North Central Coast Baseline Surveys of Kelp Forest Ecosystems: a report prepared for Sea Grant

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Executive Summary

Kelp forests are among the most productive and diverse ecosystems on Earth, and provide habitat for a wide array of fishes and invertebrates, many of which are commercially and recreationally important. Kelp forests also support a variety of recreational and commercial activities, including fishing, SCUBA diving, boating, and wildlife viewing. In addition to the structure provided by the underlying rocky reef, canopy-forming kelps and understory algae create complex habitat structure that provides food and refuge for many other species. To characterize kelp forests inside and outside of the recently established MPAs of the north-central coast of California, we use visual SCUBA surveys to assess habitat characteristics of the rocky substrate and the major players in the kelp forest community, including fishes, mobile and sessile invertebrates, and algae. Depending on the morphology and lifestyle of each species, abundance was estimated using swath surveys that count individuals within a defined area, or uniform point contact surveys that estimate the percent cover of colonial and other species for which distinguishing individuals is challenging.

The kelp forest surveys conducted for this project are designed to detect variations in the kelp forest ecosystem across space and through time, including establishing a baseline for detecting future effects of MPAs on these communities. MPAs around the world have been shown to increase both the size and abundance of fished species within their borders, but these effects take time, as organisms protected within MPAs must grow and reproduce for these changes to be apparent. The baseline study described in this report was conducted during the first two years after MPA implementation, which is not long enough for most species to respond to MPAs, thus we focus our results on the spatial variation in kelp forest communities in the region, with assessments of year to year differences mainly serving as an estimate of the natural temporal variability. These baseline surveys allow us to understand the initial condition of the kelp forest communities inside and outside of MPAs at the time of MPA implementation and will provide a valuable reference point for interpreting any changes to these communities in the future.

The baseline characterization surveys of kelp forest ecosystems conducted in 2010-2011 included roughly 35 sites sampled each year across six MPAs: Point Arena SMR, Sea Lion Cove SMCA, Saunders Reef SMCA, Del Mar SMR, Stewarts Point SMR and Salt Point SMCA (see Figure ES1). Surveys were confined to the MPAs in the northern portion of the study region due to the prevalence of great white shark activity near Point Reyes and the Farallon Islands. Divers estimated 1) the percent cover of substrate types and vertical relief of the seafloor at each site; 2) the percent cover of sessile and colonial invertebrates and non-stipitate turf algal groups; 3) the density of stipitate algae, macro-invertebrates and fishes; and 4) sizes of fishes and commercially important red sea urchins and red abalone. These data were used to quantify the community structure (composition and relative abundance of species) at each site, and to compare among sites.

Across the surveyed region, reef habitats were primarily composed of bedrock with slight relief (10 cm to 1 m), and encrusting and erect coralline algae were the predominant cover on the reef, although some other red algal groups were also quite abundant at some sites. The subcanopy algae *Pterygophora* is a major constituent of the kelp assemblage across the surveyed region, and northern sites (e.g. Point Arena and Sea Lion Cove) were characterized by greater densities of canopy-forming bull kelp (*Nereocystis)* than sites to the south, while the Del Mar MPA and associated reference area had notably high abundance of the subcanopy algae *Laminaria*.

Densities of red abalone were similar across all sites with the notable exception of the Del Mar SMR, which had extremely low densities. Densities of red urchins were also similar across all sites, but purple urchins were particularly abundant in the Point Arena and Sea Lion Cove reference sites. Densities of juvenile rockfishes, a metric of rates of replenishment of fish populations in kelp forests, were abundant across all sites except Sea Lion Cove SMCA. Densities of juvenile rockfishes were much higher in 2010 than 2011, which is indicative of high year-to-year variation in recruitment. Densities of fishes were generally similar at sites inside and outside of MPAs across the study region. With the exception of the Del Mar area, total fish densities were higher in the southern portion of the surveyed region.

Community structure differed significantly (though not dramatically) across the study region, falling out into three clusters with distinct fish, invertebrate, and algal assemblages. These clusters were distributed along the coast, with one cluster including Point Arena SMR, Saunders Reef SMCA, and the reference areas between them; a second cluster occurring within the Del Mar SMR and reference areas to the south; and the final group occurring at sites to the south of Saunders Reef SMCA and including sites from Stewarts Point SMR, Salt Point SMCA, and reference areas to the south (Figure 1). The one site located within the small Sea Lion Cove SMCA was different from all other sites and constitutes an outlier. The same analyses based on the separate species groups (fish, invertebrates, and algae) show generally similar geographic patterns. With the exception of the Del Mar area, fish density was generally highest in the southern half of the surveyed region.

One implication of these results is that the MPAs distributed across the northern portion of the study region encompass the geographic diversity of community structure within the kelp forest ecosystem. The observed geographic patterns of community structure suggest that the reference areas identified were generally well matched with associated MPAs. A key exception is the Saunders Reef SMCA where sites to the south, which were originally identified as reference areas, are less similar to the MPA sites than those to the north. In fact, these sites are more similar to sites associated with Stewarts and Salt Point MPAs. We observed notable differences in estimated abundance of many species between 2010 and 2011. Whether these differences reflect real interannual variability or reflect sampling error due spatial variability and differences in the location of surveys between years, is unclear. However, these differences suggest that multiple years of sampling will be required to accurately characterize trends in species abundance to assess MPA effectiveness.

We examined six aspects of initial changes generated by the two years of monitoring data. Generally, we would not anticipate detectable changes in either community structure or metrics of species abundance (density or percent cover) or size that could be attributed to the establishment of the MPAs so soon after their establishment. Nonetheless, we tested for an MPA (inside versus outside) by year (2010 vs. 2011) interaction, which would indicate differences between the MPAs and reference areas in how communities or species density (or size) changed between years. We also tested for differences between years (2010 versus 2011) in metrics of community structure and species abundance (density or percent cover) simply to determine whether estimates of abundance and size were consistent between years across MPAs and reference areas. We also focused on changes in density and size of red abalone between years to characterize the impact of the harmful algal bloom that occurred in Sonoma County during 2011.

