
Mobile invertebrates	8.61%
None	7.50%
Other brown seaweed	0.56%
Red seaweed	23.61%
Sessile invertebrates	1.39%

Algae Density (60 m^2) for Caspar North site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Pterygophora	*Pterygophora Californica*	10.00	10.00
Bull kelp	*Nereocustis luetkeana*	0.00	0.00
Laminaria	*Laminaria Spp*	0.00	0.00
Giant kelp	*Macrocystis pyrifera*	0.00	0.00
Giant kelp stipes	*Macrocystis pyrifera*	0.00	0.00
Southern sea palm	*Eisenia arborea*	0.00	0.00

Invertebrate Density (60 m^2) for Caspar North site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Purple urchin	*Strongylocentrotus purpuratus*	536.36	296.97
Red urchin	*Strongylocentrotus Franciscanus*	167.09	24.16
Red abalone	*Haliotis rufescens*	24.92	6.58
Flat abalone	*Haliotis wallensis*	0.08	0.08
Pinto abalone	*Haliotis kantschatkana*	0.25	0.08
Bat star	*Patiria miniata*	29.33	0.83
Giant spine star	*Pisaster giganteus*	0.00	0.00
Short spine star	*Pisaster brevispinus*	0.00	0.00
Sun/sunflower star	*Solaster spp./ Pycnopodia spp.*	0.00	0.00
Large anemone	*Anemone Spp*	4.08	1.42
Gumboot chiton	*Cryptochiton stelleri*	3.75	2.42
Rock scallop	*Crassedoma giganteum*	0.08	0.08
wavy/red turban snail	*Lithopoma Undosum*	0.00	0.00
Rock crab	*Cancer Spp.*	0.00	0.00
Sheep/masking crab	*Loxorhynchus spp.*	0.00	0.00
CA sea cucumber	*Parastichopus californicus*	0.58	0.25
warty sea cucumber	*Parastichopus parvimensis*	0.00	0.00
CA spiny lobster	*Panulirus interruptus*	0.00	0.00
Green abalone	*Haliotis fulgens*	0.00	0.00
Pink abalone	*Haliotis corrugata*	0.00	0.00
Chestnut cowry	*Cyoraes soadicea*	0.00	0.00
Kellet's whelk	*Kelletia kelletii*	0.00	0.00
Giant keyhole limpet	*Megathura crenulata*	0.00	0.00
Brown/golden gorgonian	*Muricea fruticosa, M. californica*	0.00	0.00
Red gorgonian	*Leophogorgia chilensis*	0.00	0.00

Fish Density (60 m^2) for Caspar North site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Black rockfish	*Sebastes melanops*	0.61	0.22
Black and yellow rockfish	*Sebastes chrysomelas*	0.08	0.03
Blue rockfish	*Sebastes mystinus*	9.75	4.14
Brown rockfish	*Sebastes auriculatus*	0.00	0.00
China rockfish	*Sebastes nebulosus*	0.03	0.03
Copper rockfish	*Sebastes caurinus*	0.03	0.03
Gopher rockfish	*Sebastes carnatus*	0.14	0.14
Grass rockfish	*Sebastes rastrelliger*	0.00	0.00
Kelp rockfish	*Sebastes atrovirens*	0.00	0.00
Vermillion/Canary rockfish	*Sebastes miniatus*	0.03	0.03
Yellowtail/Olive rockfish	*Sebastes serranoides*	0.14	0.14
YOY rockfish	*Sebastes spp.*	14.22	0.94
Black perch	*Embiotoca Jacksoni*	0.03	0.03
Pile perch	*Rhacochilus vacca*	0.06	0.06
Rainbow perch	*Hypsurus caryi*	0.00	0.00
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.00
Striped perch	*Embiotoca lateralis*	2.22	0.22
Kelp greenling	*Hexagrammos decagrammus*	1.69	0.64
Lingcod	*Ophiodon elongatus*	0.08	0.08
Cabezon	*Scorpaenichthys marmoratus*	0.00	0.00
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.00
Barred sand bass	*Paralabrax nebulifer*	0.00	0.00
Blacksmith	*Chromis punctipinnis*	0.00	0.00
Bocaccio	*Sebastes paucispinis*	0.00	0.00
Garibaldi	*Hypsypops rubicundus*	0.00	0.00
Horn shark	*Heterodontus francisci*	0.00	0.00
Kelp bass	*Paralabrax clathratus*	0.00	0.00
Opaleye	*Girella nigricans*	0.00	0.00
Rock wrasse	*Halichoeres semicinctus*	0.00	0.00
Sargo	*Anisotermus davidsoni*	0.00	0.00
Senorita	*Oxyjulis californica*	0.00	0.00
CA sheephead	*Semicossyphus pulcher*	0.00	0.00
Treefish	*Sebastes serriceps*	0.00	0.00

Caspar

Physical characteristics and primary substrate cover at Caspar site (2014-2015)

Average depth	10.36 meters	Depth range 3.20-8.40 meters

Substrate type	Percentage	Substrate Cover	Percentage
Bedrock	74.44%	Articulated coralline	28.89%
Boulders	10.56%	Brown seaweed	0.56%
Cobble	10.28%	Crustose coralline	30.00%
Sand	4.44%	Green seaweed	0.00%
Other	0.28%	Mobile invertebrates	9.17%
		None	9.44%
Relief	**Percentage**	Other brown seaweed	3.06%
0-10cm	0.83%	Red seaweed	18.61%
10 cm-1meter	66.39%	Sessile invertebrates	0.28%
1-2meter	26.11%		
>2 meters	6.67%		

Algae Density (60 m^2) for Caspar site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Pterygophora	*Pterygophora Californica*	3.58	2.42
Bull kelp	*Nereocustis luetkeana*	0.92	0.92
Laminaria	*Laminaria Spp*	0.00	0.00
Giant kelp	*Macrocystis pyrifera*	0.00	0.00
Giant kelp stipes	*Macrocystis pyrifera*	0.00	0.00
Southern sea palm	*Eisenia arborea*	0.00	0.00

Invertebrate Density (60 m^2) for Caspar site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Purple urchin	*Strongylocentrotus purpuratus*	393.79	387.46
Red urchin	*Strongylocentrotus Franciscanus*	131.26	23.16
Red abalone	*Haliotis rufescens*	12.42	23.16
Flat abalone	*Haliotis wallensis*	0.17	0.17
Pinto abalone	*Haliotis kantschatkana*	0.17	0.00
Bat star	*Patiria miniata*	74.39	35.40
Giant spine star	*Pisaster giganteus*	0.00	0.00
Short spine star	*Pisaster brevispinus*	0.00	0.00
Sun/sunflower star	*Solaster spp./ Pycnopodia spp.*	0.00	0.00
Large anemone	*Anemone Spp*	1.50	0.17
Gumboot chiton	*Cryptochiton stelleri*	2.50	1.67
Rock scallop	*Crassedoma giganteum*	0.00	0.00
wavy/red turban snail	*Lithopoma Undosum*	0.42	0.42
Rock crab	*Cancer Spp.*	0.00	0.00
Sheep/masking crab	*Loxorhynchus spp.*	0.00	0.00
CA sea cucumber	*Parastichopus californicus*	1.17	1.00
warty sea cucumber	*Parastichopus parvimensis*	0.00	0.00
CA spiny lobster	*Panulirus interruptus*	0.00	0.00
Green abalone	*Haliotis fulgens*	0.00	0.00
Pink abalone	*Haliotis corrugata*	0.00	0.00
Chestnut cowry	*Cyoraes soadicea*	0.00	0.00
Kellet’s whelk	*Kelletia kelletii*	0.00	0.00
Giant keyhole limpet	*Megathura crenulata*	0.00	0.00
Brown/golden gorgonian	*Muricea fruticosa, M. californica*	0.00	0.00
Red gorgonian	*Leophogorgia chilensis*	0.00	0.00

Fish Density (60 m^2) for Caspar site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Black rockfish	*Sebastes melanops*	0.61	0.39
Black and yellow rockfish	*Sebastes chrysomelas*	0.12	0.06
Blue rockfish	*Sebastes mystinus*	5.59	3.59
Brown rockfish	*Sebastes auriculatus*	0.00	0.00
China rockfish	*Sebastes nebulosus*	0.15	0.09
Copper rockfish	*Sebastes caurinus*	0.00	0.00
Gopher rockfish	*Sebastes carnatus*	0.20	0.09
Grass rockfish	*Sebastes rastrelliger*	0.00	0.00
Kelp rockfish	*Sebastes atrovirens*	0.00	0.00
Vermillion/Canary rockfish	*Sebastes miniatus*	0.00	0.00
Yellowtail/Olive rockfish	*Sebastes serranoides*	0.17	0.17
YOY rockfish	*Sebastes spp.*	20.89	8.17
Black perch	*Embiotoca Jacksoni*	0.00	0.00
Pile perch	*Rhacochilus vacca*	0.08	0.03
Rainbow perch	*Hypsurus caryi*	0.00	0.00
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.00
Striped perch	*Embiotoca lateralis*	1.01	0.54
Kelp greenling	*Hexagrammos decagrammus*	2.05	0.77
Lingcod	*Ophiodon elongatus*	0.06	0.06
Cabezon	*Scorpaenichthys marmoratus*	0.06	0.00
Rock greenling	*Hexagrammos lagocephalus*	0.09	0.09
Barred sand bass	*Paralabrax nebulifer*	0.00	0.00
Blacksmith	*Chromis punctipinnis*	0.00	0.00
Bocaccio	*Sebastes paucispinis*	0.00	0.00
Garibaldi	*Hypsypops rubicundus*	0.00	0.00
Horn shark	*Heterodontus francisci*	0.00	0.00
Kelp bass	*Paralabrax clathratus*	0.00	0.00
Opaleye	*Girella nigricans*	0.00	0.00
Rock wrasse	*Halichoeres semicinctus*	0.00	0.00
Sargo	*Anisotermus davidsoni*	0.00	0.00
Senorita	*Oxyjulis californica*	0.00	0.00
CA sheephead	*Semicossyphus pulcher*	0.00	0.00
Treefish	*Sebastes serriceps*	0.00	0.00

Frolic Cove

Physical characteristics and primary substrate cover at Frolic Cove site (2014-2015)

Average depth 5.35 meters   Depth range 3.05 – 8.08 meters

Substrate type	Percentage
Bedrock	55.28%
Boulders	20.28%
Cobble	12.50%
Sand	11.94%
Other	0.00%

Relief	Percentage
0-10cm	0.00%
10 cm-1meter	58.89%
1-2meter	31.11%
>2 meters	10.00%

Substrate Cover	Percentage
Articulated coralline	43.33%
Brown seaweed	0.28%
Crustose coralline	31.67%
Green seaweed	0.00%
Mobile invertebrates	4.72%
None	14.17%
Other brown seaweed	0.28%
Red seaweed	4.72%
Sessile invertebrates	0.83%

Algae Density (60 m^2) for Frolic Cove site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Pterygophora	*Pterygophora Californica*	73.65	19.48
Bull kelp	*Nereocustis luetkeana*	0.00	0.00
Laminaria	*Laminaria Spp*	0.58	0.58
Giant kelp	*Macrocystis pyrifera*	0.00	0.00
Giant kelp stipes	*Macrocystis pyrifera*	0.00	0.00
Southern sea palm	*Eisenia arborea*	0.00	0.00

Invertebrate Density (60 m^2) for Frolic Cove site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Purple urchin	*Strongylocentrotus purpuratus*	72.86	4.09
Red urchin	*Strongylocentrotus Franciscanus*	40.10	22.26
Red abalone	*Haliotis rufescens*	44.62	17.46
Flat abalone	*Haliotis wallensis*	0.08	0.08
Pinto abalone	*Haliotis kantschatkana*	0.08	0.08
Bat star	*Patiria miniata*	29.04	18.21
Giant spine star	*Pisaster giganteus*	0.00	0.00
Short spine star	*Pisaster brevispinus*	0.00	0.00
Sun/sunflower star	*Solaster spp./ Pycnopodia spp.*	0.00	0.00
Large anemone	*Anemone Spp*	1.33	0.33
Gumboot chiton	*Cryptochiton stelleri*	0.67	0.33
Rock scallop	*Crassedoma giganteum*	0.00	0.00
wavy/red turban snail	*Lithopoma Undosum*	0.25	0.25
Rock crab	*Cancer Spp.*	0.00	0.00
Sheep/masking crab	*Loxorhynchus spp.*	0.17	0.17
CA sea cucumber	*Parastichopus californicus*	0.00	0.00
warty sea cucumber	*Parastichopus parvimensis*	0.00	0.00
CA spiny lobster	*Panulirus interruptus*	0.00	0.00
Green abalone	*Haliotis fulgens*	0.00	0.00
Pink abalone	*Haliotis corrugata*	0.00	0.00
Chestnut cowry	*Cyoraes soadicea*	0.00	0.00
Kellet's whelk	*Kelletia kelletii*	0.00	0.00
Giant keyhole limpet	*Megathura crenulata*	0.00	0.00
Brown/golden gorgonian	*Muricea fruticosa, M. californica*	0.00	0.00
Red gorgonian	*Leophogorgia chilensis*	0.00	0.00

Fish Density (60 m^2) for Frolic Cove site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Black rockfish	*Sebastes melanops*	1.31	0.47
Black and yellow rockfish	*Sebastes chrysomelas*	0.08	0.03
Blue rockfish	*Sebastes mystinus*	1.06	0.17
Brown rockfish	*Sebastes auriculatus*	0.00	0.00
China rockfish	*Sebastes nebulosus*	0.00	0.00
Copper rockfish	*Sebastes caurinus*	0.06	0.06
Gopher rockfish	*Sebastes carnatus*	0.00	0.00
Grass rockfish	*Sebastes rastrelliger*	0.00	0.00
Kelp rockfish	*Sebastes atrovirens*	0.00	0.00
Vermillion/Canary rockfish	*Sebastes miniatus*	0.00	0.00
Yellowtail/Olive rockfish	*Sebastes serranoides*	0.06	0.06
YOY rockfish	*Sebastes spp.*	12.28	1.67
Black perch	*Embiotoca Jacksoni*	0.06	0.00
Pile perch	*Rhacochilus vacca*	0.28	0.17
Rainbow perch	*Hypsurus caryi*	0.00	0.00
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.00
Striped perch	*Embiotoca lateralis*	2.28	0.22
Kelp greenling	*Hexagrammos decagrammus*	2.31	0.53
Lingcod	*Ophiodon elongatus*	0.11	0.00
Cabezon	*Scorpaenichthys marmoratus*	0.08	0.03
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.00
Barred sand bass	*Paralabrax nebulifer*	0.00	0.00
Blacksmith	*Chromis punctipinnis*	0.00	0.00
Bocaccio	*Sebastes paucispinis*	0.00	0.00
Garibaldi	*Hypsypops rubicundus*	0.00	0.00
Horn shark	*Heterodontus francisci*	0.00	0.00
Kelp bass	*Paralabrax clathratus*	0.00	0.00
Opaleye	*Girella nigricans*	0.00	0.00
Rock wrasse	*Halichoeres semicinctus*	0.00	0.00
Sargo	*Anisotermus davidsoni*	0.00	0.00
Senorita	*Oxyjulis californica*	0.00	0.00
CA sheephead	*Semicossyphus pulcher*	0.00	0.00
Treefish	*Sebastes serriceps*	0.00	0.00

Russian Gulch

Physical characteristics and primary substrate cover at Russian Gulch site (2014-2015)

Average depth	6.9 meters	Depth range 3.2 - 11.4 meters

Substrate type	Percentage
Bedrock	46.11%
Boulders	22.22%
Cobble	24.72%
Sand	6.94%
Other	0.00%

Relief	Percentage
0-10cm	9.72%
10 cm-1meter	55.83%
1-2meter	30.00%
>2 meters	4.44%

Substrate Cover	Percentage
Articulated coralline	18.89%
Brown seaweed	5.83%
Crustose coralline	30.00%
Green seaweed	0.00%
Mobile invertebrates	1.94%
None	13.06%
Other brown seaweed	12.50%
Red seaweed	17.22%
Sessile invertebrates	0.56%

Algae Density (60 m^2) for Russian Gulch site (2014-2015)

Common Name	Scientific Name	Density	Standard Error
Pterygophora	*Pterygophora Californica*	120.86	49.12
Bull kelp	*Nereocustis luetkeana*	6.67	5.67
Laminaria	*Laminaria Spp*	0.75	0.58
Giant kelp	*Macrocystis pyrifera*	0.00	0.00
Giant kelp stipes	*Macrocystis pyrifera*	0.00	0.00
Southern sea palm	*Eisenia arborea*	0.00	0.00

Invertebrate Density (60 m^2) for Russian Gulch site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Purple urchin	*Strongylocentrotus purpuratus*	3.75	3.58
Red urchin	*Strongylocentrotus Franciscanus*	4.75	4.42
Red abalone	*Haliotis rufescens*	41.17	9.84
Flat abalone	*Haliotis wallensis*	0.75	0.08
Pinto abalone	*Haliotis kantschatkana*	0.08	0.08
Bat star	*Patiria miniata*	58.27	30.77
Giant spine star	*Pisaster giganteus*	0.00	0.00
Short spine star	*Pisaster brevispinus*	0.00	0.00
Sun/sunflower star	*Solaster spp./ Pycnopodia spp.*	0.00	0.00
Large anemone	*Anemone Spp*	0.17	0.17
Gumboot chiton	*Cryptochiton stelleri*	2.00	1.50
Rock scallop	*Crassedoma giganteum*	0.17	0.17
wavy/red turban snail	*Lithopoma Undosum*	0.25	0.25
Rock crab	*Cancer Spp.*	0.00	0.00
Sheep/masking crab	*Loxorhynchus spp.*	0.00	0.00
CA sea cucumber	*Parastichopus californicus*	0.92	0.25
warty sea cucumber	*Parastichopus parvimensis*	0.00	0.00
CA spiny lobster	*Panulirus interruptus*	0.00	0.00
Green abalone	*Haliotis fulgens*	0.00	0.00
Pink abalone	*Haliotis corrugata*	0.00	0.00
Chestnut cowry	*Cyoraes soadicea*	0.00	0.00
Kellet’s whelk	*Kelletia kelletii*	0.00	0.00
Giant keyhole limpet	*Megathura crenulata*	0.00	0.00
Brown/golden gorgonian	*Muricea fruticosa, M. californica*	0.00	0.00
Red gorgonian	*Leophogorgia chilensis*	0.00	0.00