Of the 129 taxa (fishes, invertebrates and algae combined) sampled over both years of surveys, we detected significant MPA by year interactions for only three taxa: the density of Dawson's sunstar (*Solaster dawsoni*) and juvenile Bocaccio (*Sebastes paucispinis*) and the percent cover of barnacles. None of these species are actively fished (juvenile Boccacio are too small), thus it is unlikely that any of these changes are attributable to establishment of the MPAs. Of the remaining 126 taxa, five indicated significant MPA by year by site interactions (i.e. changes between years differed inside and outside of MPAs and these differences varied among MPAs), which preclude interpretations of any MPA, year or site effects. Of the remaining 124 taxa, only 35 taxa (28%) exhibited significant changes in density or percent cover between years. Without historic data on the dynamics of these species, it is unclear whether or not these changes reflect the typical inter-annual dynamics of these species. Red abalone (*Haliotis rufescens*) exhibited a 40% decline in density between 2010 and 2011 at sites along the Sonoma Coast (Figure 2). Correspondingly, 30% of the total shells (live and dead combined) recorded in 2011 were dead. This decline along the Sonoma coast coincided with a harmful algal bloom in that region that occurred just prior to the surveys conducted along the Sonoma coast in 2011.

In conclusion, the baseline surveys show that MPA and adjacent reference sites are generally well matched and contained very similar communities at the time of MPA implementation. If differences between MPA and associated reference sites develop in the future, these differences may be attributable to MPA effects. The surveys did detect some geographic variation in kelp forest communities, indicating that it will continue to be important to match MPAs with comparable reference areas to assess MPA effects in the future. Also, differences in the abundance of some species were observed between years, indicating that inter-annual variability must be taken into account when interpreting changes through time, and it would be unwise to base management decisions upon a single year of data collection.

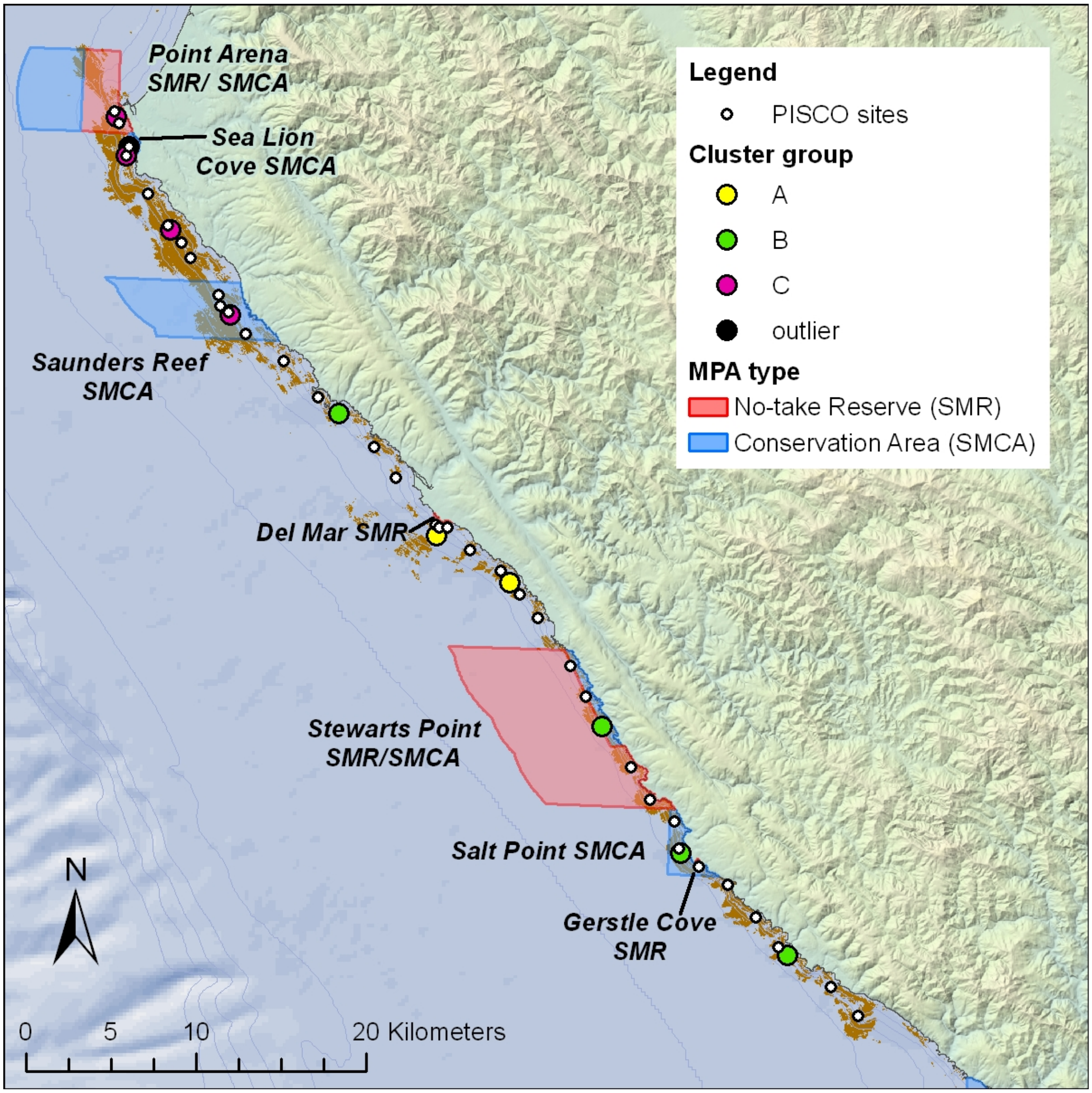


Figure 1. Locations of kelp forest survey sites ("PISCO sites") and distribution of the three distinct kelp forest communities ("A, B, C") defined by the clustering analysis.

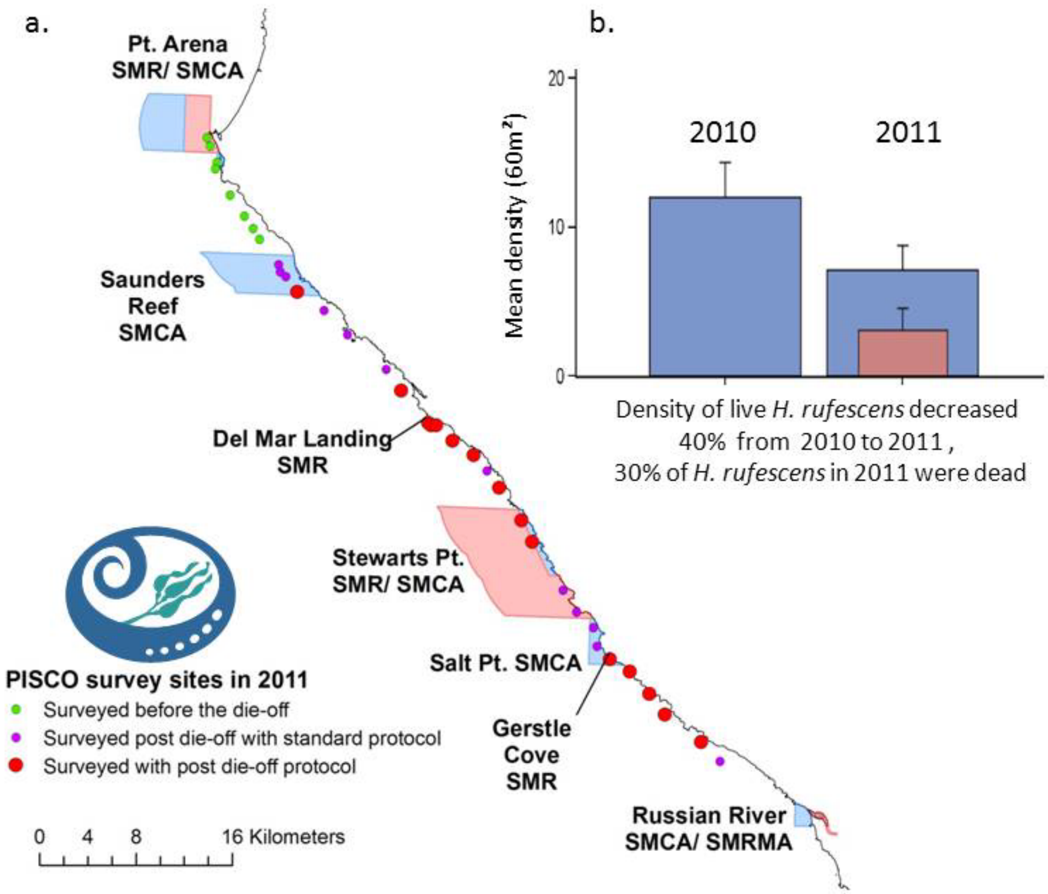


Figure 2. a) Locations of kelp forest survey sites ("PISCO sites") from 2011, including sites surveyed using special protocols to assess the impacts of the 2011 harmful algal bloom event and associated abalone die-off, and **b)** average density of live red abalone (Haliotis rufescens) in 2010, and live and dead red abalone in 2011 at those sites surveyed using post die-off protocols.

Narrative

Project Goals and Objectives

The objective of the kelp forest surveys and analyses are to (1) produce a quantitative baseline characterization of the structure of kelp forest ecosystems in those MPAs recently established by the MLPA Initiative in the NCCSR containing kelp forest habitats, where feasible, (2) provide a quantitative comparison between the kelp forest ecosystems in these MPAs and associated reference areas in the NCCSR, (3) analytically explore the baseline characterizations for potential indicators of the state of the kelp forest ecosystems, and (4) integrate these assessments with other components of the baseline survey to inform the role and design of those programs for a future monitoring and evaluation program. This report summarizes results for objectives 1, 2 and 4, whereas objective 3 will be pursued in the coming months in conjunction with staff of the Monitoring Enterprise and other PIs involved in the NCCSR Baseline Characterization.

Methods

Sampling methods

Our approach replicated and further developed the sampling design and protocols we used previously for the baseline characterization of the Central Coast Study Region (CCSR) and the network of marine reserves in the Northern Channel Islands (NCI). Sampling protocols are based on those employed at long-term monitoring sites of the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) in central and southern California. We conduct four types of diver surveys to characterize the kelp forest ecosystem: 1) fish density and size distribution are recorded along swath transects on the reef surface and mid-portion of the water column, 2) density of large/conspicuous or mobile/solitary invertebrates and stipitate algae are recorded along swath transects on the reef surface, 3) percent cover of sessile colonial invertebrates, turf algae, and geologic habitat characteristics is estimated from uniform point contact (UPC) along transects on the reef surface, and 4) size frequency data for the commercially and ecologically important red and purple urchins and red abalone.

Replicate survey sites are randomly distributed across areas identified to have stands of bull kelp, *Nereocystis*, and rocky reef extending to at least 15-20m depth. Generally, four of these sites were established in each MPA and adjacent reference area outside of each MPA (Figure 3 and Table 1). These same sites were surveyed in both 2010 and 2011. Within each site, surveys are conducted across a depth range from 5 m to 20 m, or to the deepest extent of the reef if it is less than 20 m deep. Sampling is stratified across zones defined either by depth (shallow to deep) or proximity to shore (onshore to offshore edges of the reef) to ensure surveys capture variation in species occurrence across these gradients. The basic unit of sampling is a transect. Our survey design is based on analytical models that allow us to describe the direction and magnitude of change in kelp forests over time. To achieve this, we sample randomly located transects within each of the stratified zones in each area.

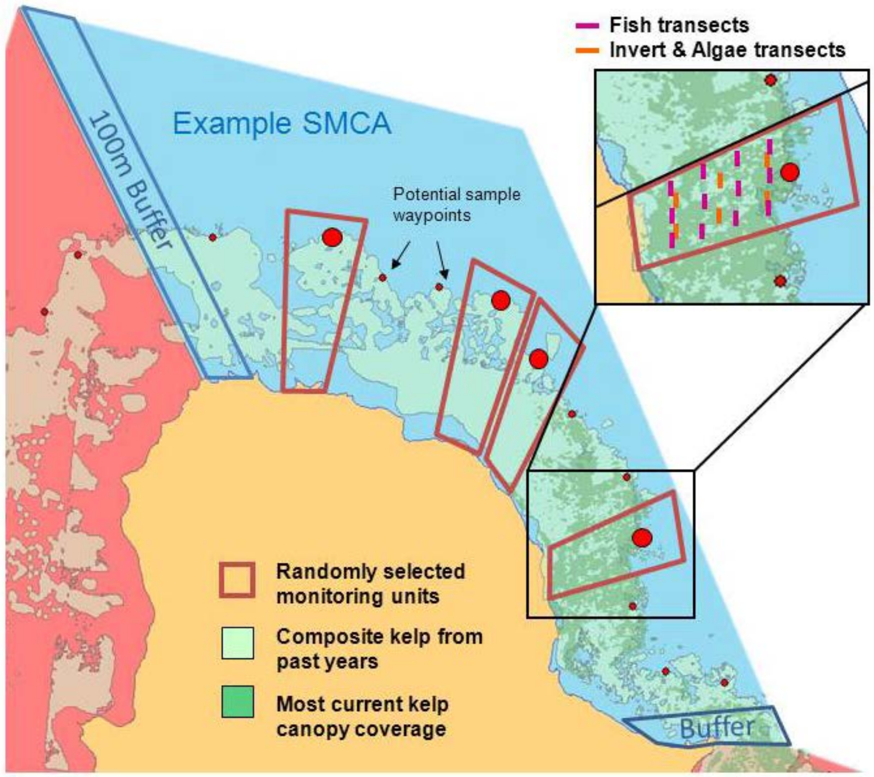


Figure 3. Kelp forest survey sampling design, including potential sample waypoints, randomly selected monitoring units, and the spatial distribution of fish, invertebrate, and algae transects within each monitoring unit.