Fish Density (60 m^2) for Russian Gulch site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Black rockfish	*Sebastes melanops*	0.08	0.03
Black and yellow rockfish	*Sebastes chrysomelas*	0.03	0.03
Blue rockfish	*Sebastes mystinus*	0.20	0.08
Brown rockfish	*Sebastes auriculatus*	0.00	0.00
China rockfish	*Sebastes nebulosus*	0.03	0.03
Copper rockfish	*Sebastes caurinus*	0.00	0.00
Gopher rockfish	*Sebastes carnatus*	0.00	0.00
Grass rockfish	*Sebastes rastrelliger*	0.00	0.00
Kelp rockfish	*Sebastes atrovirens*	0.00	0.00
Vermillion/Canary rockfish	*Sebastes miniatus*	0.00	0.00
Yellowtail/Olive rockfish	*Sebastes serranoides*	0.00	0.00
YOY rockfish	*Sebastes spp.*	14.28	12.89
Black perch	*Embiotoca Jacksoni*	0.03	0.03
Pile perch	*Rhacochilus vacca*	0.08	0.03
Rainbow perch	*Hypsurus caryi*	0.00	0.00
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.00
Striped perch	*Embiotoca lateralis*	0.61	0.33
Kelp greenling	*Hexagrammos decagrammus*	0.64	0.19
Lingcod	*Ophiodon elongatus*	0.03	0.03
Cabezon	*Scorpaenichthys marmoratus*	0.00	0.00
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.00
Barred sand bass	*Paralabrax nebulifer*	0.00	0.00
Blacksmith	*Chromis punctipinnis*	0.00	0.00
Bocaccio	*Sebastes paucispinis*	0.00	0.00
Garibaldi	*Hypsypops rubicundus*	0.00	0.00
Horn shark	*Heterodontus francisci*	0.00	0.00
Kelp bass	*Paralabrax clathratus*	0.00	0.00
Opaleye	*Girella nigricans*	0.00	0.00
Rock wrasse	*Halichoeres semicinctus*	0.00	0.00
Sargo	*Anisotermus davidsoni*	0.00	0.00
Senorita	*Oxyjulis californica*	0.00	0.00
CA sheephead	*Semicossyphus pulcher*	0.00	0.00
Treefish	*Sebastes serriceps*	0.00	0.00

Mendocino Headlands

Physical characteristics and primary substrate cover at Mendocino Headlands site (2014-2015)

Average depth	10.55 meters	Depth range 5.6 – 14.5 meters	
Substrate type	**Percentage**	**Substrate Cover**	**Percentage**
Bedrock	79.44%	Articulated coralline	21.94%
Boulders	7.50%	Brown seaweed	0.28%
Cobble	9.44%	Crustose coralline	43.06%
Sand	1.94%	Green seaweed	0.00%
Other	1.67%	Mobile invertebrates	16.11%
		None	4.17%
Relief	**Percentage**	Other brown seaweed	5.00%
0-10cm	1.11%	Red seaweed	0.28%
10 cm-1meter	73.89%	Sessile invertebrates	9.17%
1-2meter	19.44%		
>2 meters	5.56%		

Algae Density (60 m^2) for Mendocino Headlands site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Pterygophora	*Pterygophora Californica*	3.33	3.33
Bull kelp	*Nereocustis luetkeana*	0.00	0.00
Laminaria	*Laminaria Spp*	0.00	0.00
Giant kelp	*Macrocystis pyrifera*	0.00	0.00
Giant kelp stipes	*Macrocystis pyrifera*	0.00	0.00
Southern sea palm	*Eisenia arborea*	0.00	0.00

Invertebrate Density (60 m^2) for Mendocino Headlands site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Purple urchin	*Strongylocentrotus purpuratus*	705.52	544.48
Red urchin	*Strongylocentrotus Franciscanus*	68.26	36.86
Red abalone	*Haliotis rufescens*	118.75	72.91
Flat abalone	*Haliotis wallensis*	0.50	0.00
Pinto abalone	*Haliotis kantschatkana*	1.42	0.08
Bat star	*Patiria miniata*	43.21	5.06
Giant spine star	*Pisaster giganteus*	2.00	1.83
Short spine star	*Pisaster brevispinus*	0.08	0.08
Sun/sunflower star	*Solaster spp./ Pycnopodia spp.*	0.00	0.00
Large anemone	*Anemone Spp*	12.92	4.25
Gumboot chiton	*Cryptochiton stelleri*	2.00	0.50
Rock scallop	*Crassedoma giganteum*	0.17	0.17
wavy/red turban snail	*Lithopoma Undosum*	0.00	0.00
Rock crab	*Cancer Spp.*	0.08	0.08
Sheep/masking crab	*Loxorhynchus spp.*	0.33	0.17
CA sea cucumber	*Parastichopus californicus*	0.08	0.08
warty sea cucumber	*Parastichopus parvimensis*	0.00	0.00
CA spiny lobster	*Panulirus interruptus*	0.00	0.00
Green abalone	*Haliotis fulgens*	0.00	0.00
Pink abalone	*Haliotis corrugata*	0.00	0.00
Chestnut cowry	*Cyoraes soadicea*	0.00	0.00
Kellet’s whelk	*Kelletia kelletii*	0.00	0.00
Giant keyhole limpet	*Megathura crenulata*	0.00	0.00
Brown/golden gorgonian	*Muricea fruticosa, M. californica*	0.00	0.00
Red gorgonian	*Leophogorgia chilensis*	0.00	0.00

Fish Density (60 m^2) for Mendocino Headlands site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Black rockfish	*Sebastes melanops*	0.83	0.33
Black and yellow rockfish	*Sebastes chrysomelas*	0.00	0.00
Blue rockfish	*Sebastes mystinus*	3.75	3.75
Brown rockfish	*Sebastes auriculatus*	0.00	0.00
China rockfish	*Sebastes nebulosus*	0.00	0.00
Copper rockfish	*Sebastes caurinus*	0.00	0.00
Gopher rockfish	*Sebastes carnatus*	0.08	0.08
Grass rockfish	*Sebastes rastrelliger*	0.00	0.00
Kelp rockfish	*Sebastes atrovirens*	0.00	0.00
Vermillion/Canary rockfish	*Sebastes miniatus*	0.00	0.00
Yellowtail/Olive rockfish	*Sebastes serranoides*	0.00	0.00
YOY rockfish	*Sebastes spp.*	14.25	10.75
Black perch	*Embiotoca Jacksoni*	0.00	0.00
Pile perch	*Rhacochilus vacca*	0.42	0.25
Rainbow perch	*Hypsurus caryi*	0.00	0.00
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.00
Striped perch	*Embiotoca lateralis*	2.75	1.42
Kelp greenling	*Hexagrammos decagrammus*	3.42	0.75
Lingcod	*Ophiodon elongatus*	0.00	0.00
Cabezon	*Scorpaenichthys marmoratus*	0.25	0.08
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.00
Barred sand bass	*Paralabrax nebulifer*	0.00	0.00
Blacksmith	*Chromis punctipinnis*	0.00	0.00
Bocaccio	*Sebastes paucispinis*	0.00	0.00
Garibaldi	*Hypsypops rubicundus*	0.00	0.00
Horn shark	*Heterodontus francisci*	0.00	0.00
Kelp bass	*Paralabrax clathratus*	0.00	0.00
Opaleye	*Girella nigricans*	0.00	0.00
Rock wrasse	*Halichoeres semicinctus*	0.00	0.00
Sargo	*Anisotermus davidsoni*	0.00	0.00
Senorita	*Oxyjulis californica*	0.00	0.00
CA sheephead	*Semicossyphus pulcher*	0.00	0.00
Treefish	*Sebastes serriceps*	0.00	0.00

Portuguese Beach

Physical characteristics and primary substrate cover at Portuguese Beach site (2014)

Average depth	5.87 meters	Depth range 4.1 – 11.6 meters

Substrate type	Percentage
Bedrock	92.22%
Boulders	3.33%
Cobble	4.44%
Sand	0.00%
Other	0.00%

Relief	Percentage
0-10cm	9.72%
10 cm-1meter	55.83%
1-2meter	30.00%
>2 meters	4.44%

Substrate Cover	Percentage
Articulated coralline	18.89%
Brown seaweed	5.83%
Crustose coralline	30.00%
Green seaweed	0.00%
Mobile invertebrates	1.94%
None	13.06%
Other brown seaweed	12.50%
Red seaweed	17.22%
Sessile invertebrates	0.56%

Algae Density (60 m^2) for Portuguese Beach site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Pterygophora	*Pterygophora Californica*	80.73	0.00
Bull kelp	*Nereocustis luetkeana*	23.37	0.00
Laminaria	*Laminaria Spp*	0.00	0.00
Giant kelp	*Macrocystis pyrifera*	0.00	0.00
Giant kelp stipes	*Macrocystis pyrifera*	0.00	0.00
Southern sea palm	*Eisenia arborea*	0.00	0.00

Invertebrate Density (60m2) for Portuguese Beach site (2014)

Common Name	**Scientific Name**	**Mean Density**	**Standard Error**
Purple urchin	*Strongylocentrotus purpuratus*	3.75	3.58
Red urchin	*Strongylocentrotus Franciscanus*	4.75	4.42
Red abalone	*Haliotis rufescens*	41.17	9.84
Flat abalone	*Haliotis wallensis*	0.75	0.08
Pinto abalone	*Haliotis kantschatkana*	0.08	0.08
Bat star	*Patiria miniata*	58.27	30.77
Giant spine star	*Pisaster giganteus*	0.00	0.00
Short spine star	*Pisaster brevispinus*	0.00	0.00
Sun/sunflower star	*Solaster spp./ Pycnopodia spp.*	0.00	0.00
Large anemone	*Anemone Spp*	0.17	0.17
Gumboot chiton	*Cryptochiton stelleri*	2.00	1.50
Rock scallop	*Crassedoma giganteum*	0.17	0.17
wavy/red turban snail	*Lithopoma Undosum*	0.25	0.25
Rock crab	*Cancer Spp.*	0.00	0.00
Sheep/masking crab	*Loxorhynchus spp.*	0.00	0.00
CA sea cucumber	*Parastichopus californicus*	0.92	0.25
warty sea cucumber	*Parastichopus parvimensis*	0.00	0.00
CA spiny lobster	*Panulirus interruptus*	0.00	0.00
Green abalone	*Haliotis fulgens*	0.00	0.00
Pink abalone	*Haliotis corrugata*	0.00	0.00
Chestnut cowry	*Cyoraes soadicea*	0.00	0.00
Kellet’s whelk	*Kelletia kelletii*	0.00	0.00
Giant keyhole limpet	*Megathura crenulata*	0.00	0.00
Brown/golden gorgonian	*Muricea fruticosa, M. californica*	0.00	0.00
Red gorgonian	*Leophogorgia chilensis*	0.00	0.00