Fish Survey Design

At each monitoring site, visual surveys by scuba divers are used to quantify the size structure and density of fish populations and the species composition and structure (i.e., relative abundance) of fish assemblages. To ensure that the 3-dimensional habitat created by kelp forests is sampled thoroughly, fish transects are stratified across the face of the reef (alongshore and cross-shore) and vertically through the water column. In each site, three transects are sampled in each of four zones (Figure 3). The zones are stratified to encompass the offshore edge of the reef, the middle of the reef, and as shallow inshore as practical. For example, for a maximum depth of 20 meters (m) the depth zones would be 5, 10, 15, and 20 m. If no appreciable depth stratification is present, then the stratification is based on proximity to the outer edge of the reef and the shore. In each zone, three randomly located transects are sampled along isobaths (constant depth) parallel to shore (i.e., 12 transects total per site).

Fish Sampling Methods

Three portions of the water column (bottom, midwater and canopy) are sampled by two divers along each transect. Bottom transects sample the bottom 2 m of the water column, contiguous with the reef surface, and the midwater transect is located just above the bottom transect. The height of the midwater transect varies as a function of bottom depth (4-6 m above the bottom for bottom depths of 10 m or greater, 2-4 m above the bottom for bottom depths of 6 m or less). Bottom and midwater transects are sampled simultaneously by two divers. After completion of bottom and midwater transects, divers move up to the canopy and, moving in the opposite direction, count fish in the top 2 m of the water column (0-2 m depth) only. One diver samples the fish while the other diver estimates percent canopy cover along the 30 m long transect. Canopy surveys are timed to capture net annual recruitment of reef fish that settle to the kelp canopy. As a result, in north central California, canopy surveys are conducted separately and later in the season than bottom-midwater surveys.

Both divers in the team identify, count and size all conspicuous fishes on each 30 m long x 2 m tall x 2 m wide transect. If gender is visually distinguishable (e.g., kelp greenling), this is recorded as well. Divers estimate total length (TL) of small fish (< 30 cm TL) to the nearest cm, and larger fish (> 30 cm) to the nearest 5 cm interval, as they reel out a 30 m tape.

Algae and Invertebrate Survey Design

At each monitoring site, visual surveys by scuba divers are used to quantify the size structure and density of macroalgae and invertebrate populations and the species composition and structure (i.e., relative abundance) of their assemblages.

To ensure that the entire kelp forest is sampled representatively, benthic transects are stratified across the face of the reef (alongshore and cross-shore). At each site, two transects are sampled in each of three zones (Figure 3). The zones are stratified to encompass the offshore edge of the reef, the middle of the reef, and as shallow inshore as practical. For example, for a maximum depth of 20 meters (m) the depth zones would be 5, 12.5, and 20 m. If no appreciable depth stratification is present, then the stratification is based on proximity to the outer edge of the reef and the shore. In each zone, two randomly located transects are sampled along isobaths (constant depth) parallel to shore (i.e., six transects total per site).

Three sampling methods are used to quantify the density and/or cover of algae and invertebrates along each transect. Swaths (or belt transects) are used to estimate the density of species while uniform point contact (UPC) is used to estimate the cover of species. In addition to sampling biotic cover, the UPC method is used to estimate the percent cover of substratum type and relief. Each transect is sampled by two divers with each diver conducting one technique.

Swath Methods

The purpose of the swath sampling is to estimate the density of conspicuous, solitary and mobile invertebrates as well as specific macroalgae. Individual invertebrates and plants are counted along the entire 30 m long x 2 m wide transect. 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. No organisms are removed. Any organism with more than half of its body outside the swath is not counted. Transects are divided into three, 10 m segments.

Only *Macrocystis* plants taller than 1 m are recorded. The number of stipes at 1 m above the substrate on each *Macrocystis* plant is entered on the datasheet. *Nereocystis, Pterygophora, Laminaria setchellii*, and *Eisenia arborea* must have stipes taller than 30 cm to be counted. Only *Cystoseira osmundacea* plants greater than 6 cm wide are recorded. *Laminaria farlowii* must have a blade greater than 10 cm wide. All plants of *Costaria* and *Alaria* are counted.

Very high densities of some species of invertebrates and algae prohibit enumeration along the entire length of a swath. We use a variable area sampling method in these cases. Within each 10 m increment (0-10, 10-20, 20-30) along a transect, divers enumerate organisms until the species threshold abundance (thirty individuals) or the end of the 10 m segment is reached. If the threshold abundance is reached, the diver records the distance they have sampled to that point along the transect and stops counting that species until the next 10 m segment.

Uniform Point Contact Methods

Uniform point contacts (UPCs) are used to estimate the percent cover of species and reef attributes along each 30 m long transect. Divers record three types of information beneath 30 points located at every meter along the transect: 1) substrate type, 2) physical relief, and 3) percent cover of space-occupying organisms.

The percent cover of space-occupying organisms is estimated by recording what is directly under each point. The purpose is to re-create a two-dimensional, "photo style" representation of the percent cover of organisms that are directly attached to the primary substrate. Therefore, epiphytes, epizooids, and mobile organisms are not included. Algae whose blades are under the point but are attached somewhere else on the primary substrate are included. There are three exceptions that we have labeled "superlayers". If points overlay blades of *Laminaria* spp., the abundant sea cucumber *Pachythone rubra* or brittle stars, the blade or animal is removed and the species or substratum beneath it is recorded AND noted in the "superlayer" column on the datasheet. The UPC datasheets include categories for all non-motile, benthic invertebrates and algae.

Reef attributes are also noted for each point. Substrate type is recorded as sand, cobble (< 10cm diameter), boulder (10 cm - 1 m diameter) or bedrock (> 1 m diameter). Physical relief is measured as the greatest vertical relief that exists within a 1-meter wide section across the tape and a 0.5-meter section along that tape that is centered over the appropriate point.