Fish Density (60 m^2) for Portuguese Beach site (2014)

Common Name	Scientific Name	Mean Density	Standard Error
Black rockfish	*Sebastes melanops*	0.00	0.00
Black and yellow rockfish	*Sebastes chrysomelas*	0.00	0.00
Blue rockfish	*Sebastes mystinus*	0.00	0.00
Brown rockfish	*Sebastes auriculatus*	0.00	0.00
China rockfish	*Sebastes nebulosus*	0.00	0.00
Copper rockfish	*Sebastes caurinus*	0.00	0.00
Gopher rockfish	*Sebastes carnatus*	0.00	0.00
Grass rockfish	*Sebastes rastrelliger*	0.00	0.00
Kelp rockfish	*Sebastes atrovirens*	0.00	0.00
Vermillion/Canary rockfish	*Sebastes miniatus*	0.00	0.00
Yellowtail/Olive rockfish	*Sebastes serranoides*	0.00	0.00
YOY rockfish	*Sebastes spp.*	0.00	0.00
Black perch	*Embiotoca Jacksoni*	0.06	0.00
Pile perch	*Rhacochilus vacca*	0.28	0.00
Rainbow perch	*Hypsurus caryi*	0.06	0.00
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.00
Striped perch	*Embiotoca lateralis*	1.67	0.00
Kelp greenling	*Hexagrammos decagrammus*	0.83	0.00
Lingcod	*Ophiodon elongatus*	0.06	0.00
Cabezon	*Scorpaenichthys marmoratus*	0.00	0.00
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.00
Barred sand bass	*Paralabrax nebulifer*	0.00	0.00
Blacksmith	*Chromis punctipinnis*	0.00	0.00
Bocaccio	*Sebastes paucispinis*	0.00	0.00
Garibaldi	*Hypsypops rubicundus*	0.00	0.00
Horn shark	*Heterodontus francisci*	0.00	0.00
Kelp bass	*Paralabrax clathratus*	0.00	0.00
Opaleye	*Girella nigricans*	0.00	0.00
Rock wrasse	*Halichoeres semicinctus*	0.00	0.00
Sargo	*Anisotermus davidsoni*	0.00	0.00
Senorita	*Oxyjulis californica*	0.00	0.00
CA sheephead	*Semicossyphus pulcher*	0.00	0.00
Treefish	*Sebastes serriceps*	0.00	0.00

Van Damme

Physical characteristics and primary substrate cover at Van Damme State Beach site (2014-2015)

Average depth	7.69 meters	Depth range 3.4 – 11.4 meters

Substrate type	Percentage
Bedrock	55.00%
Boulders	9.72%
Cobble	28.06%
Sand	7.22%
Other	0.00%

Relief	Percentage
0-10cm	10.00%
10 cm-1meter	80.00%
1-2meter	7.22%
>2 meters	2.78%

Substrate Cover	Percentage
Articulated coralline	7.22%
Brown seaweed	1.11%
Crustose coralline	45.00%
Green seaweed	0.28%
Mobile invertebrates	6.39%
None	10.83%
Other brown seaweed	4.17%
Red seaweed	21.67%
Sessile invertebrates	3.33%

Algae Density (60 m^2) for Van Damme State Beach site (2014-2015)

Common Name	Scientific Name	Density	Standard Error
Pterygophora	*Pterygophora californica*	31.09	25.93
Bull kelp	*Nereocustis luetkeana*	0.25	0.25
Laminaria	*Laminaria Spp*	0.42	0.25
Giant kelp	*Macrocystis pyrifera*	0.42	0.42
Giant kelp stipes	*Macrocystis pyrifera*	29.92	29.92
Southern sea palm	*Eisenia arborea*	0.00	0.00

Invertebrate Density (60 m^2) for Van Damme State Beach site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Purple urchin	*Strongylocentrotus purpuratus*	129.83	117.67
Red urchin	*Strongylocentrotus Franciscanus*	72.82	27.40
Red abalone	*Haliotis rufescens*	31.04	6.71
Flat abalone	*Haliotis wallensis*	0.42	0.25
Pinto abalone	*Haliotis kantschatkana*	2.67	0.67
Bat star	*Patiria miniata*	27.65	2.90
Giant spine star	*Pisaster giganteus*	0.00	0.00
Short spine star	*Pisaster brevispinus*	0.00	0.00
Sun/sunflower star	*Solaster spp./ Pycnopodia spp.*	0.00	0.00
Large anemone	*Anemone Spp*	2.25	1.25
Gumboot chiton	*Cryptochiton stelleri*	2.33	1.83
Rock scallop	*Crassedoma giganteum*	0.17	0.17
wavy/red turban snail	*Lithopoma Undosum*	0.17	0.17
Rock crab	*Cancer Spp.*	0.00	0.00
Sheep/masking crab	*Loxorhynchus spp.*	0.08	0.08
CA sea cucumber	*Parastichopus californicus*	3.75	2.92
warty sea cucumber	*Parastichopus parvimensis*	0.00	0.00
CA spiny lobster	*Panulirus interruptus*	0.00	0.00
Green abalone	*Haliotis fulgens*	0.00	0.00
Pink abalone	*Haliotis corrugata*	0.00	0.00
Chestnut cowry	*Cyoraes soadicea*	0.00	0.00
Kellet’s whelk	*Kelletia kelletii*	0.00	0.00
Giant keyhole limpet	*Megathura crenulata*	0.00	0.00
Brown/golden gorgonian	*Muricea fruticosa, M. californica*	0.00	0.00
Red gorgonian	*Leophogorgia chilensis*	0.00	0.00

Fish Density (60 m^2) for Van Damme State Beach site (2014-2015)

Common Name	Scientific Name	Mean Density	Standard Error
Black rockfish	*Sebastes melanops*	0.08	0.08
Black and yellow rockfish	*Sebastes chrysomelas*	0.00	0.00
Blue rockfish	*Sebastes mystinus*	0.33	0.33
Brown rockfish	*Sebastes auriculatus*	0.00	0.00
China rockfish	*Sebastes nebulosus*	0.00	0.00
Copper rockfish	*Sebastes caurinus*	0.00	0.00
Gopher rockfish	*Sebastes carnatus*	0.08	0.08
Grass rockfish	*Sebastes rastrelliger*	0.00	0.00
Kelp rockfish	*Sebastes atrovirens*	0.00	0.00
Vermillion/Canary rockfish	*Sebastes miniatus*	0.00	0.00
Yellowtail/Olive rockfish	*Sebastes serranoides*	0.00	0.00
YOY rockfish	*Sebastes spp.*	0.22	0.11
Black perch	*Embiotoca Jacksoni*	0.00	0.00
Pile perch	*Rhacochilus vacca*	0.00	0.00
Rainbow perch	*Hypsurus caryi*	0.00	0.00
Rubberlip perch	*Rhacochilus toxotes*	0.00	0.00
Striped perch	*Embiotoca lateralis*	0.06	0.06
Kelp greenling	*Hexagrammos decagrammus*	1.22	0.00
Lingcod	*Ophiodon elongatus*	0.06	0.06
Cabezon	*Scorpaenichthys marmoratus*	0.00	0.00
Rock greenling	*Hexagrammos lagocephalus*	0.00	0.00
Barred sand bass	*Paralabrax nebulifer*	0.00	0.00
Blacksmith	*Chromis punctipinnis*	0.00	0.00
Bocaccio	*Sebastes paucispinis*	0.00	0.00
Garibaldi	*Hypsypops rubicundus*	0.00	0.00
Horn shark	*Heterodontus francisci*	0.00	0.00
Kelp bass	*Paralabrax clathratus*	0.00	0.00
Opaleye	*Girella nigricans*	0.00	0.00
Rock wrasse	*Halichoeres semicinctus*	0.00	0.00
Sargo	*Anisotermus davidsoni*	0.00	0.00
Senorita	*Oxyjulis californica*	0.00	0.00
CA sheephead	*Semicossyphus pulcher*	0.00	0.00
Treefish	*Sebastes serriceps*	0.00	0.00

Appendix D

SIMPER Analyses

Results of a SIMPER analysis of the differences among communities identified as significantly different (alpha =0.05) in a Simprof test in a Cluster analysis in PRIMER:

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Data2 -weighted and square root transformed
Data type: Abundance
Sample selection: All
Variable selection: 1-20,22-43

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

```
Sample                symprof all spp_w/o YOY
Caspar                d
Caspar North          d
Frolic Cove           e
Glass Beach           e
Mendocino Headlands   c
Portuguese Beach      a
Russian Gulch         a
Van Damme             b
```

Group d
Average similarity: 84.59

```
Species            Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
purple_urchin          4.41   19.82 #######     23.43  23.43
blue_rockfish          2.91   12.24 #######     14.46  37.89
red_urchin             2.50   11.44 #######     13.53  51.42
kelp_greenling         1.45    6.74 #######      7.96  59.39
bat_star               1.44    5.41 #######      6.39  65.78
striped_perch          1.33    5.21 #######      6.16  71.94
black_rockfish         0.83    4.05 #######      4.78  76.72
red_abalone            0.87    3.52 #######      4.16  80.88
pterygophora           0.88    3.22 #######      3.80  84.69
gopher_rockfish        0.44    1.93 #######      2.28  86.97
yellowtail_olive       0.41    1.93 #######      2.28  89.25
gumboot_chiton         0.36    1.58 #######      1.87  91.12
```

Group e
Average similarity: 70.16

```
Species            Av.Abund  Av.Sim   Sim/SD  Contrib%  Cum.%
purple_urchin          1.88    9.87  #######     14.07  14.07
striped_perch          1.49    7.74  #######     11.03  25.10
red_abalone            1.37    7.73  #######     11.01  36.11
black_rockfish         1.62    6.85  #######      9.76  45.87
kelp_greenling         1.38    6.47  #######      9.23  55.10
bat_star               1.30    6.23  #######      8.88  63.98
blue_rockfish          1.49    6.16  #######      8.78  72.76
pterygophora           1.94    4.95  #######      7.06  79.82
red_urchin             0.96    3.50  #######      4.99  84.81
lingcod                0.55    2.00  #######      2.85  87.66
black_and_yellow       0.46    1.73  #######      2.47  90.13
```

Group c
Less than 2 samples in group

Group a
Average similarity: 67.58

```
Species          Av.Abund  Av.Sim   Sim/SD  Contrib%  Cum.%
pterygophora         3.49   23.56  #######     34.87  34.87
bull_kelp            1.29    6.77  #######     10.02  44.89
kelp_greenling       0.91    6.38  #######      9.44  54.33
striped_perch        1.10    6.24  #######      9.24  63.57
red_abalone          1.06    6.07  #######      8.98  72.54
red_urchin           0.54    3.36  #######      4.97  77.51
purple_urchin        1.09    2.98  #######      4.41  81.93
pile_perch           0.43    2.30  #######      3.41  85.34
gumboot_chiton       0.41    2.18  #######      3.22  88.56
bat_star             0.89    1.66  #######      2.46  91.02
```

Group b
Less than 2 samples in group

Groups d & e
Average dissimilarity = 34.94

```
                    Group d   Group e
Species            Av.Abund  Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
purple_urchin          4.41      1.88     6.59     6.61     18.87  18.87
red_urchin             2.50      0.96     4.01     3.87     11.48  30.34
blue_rockfish          2.91      1.49     3.71     2.20     10.63  40.97
pterygophora           0.88      1.94     3.09     1.04      8.84  49.81
black_rockfish         0.83      1.62     2.06     1.70      5.91  55.71
red_abalone            0.87      1.37     1.32     2.72      3.78  59.50
black_perch            0.09      0.50     1.08     1.35      3.08  62.58
cabezon                0.13      0.53     1.04     1.38      2.97  65.55
bat_star               1.44      1.30     0.88     1.20      2.51  68.05
laminaria_spp          0.00      0.33     0.87     4.46      2.50  70.55
gopher_rockfish        0.44      0.13     0.81     2.06      2.33  72.88
china_rockfish         0.29      0.00     0.77     2.12      2.20  75.08
yellowtail_olive       0.41      0.13     0.75     2.01      2.16  77.24
pile_perch             0.28      0.28     0.73     8.06      2.10  79.34
striped_perch          1.33      1.49     0.71     1.22      2.02  81.36
lingcod                0.28      0.55     0.70     1.18      2.01  83.37
kelp_greenling         1.45      1.38     0.61     2.01      1.74  85.11
kelp_rockfish          0.00      0.22     0.56     0.87      1.61  86.71
rainbow_perch          0.00      0.22     0.56     0.87      1.61  88.32
rubberlip_perch        0.00      0.22     0.56     0.87      1.61  89.92
ca_sea_cucumber        0.19      0.00     0.50     4.52      1.42  91.34
```

Groups d & c
Average dissimilarity = 23.81

```
                   Group d  Group c
Species            Av.Abund Av.Abund Av.Diss Diss/SD Contrib% Cum.%
red_abalone            0.87     2.23    3.23    5.49    13.56 13.56
purple_urchin          4.41     5.44    2.47    2.06    10.38 23.94
blue_rockfish          2.91     2.06    2.01    1.55     8.45 32.39
red_urchin             2.50     1.69    1.90    4.18     7.98 40.38
kelp_greenling         1.45     1.96    1.21    6.03     5.08 45.45
striped_perch          1.33     1.76    1.04    1.17     4.38 49.83
yellowtail_olive       0.41     0.00    0.98   11.07     4.13 53.96
large_anemone          0.33     0.74    0.96    3.22     4.03 57.99
pile_perch             0.28     0.69    0.96   12.92     4.03 62.02
cabezon                0.13     0.53    0.95    2.38     4.00 66.02
black_and_yellow       0.33     0.00    0.79    7.02     3.33 69.35
bat_star               1.44     1.35    0.78    2.39     3.29 72.64
china_rockfish         0.29     0.00    0.69    1.74     2.92 75.55
giant_spined_star      0.00     0.29    0.69   38.42     2.88 78.44
lingcod                0.28     0.00    0.67   10.31     2.80 81.24
pterygophora           0.88     0.64    0.57    0.78     2.40 83.63
bull_kelp              0.17     0.00    0.40    0.71     1.69 85.33
rock_greenling         0.16     0.00    0.38    0.71     1.60 86.92
pinto_abalone          0.09     0.24    0.36    8.77     1.50 88.43
black_rockfish         0.83     0.97    0.33   38.42     1.39 89.81
gopher_rockfish        0.44     0.31    0.31    2.13     1.30 91.12
```

Groups e & c
Average dissimilarity = 34.67

```
                   Group e  Group c
Species            Av.Abund Av.Abund Av.Diss Diss/SD Contrib% Cum.%
purple_urchin          1.88     5.44    9.04   14.68    26.07 26.07
pterygophora           1.94     0.64    3.32    0.86     9.59 35.65
red_abalone            1.37     2.23    2.18   40.33     6.28 41.93
red_urchin             0.96     1.69    1.85    1.56     5.34 47.28
black_rockfish         1.62     0.97    1.65    1.14     4.75 52.03
kelp_greenling         1.38     1.96    1.47    1.81     4.25 56.28
blue_rockfish          1.49     2.06    1.45    0.99     4.17 60.45
lingcod                0.55     0.00    1.40    2.02     4.03 64.48
black_perch            0.50     0.00    1.26    1.44     3.64 68.12
large_anemone          0.27     0.74    1.17    7.55     3.38 71.50
black_and_yellow       0.46     0.00    1.16    2.19     3.35 74.85
pile_perch             0.28     0.69    1.02    1.03     2.95 77.80
laminaria_spp          0.33     0.00    0.85    3.66     2.44 80.24
giant_spined_star      0.00     0.29    0.74   64.57     2.12 82.36
striped_perch          1.49     1.76    0.69    1.71     2.00 84.36
cabezon                0.53     0.53    0.56   33.63     1.63 85.98
kelp_rockfish          0.22     0.00    0.54    0.71     1.57 87.55
rainbow_perch          0.22     0.00    0.54    0.71     1.57 89.12
rubberlip_perch        0.22     0.00    0.54    0.71     1.57 90.69
```

Groups d & a
Average dissimilarity = 51.45

```
                 Group d  Group a
Species          Av.Abund Av.Abund Av.Diss Diss/SD Contrib% Cum.%
purple_urchin        4.41     1.09    9.79    3.82    19.02 19.02
blue_rockfish        2.91     0.24    7.89    5.61    15.34 34.36
```

```
pterygophora        0.88     3.49    7.72    4.98     15.00  49.36
red_urchin          2.50     0.54    5.77   11.48     11.21  60.57
bull_kelp           0.17     1.29    3.32    2.34      6.45  67.02
bat_star            1.44     0.89    2.29    1.29      4.45  71.48
black_rockfish      0.83     0.15    2.00    3.84      3.89  75.37
kelp_greenling      1.45     0.91    1.61    4.61      3.13  78.49
gopher_rockfish     0.44     0.00    1.30    7.41      2.52  81.01
yellowtail_olive    0.41     0.00    1.23   12.64      2.39  83.40
striped_perch       1.33     1.10    1.11    1.52      2.15  85.55
red_abalone         0.87     1.06    0.88    1.34      1.71  87.26
black_and_yellow    0.33     0.09    0.73    2.27      1.41  88.68
china_rockfish      0.29     0.09    0.61    1.20      1.18  89.86
large_anemone       0.33     0.22    0.49    1.42      0.95  90.80
```

Groups e & a
Average dissimilarity = 40.21

```
                  Group e  Group a
Species           Av.Abund Av.Abund Av.Diss Diss/SD Contrib% Cum.%
pterygophora        1.94     3.49    4.95    1.21     12.31  12.31
black_rockfish      1.62     0.15    4.72    3.04     11.74  24.05
bull_kelp           0.00     1.29    4.17    2.87     10.36  34.41
blue_rockfish       1.49     0.24    4.02    2.42     10.01  44.42
purple_urchin       1.88     1.09    2.61    1.02      6.49  50.91
bat_star            1.30     0.89    2.16    1.32      5.38  56.28
cabezon             0.53     0.00    1.69    2.12      4.21  60.50
kelp_greenling      1.38     0.91    1.53    1.66      3.80  64.30
red_urchin          0.96     0.54    1.39    1.08      3.45  67.75
striped_perch       1.49     1.10    1.25    1.13      3.12  70.87
black_and_yellow    0.46     0.09    1.19    1.86      2.96  73.83
lingcod             0.55     0.21    1.08    1.48      2.70  76.52
red_abalone         1.37     1.06    1.01    1.07      2.51  79.03
black_perch         0.50     0.21    0.91    0.99      2.27  81.30
pile_perch          0.28     0.43    0.90    1.23      2.23  83.53
rainbow_perch       0.22     0.13    0.69    1.21      1.73  85.26
kelp_rockfish       0.22     0.00    0.69    0.87      1.71  86.97
rubberlip_perch     0.22     0.00    0.69    0.87      1.71  88.69
laminaria_spp       0.33     0.15    0.65    1.23      1.61  90.29
```