Analyses

Spatial and temporal patterns in kelp forest community structure

To test for and identify significant differences in community structure among sites across the study region, inside and outside of MPAs and between sampling years, we used Bray-Curtis Similarity matrices to generate cluster dendrograms and multi-dimensional scaling plots (MDS) illustrating patterns of community similarity characterizing the region during the baseline characterization (PRIMER v.6). These analyses were conducted separately for (1) the assemblage of sessile and colonial invertebrates and non-stipitate turf algal species recorded by UPC sampling, (2) the stipitate algae and macroinvertebrate assemblage recorded by benthic swath transects, (3) the fish assemblage recorded on swath transects, and (4) the overall community comprised of all three of these assemblages.

Similarity matrices were calculated using mean density or percent cover estimates for each MPA or reference area in each of the two years sampled. Bray-Curtis similarity indices were calculated for each pair-wise comparison of these mean samples according to 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). Prior to calculation of similarity indices, all observed values were square-root transformed to allow for equitable contribution of less abundant species to patterns of community similarity. Cluster analysis was performed using the group-average linking method and all distinctions detected between groups were evaluated using the SIMPROV test (P<0.05). MDS plots were then generated to aid in visualization of similarity distances among samples.

Assessment of Initial Changes

We examined seven aspects of initial changes recorded by the two years of monitoring data. Generally, we would not anticipate detectable changes in either community structure or metrics of species abundance (density or percent cover) or size that could be attributed to the establishment of the MPAs so soon after their establishment. We also tested for differences between years (2010 versus 2011) in metrics of community structure, species abundance (density or percent cover) and population size structure of key species simply to determine whether these estimates were consistent between years across MPAs and reference areas. We focused on changes in density and size of red abalone and red sea urchins between years because of their economic importance and to characterize the impact of the harmful algal bloom that occurred in Sonoma County during 2011. We also examined changes in the density and surface canopy cover of bull kelp, *Nereocystis*.

We used a 3-factor (year, site, MPA level) analysis of variance (ANOVA) to test for MPA effects on univariate responses, including the density and cover of individual species. We tested for an MPA (inside versus outside) by year (2010 vs. 2011) interaction, which would indicate differences between the MPAs and reference areas in how communities or species density (or size) changed between years. In this analysis the mean abundance (density or percent cover) at each of the sites (typically four) within an MPA or associated reference area surveyed in 2010 and 2011 were used as replicates. We used the year term in this ANOVA to test for annual differences in density or percent cover of species, including the density of bull kelp, red abalone and red sea urchins across all sites. These same analyses were conducted using mean size estimates of red abalone and red sea urchins in collaboration with Reef Check, and the results of these analyses are reported in the Reef Check report. To test for an MPA effect on community structure as well as differences among sites, MPA levels (inside, outside) and years, we used a multivariate PERMANOVA. Again, the sample sites within each MPA and associated reference area surveyed over two years were used as replicates for this analysis.

Spatial and temporal context: comparison of baseline results with longer time series

To provide context for the spatial and temporal variation in bull kelp recorded in our baseline surveys, we compared the coefficient of variation (CV) of our stipe densities with the spatial and temporal CVs of surface canopy cover from aerial surveys conducted by the California Department of Fish and Wildlife for six years during the period from 1999 to 2008. Surface canopy cover recorded by the aerial surveys was calculated in a 500 m buffer area surrounding each of our 35 sampling sites. The proportion of each 500 m buffer area with canopy cover was calculated to estimate cover for each site and sample year. We used a paired t-test to test for differences between our estimates of inter-annual (2010-2011) variation (CV) with the six-year inter-annual variation (CV) of canopy cover at each of the 35 study sites. To determine whether the spatial variation in kelp abundance recorded across our 35 study sites is representative of typical among-site variation in other years, we used a two sample t-test to test for a difference in the mean spatial variation (CV) estimated in our baseline surveys (n= two years; 2010-2011) with the mean spatial variation (CV) of canopy cover across the same 35 sites (n= six years).

To provide context for the spatial and temporal variation in red abalone and red sea urchin densities recorded in our baseline surveys, we compared our mean density estimates at five study sites sampled in common with the California Department of Fish and Wildlife (CDFW) and Reef Check over the period of 2003 to 2012. All three programs use 30 m by 2 m band transects to estimate abalone and sea urchin density. However, CDFW only counts abalone that are exposed (“emergent”) and not tucked in cracks or crevices. CDFW samples four depth strata 0-4.5, 4.5-9, 9-13.7, 13.7-18.3 m) with equal numbers of transects. Reef Check samples across the same depth range, but disproportionately samples shallower depths (mean across all sites= 6.6 m depth). The depth discrepancy between Reef Check and PISCO surveys was by design to complement one another and generate a broader depth distribution of samples at each site. Without raw data for the CDFW sites, we simply visually compare our estimates and graphed trends with the other two programs.

Description and Location of Sites

We have established a total of 35 kelp forest survey sites within the North Central Coast Study Region (NCCSR). 17 of these sites are located within MPAs, and 18 are located outside of MPAs (Table 1).

Table 1. Kelp forest survey sites located within the NCCSR.

Site Name	MPA Designation	Latitude	Longitude
POINT_ARENA_MPA_1_CEN	SMR	38.95117	-123.74404
POINT_ARENA_MPA_2_CEN	SMR	38.94484	-123.74052
POINT_ARENA_REFERENCE_1_CEN	reference	38.908	-123.7191
POINT_ARENA_REFERENCE_2_CEN	reference	38.89199	-123.70432
POINT_ARENA_REFERENCE_3_CEN	reference	38.88296	-123.69521
POINT_ARENA_REFERENCE_4_CEN	reference	38.87487	-123.68838
SEA_LION_MPA_1_CEN	SMCA	38.93241	-123.73328
SEA_LION_REFERENCE_1_CEN	reference	38.92769	-123.73447
SAUNDERS_MPA_1_CEN	SMCA	38.85586	-123.66841
SAUNDERS_MPA_2_CEN	SMCA	38.85035	-123.66661
SAUNDERS_MPA_3_CEN	SMCA	38.84695	-123.66129