Groups c & a
Average dissimilarity = 55.08

```
                 Group c  Group a
Species          Av.Abund Av.Abund Av.Diss Diss/SD Contrib% Cum.%
purple_urchin      5.44     1.09   12.43    4.37     22.57  22.57
pterygophora       0.64     3.49    8.14    5.65     14.77  37.34
blue_rockfish      2.06     0.24    5.20    5.54      9.44  46.78
bull_kelp          0.00     1.29    3.69    2.34      6.70  53.49
red_abalone        2.23     1.06    3.35    3.29      6.08  59.56
red_urchin         1.69     0.54    3.28    8.08      5.96  65.52
kelp_greenling     1.96     0.91    3.01   11.90      5.47  70.98
black_rockfish     0.97     0.15    2.33    3.81      4.23  75.21
bat_star           1.35     0.89    1.91    1.05      3.48  78.69
striped_perch      1.76     1.10    1.89    1.72      3.43  82.12
cabezon            0.53     0.00    1.52  323.47      2.75  84.87
large_anemone      0.74     0.22    1.48    2.68      2.68  87.56
gopher_rockfish    0.31     0.00    0.88  323.47      1.59  89.15
pile_perch         0.69     0.43    0.72    1.41      1.31  90.46
```

Groups d & b

Average dissimilarity = 39.18

```
                    Group d  Group b
Species            Av.Abund Av.Abund Av.Diss Diss/SD Contrib% Cum.%
blue_rockfish          2.91     0.61    6.38    4.59    16.29 16.29
purple_urchin          4.41     2.34    5.75    4.95    14.68 30.97
giant_kelp_stipes      0.00     1.91    5.32   32.67    13.57 44.54
striped_perch          1.33     0.25    2.98    3.24     7.61 52.15
pterygophora           0.88     1.95    2.98    3.09     7.60 59.75
red_urchin             2.50     1.75    2.08    3.93     5.31 65.05
black_rockfish         0.83     0.31    1.46   32.67     3.72 68.78
yellowtail_olive       0.41     0.00    1.16   10.53     2.95 71.73
bat_star               1.44     1.08    1.03    0.77     2.62 74.35
black_and_yellow       0.33     0.00    0.93    6.80     2.38 76.73
china_rockfish         0.29     0.00    0.82    1.73     2.09 78.81
pile_perch             0.28     0.00    0.78    5.56     2.00 80.81
kelp_greenling         1.45     1.17    0.78    2.62     1.98 82.79
red_abalone            0.87     1.14    0.76    1.23     1.94 84.73
pinto_abalone          0.09     0.33    0.67   11.69     1.72 86.45
giant_kelp             0.00     0.23    0.63   32.67     1.60 88.05
laminaria_spp          0.00     0.23    0.63   32.67     1.60 89.65
ca_sea_cucumber        0.19     0.40    0.58    5.25     1.47 91.13
```

Groups e & b
Average dissimilarity = 39.02

```
                    Group e  Group b
Species            Av.Abund Av.Abund Av.Diss Diss/SD Contrib% Cum.%
giant_kelp_stipes      0.00     1.91    5.76   54.23    14.77 14.77
black_rockfish         1.62     0.31    3.96    2.36    10.15 24.92
striped_perch          1.49     0.25    3.74    6.63     9.58 34.51
pterygophora           1.94     1.95    3.20  170.25     8.19 42.69
blue_rockfish          1.49     0.61    2.63    1.59     6.75 49.44
red_urchin             0.96     1.75    2.37    1.69     6.08 55.52
cabezon                0.53     0.00    1.59    1.73     4.07 59.59
black_perch            0.50     0.00    1.50    1.44     3.85 63.44
black_and_yellow       0.46     0.00    1.38    2.20     3.54 66.99
purple_urchin          1.88     2.34    1.37    2.32     3.52 70.51
ca_sea_cucumber        0.00     0.40    1.20   54.23     3.07 73.58
pinto_abalone          0.03     0.33    0.92    8.42     2.36 75.94
lingcod                0.55     0.25    0.90    1.09     2.32 78.26
pile_perch             0.28     0.00    0.86    0.71     2.19 80.45
kelp_greenling         1.38     1.17    0.71    0.80     1.82 82.27
red_abalone            1.37     1.14    0.70   62.93     1.80 84.08
giant_kelp             0.00     0.23    0.68   54.23     1.74 85.82
bat_star               1.30     1.08    0.65    0.81     1.67 87.49
kelp_rockfish          0.22     0.00    0.65    0.71     1.66 89.14
rainbow_perch          0.22     0.00    0.65    0.71     1.66 90.80
```

Groups c & b
Average dissimilarity = 42.27

```
                    Group c  Group b
Species            Av.Abund Av.Abund Av.Diss     Diss/SD Contrib% Cum.%
purple_urchin          5.44     2.34    8.38  Undefined!    19.82 19.82
giant_kelp_stipes      0.00     1.91    5.14  Undefined!    12.17 31.99
striped_perch          1.76     0.25    4.07  Undefined!     9.63 41.62
blue_rockfish          2.06     0.61    3.89  Undefined!     9.20 50.82
pterygophora           0.64     1.95    3.53  Undefined!     8.34 59.16
red_abalone            2.23     1.14    2.94  Undefined!     6.96 66.12
kelp_greenling         1.96     1.17    2.13  Undefined!     5.03 71.15
```

```
pile_perch            0.69      0.00     1.85  Undefined!      4.37  75.52
black_rockfish        0.97      0.31     1.79  Undefined!      4.23  79.75
cabezon               0.53      0.00     1.43  Undefined!      3.39  83.14
large_anemone         0.74      0.31     1.16  Undefined!      2.74  85.87
ca_sea_cucumber       0.06      0.40     0.91  Undefined!      2.15  88.03
giant_spined_star     0.29      0.00     0.78  Undefined!      1.85  89.87
bat_star              1.35      1.08     0.73  Undefined!      1.72  91.59
```

Groups a & b
Average dissimilarity = 42.54

```
                     Group a   Group b
Species              Av.Abund  Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
giant_kelp_stipes       0.00      1.91     6.65   265.10     15.63  15.63
pterygophora            3.49      1.95     5.37     3.07     12.62  28.25
purple_urchin           1.09      2.34     4.34     1.26     10.20  38.45
red_urchin              0.54      1.75     4.20     8.41      9.87  48.32
bull_kelp               1.29      0.17     3.90     2.03      9.16  57.48
striped_perch           1.10      0.25     2.96     2.24      6.96  64.44
bat_star                0.89      1.08     2.34     2.59      5.50  69.93
pile_perch              0.43      0.00     1.51     2.44      3.55  73.48
blue_rockfish           0.24      0.61     1.31     1.13      3.08  76.56
gopher_rockfish         0.00      0.31     1.07   265.10      2.51  79.08
pinto_abalone           0.03      0.33     1.06     7.50      2.50  81.57
kelp_greenling          0.91      1.17     0.92     3.07      2.17  83.75
red_abalone             1.06      1.14     0.88     2.24      2.08  85.83
giant_kelp              0.00      0.23     0.78   265.10      1.84  87.67
ca_sea_cucumber         0.18      0.40     0.75    10.97      1.76  89.43
black_perch             0.21      0.00     0.74     4.18      1.75  91.18
```

Results of a SIMPER analysis of the differences among fish assemblages identified as significantly different (alpha =0.05) in a Simprof test in a Cluster analysis in PRIMER:

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Data2 -weighted and square root transformed
Data type: Abundance
Sample selection: All
Variable selection: 1-20

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

```
Sample                symprof_fish_w/o YOY
Caspar                b
Caspar North          b
Frolic Cove           b
Mendocino Headlands   b
Glass Beach           a
Portuguese Beach      c
Russian Gulch         c
Van Damme             c
```

Group b
Average similarity: 76.36

```
Species          Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
blue_rockfish        2.24   19.05    2.87     24.95  24.95
kelp_greenling       1.62   17.18    9.00     22.50  47.45
striped_perch        1.50   15.56    4.39     20.37  67.82
black_rockfish       0.96    9.99    9.38     13.08  80.90
pile_perch           0.45    3.80    2.36      4.98  85.88
gopher_rockfish      0.36    3.41    6.42      4.46  90.34
```

Group a
Less than 2 samples in group

Group c
Average similarity: 58.35

```
Species         Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
kelp_greenling      1.00   26.69    9.27     45.74  45.74
striped_perch       0.82   12.93    1.44     22.17  67.91
lingcod             0.23    6.05    4.31     10.38  78.28
blue_rockfish       0.36    4.94    0.58      8.47  86.75
black_rockfish      0.20    3.21    0.58      5.50  92.24
```

Groups b & a
Average dissimilarity = 37.93

```
                   Group b  Group a
Species            Av.Abund Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
black_rockfish         0.96     2.03     5.58     7.11     14.70  14.70
blue_rockfish          2.24     1.89     3.88     1.50     10.24  24.94
black_perch            0.11     0.75     3.36     5.08      8.86  33.79
lingcod                0.23     0.75     2.72     3.19      7.18  40.97
kelp_greenling         1.62     1.15     2.49     1.85      6.56  47.53
cabezon                0.27     0.75     2.47     2.35      6.52  54.05
pile_perch             0.45     0.00     2.38     2.09      6.27  60.32
kelp_rockfish          0.00     0.43     2.26    27.02      5.97  66.29
rainbow_perch          0.00     0.43     2.26    27.02      5.97  72.25
rubberlip_perch        0.00     0.43     2.26    27.02      5.97  78.22
black_and_yellow       0.24     0.61     1.93     2.18      5.10  83.32
gopher_rockfish        0.36     0.00     1.86     3.87      4.89  88.21
striped_perch          1.50     1.37     1.49     3.38      3.92  92.13
```

Groups b & c
Average dissimilarity = 49.54

```
                   Group b  Group c
Species            Av.Abund Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
blue_rockfish          2.24     0.36    15.45     2.36     31.19  31.19
black_rockfish         0.96     0.20     6.41     3.10     12.94  44.13
striped_perch          1.50     0.82     6.32     1.49     12.76  56.89
kelp_greenling         1.62     1.00     5.27     2.28     10.64  67.53
cabezon                0.27     0.00     2.36     1.38      4.76  72.29
pile_perch             0.45     0.29     2.28     1.20      4.61  76.90
yellowtail_olive       0.27     0.00     2.23     1.55      4.51  81.41
gopher_rockfish        0.36     0.10     2.18     1.72      4.40  85.81
black_and_yellow       0.24     0.06     1.80     1.63      3.63  89.43
china_rockfish         0.15     0.06     1.21     0.96      2.43  91.87
```

Groups a & c
Average dissimilarity = 58.73

```
                   Group a  Group c
Species            Av.Abund Av.Abund  Av.Diss  Diss/SD  Contrib%  Cum.%
black_rockfish         2.03     0.20    13.10    12.65     22.31  22.31
blue_rockfish          1.89     0.36    10.92     5.35     18.60  40.91
cabezon                0.75     0.00     5.39    35.15      9.17  50.09
black_perch            0.75     0.14     4.38     4.14      7.46  57.55
striped_perch          1.37     0.82     4.05     0.97      6.89  64.44
black_and_yellow       0.61     0.06     3.98     5.15      6.78  71.21
lingcod                0.75     0.23     3.76    13.11      6.41  77.62
kelp_rockfish          0.43     0.00     3.11    35.15      5.30  82.92
rubberlip_perch        0.43     0.00     3.11    35.15      5.30  88.21
rainbow_perch          0.43     0.08     2.52     2.35      4.30  92.51
```

Appendix E

Fish Sizes at Study Sites

Average and median fish sizes at RCCA study sites during the baseline period 2014/15. Data from both years is pooled.

Site	Species	N	Mean size (cm)	Standard Error	Median size (cm)
Glass Beach	black rockfish	22	12.27	0.54	10.0
Glass Beach	blue rockfish	19	13.47	1.68	10.0
Glass Beach	cabezon	3	30.00	9.64	33.0
Glass Beach	kelp greenling	7	26.14	3.47	27.0
Glass Beach	lingcod	3	43.33	4.37	40.0
Glass Beach	striped perch	10	15.50	1.71	15.5
Caspar North	black rockfish	26	17.58	1.38	20.0
Caspar North	blue rockfish	375	9.70	0.28	8.0
Caspar North	cabezon	2	65.00	15.00	65.0
Caspar North	kelp greenling	73	25.45	1.15	25.0
Caspar North	lingcod	7	62.57	7.39	48.0
Caspar North	pile perch	2	26.50	1.50	26.5
Caspar North	striped perch	101	11.91	0.63	10.0
Caspar	black rockfish	29	14.98	1.08	15.0
Caspar	blue rockfish	225	10.33	0.25	8.0
Caspar	cabezon	2	30.00	5.00	30.0
Caspar	kelp greenling	83	21.61	0.89	21.0
Caspar	lingcod	6	44.67	7.65	41.5
Caspar	pile perch	3	22.67	1.67	21.0
Caspar	striped perch	47	13.28	0.95	12.0
Frolic Cove	black rockfish	60	23.47	1.31	25.0
Frolic Cove	blue rockfish	59	12.31	0.61	10.0
Frolic Cove	cabezon	11	43.82	2.92	45.0
Frolic Cove	kelp greenling	97	26.96	0.92	26.0
Frolic Cove	lingcod	10	69.60	3.72	70.0
Frolic Cove	pile perch	24	26.79	1.72	25.0
Frolic Cove	striped perch	113	15.80	0.67	15.0
Russian Gulch	black rockfish	3	27.00	1.53	28.0
Russian Gulch	blue rockfish	7	11.57	1.86	11.0
Russian Gulch	kelp greenling	46	31.83	1.27	32.0
Russian Gulch	lingcod	2	47.00	5.00	47.0
Russian Gulch	pile perch	3	21.67	4.63	21.0
Russian Gulch	striped perch	29	21.52	1.52	23.0

Mendocino Headlands	black rockfish	19	25.32	1.25	25.0
Mendocino Headlands	blue rockfish	84	7.68	0.27	8.0
Mendocino Headlands	cabezon	5	31.60	5.91	35.0
Mendocino Headlands	kelp greenling	51	26.08	1.32	25.0
Mendocino Headlands	pile perch	6	15.33	1.73	15.0
Mendocino Headlands	striped perch	46	16.46	1.17	15.0
Portuguese Beach	kelp greenling	15	31.60	1.46	32.0
Portuguese Beach	lingcod	1	75.00		75.0
Portuguese Beach	pile perch	5	24.00	1.64	25.0
Portuguese Beach	striped perch	30	23.43	0.50	24.3
Van Damme	black rockfish	36	22.14	1.15	20.0
Van Damme	blue rockfish	92	13.77	0.49	12.8
Van Damme	kelp greenling	60	26.43	1.36	27.0
Van Damme	lingcod	10	38.70	6.87	35.0
Van Damme	pile perch	1	15.00		15.0
Van Damme	striped perch	13	20.54	1.96	20.0

Fish Size Frequencies

Fish size frequency distributions for all RCCA study sites during the baseline period 2014/15. Data from both years is pooled.

Site	Species	Mid point of size bin (cm)	Percent	Count
Caspar	black rockfish	5	13.79	4
Caspar	black rockfish	10	17.24	5
Caspar	black rockfish	15	31.03	9
Caspar	black rockfish	20	31.03	9
Caspar	black rockfish	25	3.45	1
Caspar	black rockfish	30	3.45	1
Caspar	blue rockfish	5	10.67	24
Caspar	blue rockfish	10	68.00	153
Caspar	blue rockfish	15	10.22	23
Caspar	blue rockfish	20	11.11	25
Caspar	cabezon	25	50.00	1
Caspar	cabezon	30	0.00	0
Caspar	cabezon	35	50.00	1
Caspar	kelp greenling	10	20.48	17
Caspar	kelp greenling	15	9.64	8
Caspar	kelp greenling	20	26.51	22
Caspar	kelp greenling	25	16.87	14
Caspar	kelp greenling	30	16.87	14
Caspar	kelp greenling	35	7.23	6
Caspar	kelp greenling	40	2.41	2
Caspar	lingcod	25	16.67	1
Caspar	lingcod	30	16.67	1
Caspar	lingcod	35	0.00	0
Caspar	lingcod	40	33.33	2
Caspar	lingcod	45	0.00	0
Caspar	lingcod	50	0.00	0
Caspar	lingcod	55	16.67	1
Caspar	lingcod	60	0.00	0
Caspar	lingcod	65	0.00	0
Caspar	lingcod	70	0.00	0
Caspar	lingcod	75	16.67	1
Caspar	pile perch	20	66.67	2
Caspar	pile perch	25	33.33	1
Caspar	striped perch	5	6.38	3
Caspar	striped perch	10	53.19	25
Caspar	striped perch	15	12.77	6
Caspar	striped perch	20	17.02	8
Caspar	striped perch	25	6.38	3
Caspar	striped perch	30	4.26	2
Caspar North	black rockfish	5	7.69	2

Caspar North	black rockfish	10	26.92	7
Caspar North	black rockfish	15	3.85	1
Caspar North	black rockfish	20	42.31	11
Caspar North	black rockfish	25	7.69	2
Caspar North	black rockfish	30	11.54	3
Caspar North	blue rockfish	5	43.20	162
Caspar North	blue rockfish	10	39.73	149
Caspar North	blue rockfish	15	5.33	20
Caspar North	blue rockfish	20	6.67	25
Caspar North	blue rockfish	25	2.93	11
Caspar North	blue rockfish	30	2.13	8
Caspar North	cabezon	50	50.00	1
Caspar North	cabezon	55	0.00	0
Caspar North	cabezon	60	0.00	0
Caspar North	cabezon	65	0.00	0
Caspar North	cabezon	70	0.00	0
Caspar North	cabezon	75	0.00	0
Caspar North	cabezon	80	50.00	1
Caspar North	kelp greenling	10	12.33	9
Caspar North	kelp greenling	15	13.70	10
Caspar North	kelp greenling	20	12.33	9
Caspar North	kelp greenling	25	17.81	13
Caspar North	kelp greenling	30	23.29	17
Caspar North	kelp greenling	35	6.85	5
Caspar North	kelp greenling	40	8.22	6
Caspar North	kelp greenling	45	5.48	4
Caspar North	lingcod	45	14.29	1
Caspar North	lingcod	50	42.86	3
Caspar North	lingcod	55	0.00	0
Caspar North	lingcod	60	0.00	0
Caspar North	lingcod	65	0.00	0
Caspar North	lingcod	70	0.00	0
Caspar North	lingcod	75	0.00	0
Caspar North	lingcod	80	14.29	1
Caspar North	lingcod	85	28.57	2
Caspar North	pile perch	25	50.00	1
Caspar North	pile perch	30	50.00	1
Caspar North	striped perch	5	23.76	24
Caspar North	striped perch	10	44.55	45
Caspar North	striped perch	15	8.91	9
Caspar North	striped perch	20	15.84	16
Caspar North	striped perch	25	4.95	5
Caspar North	striped perch	30	0.99	1
Caspar North	striped perch	35	0.99	1
Frolic Cove	black rockfish	5	10.00	6
Frolic Cove	black rockfish	10	15.00	9
Frolic Cove	black rockfish	15	3.33	2