SAUNDERS_MPA_4_CEN	SMCA	38.83573	-123.64898
SAUNDERS_REFERENCE_1_CEN	reference	38.82226	-123.62233
SAUNDERS_REFERENCE_2_CEN	reference	38.80408	-123.5981
SAUNDERS_REFERENCE_3_CEN	reference	38.77883	-123.55918
SAUNDERS_REFERENCE_4_CEN	reference	38.76295	-123.54342
DEL_MAR_MPA_1_CEN	SMR	38.73895	-123.51562
DEL_MAR_MPA_3_CEN	SMR	38.73736	-123.50758
DEL_MAR_MPA_2_CEN	SMR	38.73729	-123.51281
DEL_MAR_REFERENCE_1_CEN	reference	38.72604	-123.49116
DEL_MAR_REFERENCE_2_CEN	reference	38.71557	-123.4698
DEL_MAR_REFERENCE_3_CEN	reference	38.70378	-123.45642
DEL_MAR_REFERENCE_4_CEN	reference	38.69138	-123.44355
STEWARTS_POINT_MPA_1_CEN	SMR	38.6668	-123.42064
STEWARTS_POINT_MPA_2_CEN	SMR	38.65073	-123.40953
STEWARTS_POINT_MPA_3_CEN	SMR	38.61415	-123.37745
STEWARTS_POINT_MPA_4_CEN	SMR	38.59765	-123.36371
SALT_POINT_MPA_1_CEN	SMCA	38.58623	-123.34668
SALT_POINT_MPA_2_CEN	SMCA	38.57217	-123.34266
SALT_POINT_MPA_3_CEN	SMCA	38.56274	-123.32922
SALT/STEWARTS_REFERENCE_5_CEN	reference	38.55381	-123.30908
SALT/STEWARTS_REFERENCE_1_CEN	reference	38.53724	-123.28933
SALT/STEWARTS_REFERENCE_2_CEN	reference	38.52177	-123.27335
SALT/STEWARTS_REFERENCE_3_CEN	reference	38.50151	-123.23712
SALT/STEWARTS_REFERENCE_4_CEN	reference	38.4871	-123.21817

Baseline Characterization North Central Coast Ecosystems

Spatial and temporal patterns in kelp forest community structure

Spatial and temporal variation in community structure, which was revealed through cluster analysis of site similarity matrices, simultaneously shows differences across the region, within and outside of MPAs, and between years. The overall community structure (fishes, invertebrates, and algae) at most of the MPAs was more similar to their reference areas than to other MPAs across the region (**Figure 4**). The implication of this result is that MPAs and reference areas were well matched and at an appropriate spatial scale. The exceptions to this result are Saunders and Sea Lion MPAs where the community structure of the reference area was markedly different from the MPA. This reflects the unique locations of these MPAs and the lack of nearby habitat similar to that within the MPA. The dramatic difference between Sea Lion MPA and its reference is also an artifact of the limited sampling permitted by this smaller MPA. The majority of sites, both MPA and reference areas, exhibit consistent patterns of community structure between sample years. The exception to this is the cluster of Saunders MPA, Point Arena MPA and reference, and Sea Lion reference where community structure differences between years were greater than those among sites.

As observed previously in the Northern Channel Islands and the Central Coast MLPA Study Region, community structure (i.e. composition and relative abundance of fishes, invertebrates and species of algae) supported by kelp forest ecosystems of the North Central Coast Study Region (NCCSR) varied across the study region (Figure 4). Generally, the three distinct community structures are distributed across a latitudinal gradient along the study region (Figure 5).

The first distinct community type included Salt Point SMCA, Stewart's Point SMR, the Salt/Stewart's reference area just south of Salt Point SMCA, and five sites just south of Saunders Reef SMCA (green bullets on Figure 5). With the exception of the sites just south of Saunders Reef SMCA, these sites are characterized by a preponderance of bedrock and more boulder substrate relative to other sites in the study area (Figure 6). All sites in the study region are dominated by slight relief, however Stewart's Point SMR has more moderate and high relief than other sites in this cluster (Figure 7). The benthos (species on the reef surface) at sites in this cluster is dominated by encrusting and erect coralline algae and other encrusting red algae (Figure 8). The stipitate algal assemblage at these sites is primarily composed of *Pterygophora*, *Laminaria* and *Nereocystis* with relatively more *Laminaria* in the Stewart's Point and Salt Point MPAs and the reference areas south of Saunders Reef SMCA (Figure 9). There are relatively high levels of *Pterygophora* and less *Nereocystis* at these sites compared to others with the exception of the reference sites south of Saunders Reef SMCA. With the exception of the reference sites south of Saunders Reef SMCA, these sites have a disproportionately higher density of bat stars than other sites (Figure 10). Densities of purple and red sea urchins and red abalone are typical of other sites. Of the fishes, the only notable pattern at these sites is the much higher densities of young-of -year rockfishes compared to other sites in the study region (Figure 13). The reference sites south of Saunders Reef SMCA have the highest densities of olive/yellowtail rockfish across the region (Figure 11).

The second distinct community type included Del Mar SMR and associated reference sites (yellow bullet on Figure 5). These sites are characterized by a preponderance of bedrock and very little boulder or cobble substrate and slightly more sand than other sites in the region (Figure 6). The Del Mar SMR has much greater cover of sand than other sites in this cluster and throughout the region. Though all sites in the region are dominated by slight relief, there is more moderate and high relief at these sites than other sites in the region (Figure 7). The benthos (species on the reef surface) at sites in this cluster support more cover of branching and leaf-like red algae and less encrusting algae or erect coralline algae (Figure 8). The stipitate algal assemblage at these sites is includes particularly high densities of *Laminaria* and low densities of *Nereocystis* (Figure 9). There are also high relative densities of *Pleurophycus* in the Del Mar SMR and a higher density of *Pterygophora* in the SMR relative to the reference area. Overall, macroinvertebrate density in the Del Mar SMR is low relative to other sites in the region (Figure 10). Of the macroinvertebrate assemblage, the most notable observations are the low densities of red abalone and purple urchins in the Del Mar SMR. Red urchin densities in this group are typical of other sites in the region. The sites show moderate relative densities of kelp greenling, black rockfish and young-of-year rockfishes (Figure 11, Figure 12, and Figure 13).

The third distinct community type included Saunders Reef SMCA, Point Arena SMR and the reference areas between these MPAs (magenta bullet on Figure 5). These sites are characterized by substrates typical of the region with no notable distinction from other sites in the study area (Figure 6). Although all sites in this cluster are dominated by substrates with slight relief, the MPAs in this cluster have more moderate and high relief than their associated reference sites (Figure 7). The benthos (species on the reef surface) at sites in this cluster is dominated by encrusting and erect coralline algae and other encrusting red algae (Figure 8). The stipitate algal assemblage at these sites is primarily composed of *Pterygophora*, *Nereocystis* and *Laminaria*, with notable densities of *Pleurophycus* at Saunders Reef SMCA (Figure 9). There are high relative densities of *Nereocystis* in the Point Arena SMR and reference area relative to other sites in the study region. Point Arena SMR supports a higher density of stipitate algae, especially *Pterygophora* and *Nereocystis* than the Saunders Reef SMCA. Of the macroinvertebrate assemblage, these sites have a disproportionately higher density of purple sea urchin at the reference sites in this cluster (Figure 10). Densities of red sea urchins and red abalone are typical of other sites in the region. Fish densities in this cluster are relatively low compared to the rest of the region. Only Sea Lion Cove SMCA has lower fish densities relative to these sites (Figure 11, Figure 12, and Figure 13).

Sea Lion Cove SMCA is an outlier relative to all other sites in the region (black bullet on Figure 5). This site is characterized by a greater cover of cobble and flat relief substrate relative to all other sites in the study area (Figure 6 and Figure 7). The benthos (species on the reef surface) includes greater cover of bare rock and red filamentous turf algae (Figure 8). The stipitate algal assemblage is notable by the very low densities of *Laminaria* and *Pterygophora* and high densities of *Nereocystis* relative to the rest of the region (Figure 9). Overall, the density of macroinvertebrates in the Sea Lion Cove SMCA is low relative to all other sites and comprised largely of red and purple sea urchins and red abalone (Figure 10). The Sea Lion Cove SMCA is characterized by low densities of all fish species, including young-of-year rockfish (Figure 11, Figure 12, and Figure 13). The depauperate fish assemblage is dominated by black rockfish and kelp greenling.

Within the kelp forest community, the assemblage of sessile and colonial invertebrates and non-stipitate turf algal groups recorded by the UPC sampling exhibit similar spatial patterns as the overall community patterns (i.e. fishes, invertebrates and algae combined) with one key exception (Figure 14). Similar to the patterns of overall community structure, four distinct clusters were identified: Salt Point SMCA, Stewarts Point SMR and their associated reference; Del Mar MPA and reference sites; Saunders Reef SMCA, Pt. Arena SMR and associated reference areas; and Sea Lion Cove SMCA as a distinct outlier again. However, based on this assemblage, the reference sites just south of Saunders Reef SMCA clustered with the Saunders Reef SMCA and reference areas further north (MDS plot in Figure 14). There is also distinction in the Saunders Reef SMCA, Point Arena Reference sites, and Sea Lion Cove reference sites between the two years of sampling (dendrogram in Figure 14).

The assemblage of stipitate algae and solitary macroinvertebrates exhibit patterns similar to that of the sessile assemblage with one key exception. Stewarts Point SMR, Salt Point SMCA and their associated reference areas cluster separately. Point Arena SMR, its reference areas, and Sea Lion Cove reference again cluster separately, and again, Sea Lion Cove SMCA is an outlier (Figure 15). However, for this assemblage the Del Mar MPA and reference areas were distinct but clustered separately, and Saunders Reef SMCA clustered separately with at least one of its reference sites.

When considered separately, the fish assemblage exhibits the least cohesive geographic pattern of structure (Figure 16). Nonetheless, Stewarts Point SMR, Salt Point SMCA and their associated reference areas again cluster separately from sites to the north, the Point Arena SMR, its reference areas and Sea Lion Cove reference areas cluster separately, and Sea Lion Cove SMCA was again an outlier. As in the pattern of the overall community, reference sites to the south of Saunders Reef SMCA clustered with the Salt Point and Stewarts Point MPAs and reference sites.

Assessment of Initial Changes

Across the 36 taxa of fishes recorded over both years of surveys, only one, juvenile Bocaccio (*Sebastes paucispinis*), exhibited a significant year by MPA (inside vs. outside) interaction, however it is unclear how this could be in response to the establishment of MPAs (**Table 31**). This rate of detection is also below what would be expected by chance even if no effects of MPAs over time were present. Of the remaining fishes, quillback rockfish exhibited a significant MPA by year by site interaction (i.e. changes between years differed inside and outside of MPAs and these differences varied among the MPAs), which precludes interpretation of any MPA, year or site effects. Significant differences in density between years were detected for only seven of the remaining 34 fish taxa (21%), and these changes varied significantly among sites for three of these taxa (i.e. significant year by site interaction).

Across the eight taxa of brown algae for which densities were estimated over both years of surveys, none exhibited any evidence of an MPA effect (i.e. no significant year by MPA (inside vs. outside) interaction), nor did the density of any of these species differ between years. Of the 17 taxa of brown, red and green algae for which percent cover was estimated, none exhibited any evidence of an MPA effect (i.e. no significant year by MPA (inside vs. outside) interaction), and only five (29%) of these exhibited significant differences in cover between years.

Of the 44 taxa of invertebrates for which density was estimated, only one, Dawson's sunstar (*Solaster dawsoni*) exhibited a significant MPA by year interaction; however, it is unclear how this could be in response to the establishment of MPAs. Significant year by site by MPA level interactions precluded assessments of MPA or annual differences for only two species. Of the remaining 41 taxa, 15 (34%) exhibited significant differences in density between years, four of these taxa showed different rates of change among sites (i.e. significant year by site interaction). Of the 19 taxa of invertebrates for which percent cover was estimated, only one (barnacles) exhibited a significant MPA by year interaction, and again it is unclear how this could be in response to the establishment of MPAs. Of the remaining 18 taxa, eight (44%) exhibited significant differences in cover between years.

Red abalone (*Haliotis rufescens*) exhibited a 40% decline in density between 2010 and 2011 at sites along the Sonoma Coast (**Figure 2**). Correspondingly, 30% of the total shells (live and dead combined) recorded in 2011 were dead (**Figure 2**). This decline along the Sonoma coast coincided with a harmful algal bloom I that region that occurred just prior to the surveys conducted along the Sonoma coast in 2011.

No significant differences were seen between MPA and reference areas in the mean size estimates of the six most abundant species (**Table 32**). Mean size estimates differed (increased) between years for only two species (kelp greenling and black rockfish), and these increases were consistent between MPA and reference areas (i.e., no year by MPA interaction).