Frolic Cove	black rockfish	20	8.33	5
Frolic Cove	black rockfish	25	18.33	11
Frolic Cove	black rockfish	30	28.33	17
Frolic Cove	black rockfish	35	11.67	7
Frolic Cove	black rockfish	40	3.33	2
Frolic Cove	black rockfish	45	1.67	1
Frolic Cove	blue rockfish	5	6.78	4
Frolic Cove	blue rockfish	10	55.93	33
Frolic Cove	blue rockfish	15	16.95	10
Frolic Cove	blue rockfish	20	20.34	12
Frolic Cove	cabezon	30	18.18	2
Frolic Cove	cabezon	35	9.09	1
Frolic Cove	cabezon	40	0.00	0
Frolic Cove	cabezon	45	36.36	4
Frolic Cove	cabezon	50	27.27	3
Frolic Cove	cabezon	55	0.00	0
Frolic Cove	cabezon	60	9.09	1
Frolic Cove	kelp greenling	10	6.19	6
Frolic Cove	kelp greenling	15	9.28	9
Frolic Cove	kelp greenling	20	20.62	20
Frolic Cove	kelp greenling	25	15.46	15
Frolic Cove	kelp greenling	30	19.59	19
Frolic Cove	kelp greenling	35	13.40	13
Frolic Cove	kelp greenling	40	13.40	13
Frolic Cove	kelp greenling	45	2.06	2
Frolic Cove	lingcod	50	10.00	1
Frolic Cove	lingcod	55	10.00	1
Frolic Cove	lingcod	60	10.00	1
Frolic Cove	lingcod	65	0.00	0
Frolic Cove	lingcod	70	40.00	4
Frolic Cove	lingcod	75	0.00	0
Frolic Cove	lingcod	80	10.00	1
Frolic Cove	lingcod	85	20.00	2
Frolic Cove	pile perch	10	12.50	3
Frolic Cove	pile perch	15	0.00	0
Frolic Cove	pile perch	20	8.33	2
Frolic Cove	pile perch	25	33.33	8
Frolic Cove	pile perch	30	8.33	2
Frolic Cove	pile perch	35	29.17	7
Frolic Cove	pile perch	40	8.33	2
Frolic Cove	striped perch	5	12.39	14
Frolic Cove	striped perch	10	24.78	28
Frolic Cove	striped perch	15	28.32	32
Frolic Cove	striped perch	20	17.70	20
Frolic Cove	striped perch	25	10.62	12
Frolic Cove	striped perch	30	4.42	5
Frolic Cove	striped perch	35	1.77	2

Glass Beach	black rockfish	10	54.55	12
Glass Beach	black rockfish	15	45.45	10
Glass Beach	blue rockfish	5	21.05	4
Glass Beach	blue rockfish	10	36.84	7
Glass Beach	blue rockfish	15	10.53	2
Glass Beach	blue rockfish	20	10.53	2
Glass Beach	blue rockfish	25	21.05	4
Glass Beach	cabezon	10	33.33	1
Glass Beach	cabezon	15	0.00	0
Glass Beach	cabezon	20	0.00	0
Glass Beach	cabezon	25	0.00	0
Glass Beach	cabezon	30	0.00	0
Glass Beach	cabezon	35	33.33	1
Glass Beach	cabezon	40	0.00	0
Glass Beach	cabezon	45	33.33	1
Glass Beach	kelp greenling	15	28.57	2
Glass Beach	kelp greenling	20	14.29	1
Glass Beach	kelp greenling	25	14.29	1
Glass Beach	kelp greenling	30	14.29	1
Glass Beach	kelp greenling	35	28.57	2
Glass Beach	lingcod	40	66.67	2
Glass Beach	lingcod	45	0.00	0
Glass Beach	lingcod	50	33.33	1
Glass Beach	striped perch	5	10.00	1
Glass Beach	striped perch	10	20.00	2
Glass Beach	striped perch	15	30.00	3
Glass Beach	striped perch	20	40.00	4
Mendocino Headlands	black rockfish	15	10.53	2
Mendocino Headlands	black rockfish	20	26.32	5
Mendocino Headlands	black rockfish	25	26.32	5
Mendocino Headlands	black rockfish	30	31.58	6
Mendocino Headlands	black rockfish	35	5.26	1
Mendocino Headlands	blue rockfish	5	47.62	40
Mendocino Headlands	blue rockfish	10	44.05	37
Mendocino Headlands	blue rockfish	15	8.33	7
Mendocino Headlands	cabezon	10	20.00	1
Mendocino Headlands	cabezon	15	0.00	0
Mendocino Headlands	cabezon	20	0.00	0
Mendocino Headlands	cabezon	25	20.00	1
Mendocino Headlands	cabezon	30	0.00	0
Mendocino Headlands	cabezon	35	20.00	1
Mendocino Headlands	cabezon	40	0.00	0
Mendocino Headlands	cabezon	45	40.00	2
Mendocino Headlands	kelp greenling	10	9.80	5
Mendocino Headlands	kelp greenling	15	3.92	2
Mendocino Headlands	kelp greenling	20	27.45	14
Mendocino Headlands	kelp greenling	25	23.53	12

Mendocino Headlands	kelp greenling	30	11.76	6
Mendocino Headlands	kelp greenling	35	7.84	4
Mendocino Headlands	kelp greenling	40	9.80	5
Mendocino Headlands	kelp greenling	45	5.88	3
Mendocino Headlands	pile perch	10	33.33	2
Mendocino Headlands	pile perch	15	33.33	2
Mendocino Headlands	pile perch	20	33.33	2
Mendocino Headlands	striped perch	5	2.17	1
Mendocino Headlands	striped perch	10	28.26	13
Mendocino Headlands	striped perch	15	47.83	22
Mendocino Headlands	striped perch	20	6.52	3
Mendocino Headlands	striped perch	25	4.35	2
Mendocino Headlands	striped perch	30	2.17	1
Mendocino Headlands	striped perch	35	4.35	2
Mendocino Headlands	striped perch	40	4.35	2
Portuguese Beach	kelp greenling	20	6.67	1
Portuguese Beach	kelp greenling	25	13.33	2
Portuguese Beach	kelp greenling	30	33.33	5
Portuguese Beach	kelp greenling	35	33.33	5
Portuguese Beach	kelp greenling	40	13.33	2
Portuguese Beach	lingcod	75	100.00	1
Portuguese Beach	pile perch	20	20.00	1
Portuguese Beach	pile perch	25	60.00	3
Portuguese Beach	pile perch	30	20.00	1
Portuguese Beach	striped perch	15	3.33	1
Portuguese Beach	striped perch	20	20.00	6
Portuguese Beach	striped perch	25	70.00	21
Portuguese Beach	striped perch	30	6.67	2
Russian Gulch	black rockfish	25	33.33	1
Russian Gulch	black rockfish	30	66.67	2
Russian Gulch	blue rockfish	5	14.29	1
Russian Gulch	blue rockfish	10	57.14	4
Russian Gulch	blue rockfish	15	14.29	1
Russian Gulch	blue rockfish	20	14.29	1
Russian Gulch	kelp greenling	10	2.17	1
Russian Gulch	kelp greenling	15	2.17	1
Russian Gulch	kelp greenling	20	6.52	3
Russian Gulch	kelp greenling	25	13.04	6
Russian Gulch	kelp greenling	30	36.96	17
Russian Gulch	kelp greenling	35	17.39	8
Russian Gulch	kelp greenling	40	15.22	7
Russian Gulch	kelp greenling	45	2.17	1
Russian Gulch	kelp greenling	50	2.17	1
Russian Gulch	kelp greenling	55	0.00	0
Russian Gulch	kelp greenling	60	2.17	1
Russian Gulch	lingcod	40	50.00	1
Russian Gulch	lingcod	45	0.00	0

Russian Gulch	lingcod	50	50.00	1
Russian Gulch	pile perch	15	33.33	1
Russian Gulch	pile perch	20	33.33	1
Russian Gulch	pile perch	25	0.00	0
Russian Gulch	pile perch	30	33.33	1
Russian Gulch	striped perch	10	20.69	6
Russian Gulch	striped perch	15	10.34	3
Russian Gulch	striped perch	20	17.24	5
Russian Gulch	striped perch	25	31.03	9
Russian Gulch	striped perch	30	13.79	4
Russian Gulch	striped perch	35	3.45	1
Russian Gulch	striped perch	40	3.45	1
Van Damme	black rockfish	15	13.89	5
Van Damme	black rockfish	20	58.33	21
Van Damme	black rockfish	25	13.89	5
Van Damme	black rockfish	30	8.33	3
Van Damme	black rockfish	35	2.78	1
Van Damme	black rockfish	40	0.00	0
Van Damme	black rockfish	45	0.00	0
Van Damme	black rockfish	50	0.00	0
Van Damme	black rockfish	55	2.78	1
Van Damme	blue rockfish	5	1.09	1
Van Damme	blue rockfish	10	21.74	20
Van Damme	blue rockfish	15	68.48	63
Van Damme	blue rockfish	20	0.00	0
Van Damme	blue rockfish	25	4.35	4
Van Damme	blue rockfish	30	4.35	4
Van Damme	kelp greenling	10	10.00	6
Van Damme	kelp greenling	15	15.00	9
Van Damme	kelp greenling	20	13.33	8
Van Damme	kelp greenling	25	13.33	8
Van Damme	kelp greenling	30	26.67	16
Van Damme	kelp greenling	35	8.33	5
Van Damme	kelp greenling	40	6.67	4
Van Damme	kelp greenling	45	3.33	2
Van Damme	kelp greenling	50	0.00	0
Van Damme	kelp greenling	55	3.33	2
Van Damme	lingcod	15	30.00	3
Van Damme	lingcod	20	0.00	0
Van Damme	lingcod	25	10.00	1
Van Damme	lingcod	30	10.00	1
Van Damme	lingcod	35	0.00	0
Van Damme	lingcod	40	10.00	1
Van Damme	lingcod	45	0.00	0
Van Damme	lingcod	50	10.00	1
Van Damme	lingcod	55	0.00	0
Van Damme	lingcod	60	10.00	1

Van Damme	lingcod	65	10.00	1
Van Damme	lingcod	70	10.00	1
Van Damme	pile perch	15	100.00	1
Van Damme	striped perch	5	15.38	2
Van Damme	striped perch	10	0.00	0
Van Damme	striped perch	15	7.69	1
Van Damme	striped perch	20	30.77	4
Van Damme	striped perch	25	38.46	5
Van Damme	striped perch	30	7.69	1