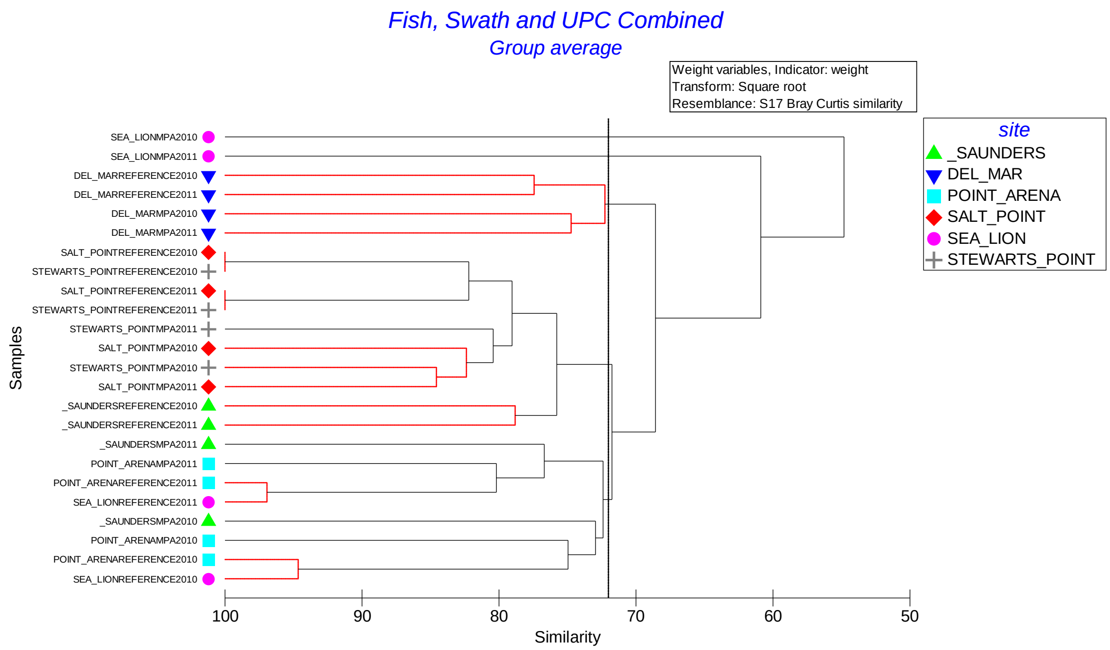
Spatial and temporal context: comparison of baseline results with longer time series

The mean inter-annual variability in bull kelp abundance at each of our 35 sample sites, measured as the coefficient of variation in stipe densities between 2010 and 2011 (mean CV= 84.7), was not different from the mean inter-annual variability in surface canopy cover at the same sites over six years during the period from 1999 to 2008 (mean CV= 72.7; paired t-test: p= 0.14845). The mean spatial variation in bull kelp stipe density across our 35 study sites over the two sample years (mean CV= 150.3) was not different from the mean spatial variability in surface canopy cover across the same 35 sites over six years during the period from 1999 to 2008 (mean CV= 104.7; Figure 17; two sample t-test: p= 0.1507). Thus, the spatial and temporal variability in bull kelp abundance as characterized by these two methods (stipe density and canopy cover) was not dissimilar between the baseline years and the longer time series of aerial surveys.

Our estimates of abalone density were generally lower than those generated by the California Department of Fish and Wildlife and Reef Check, with the exception on one site, Point Arena (Figure 18). Density estimates at Point Arena differed markedly among the three programs, likely reflecting differences in sample location at this site (**Figure 18**a). PISCO density estimates were very similar to those of the other programs at the Salt Point site (**Figure 18**b). Although PISCO's density estimates were lower than CDFW at Timber Cove and Ocean Cove, both programs detected a decline associated with the abalone die-off associated with the harmful algal bloom event that occurred between surveys at that site (**Figure 18**c and d). The Reef Check survey at Ocean Cove in 2011 did not show a decrease from the previous year; however, this survey was conducted prior to the die-off in 2011 at that site. At Fort Ross, PISCO estimates were lower than both the contemporary and longer-term estimates generated by the other programs (**Figure 18**e). The decline between 2010 and 2011 recorded by PISCO reflects the die off. Again in this case, the contrasting increase recorded by Reef Check between those years reflects that their surveys were conducted prior to the die-off in 2011.

Density estimates of red sea urchins were generally similar between PISCO, CDFW and Reef Check surveys (Figure 19). At the Point Arena site there was close agreement between surveys CDFW and PISCO in 2010 and between PISCO and Reef Check in 2011 with a strongly increasing trend during the 2010-2012 period (**Figure 19**a). At Salt Point densities decreased between 2010 and 2011 in both the PISCO and Reef Check surveys corresponding to the HAB event in 2011, however densities were consistent between CDFW surveys in 2005 and 2012 (**Figure 19**b). At Timber Cove and Ocean Cove

CDFW surveys were not coincident with the baseline surveys, but densities were generally similar to PISCO estimates (**Figure 19**c and d). Density estimates at the Reef Check site at Ocean Cove were lower throughout the period. At Fort Ross, all three programs generated density estimates that were similar and consistent throughout the period (**Figure 19**e).



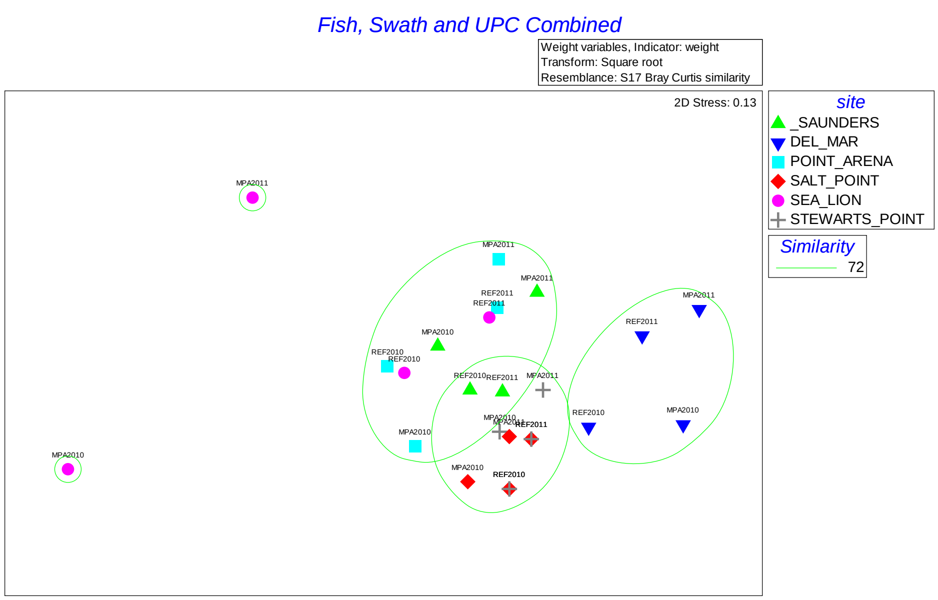


Figure 4. Cluster dendrogram and MDS (multi-dimensional scaling) plot of community structure based on all fish, algae and invertebrate species combined. Vertical lines on the cluster dendrogram indicate the 72% level of community similarity that distinguishes the three community structures. Similarly, green circles on the MDS plot indicate the clusters of sites that constitute the three significantly different community structures. Each line in the dendrogram and point on the MDS plot is the community structure by MPA (or reference area) and year.

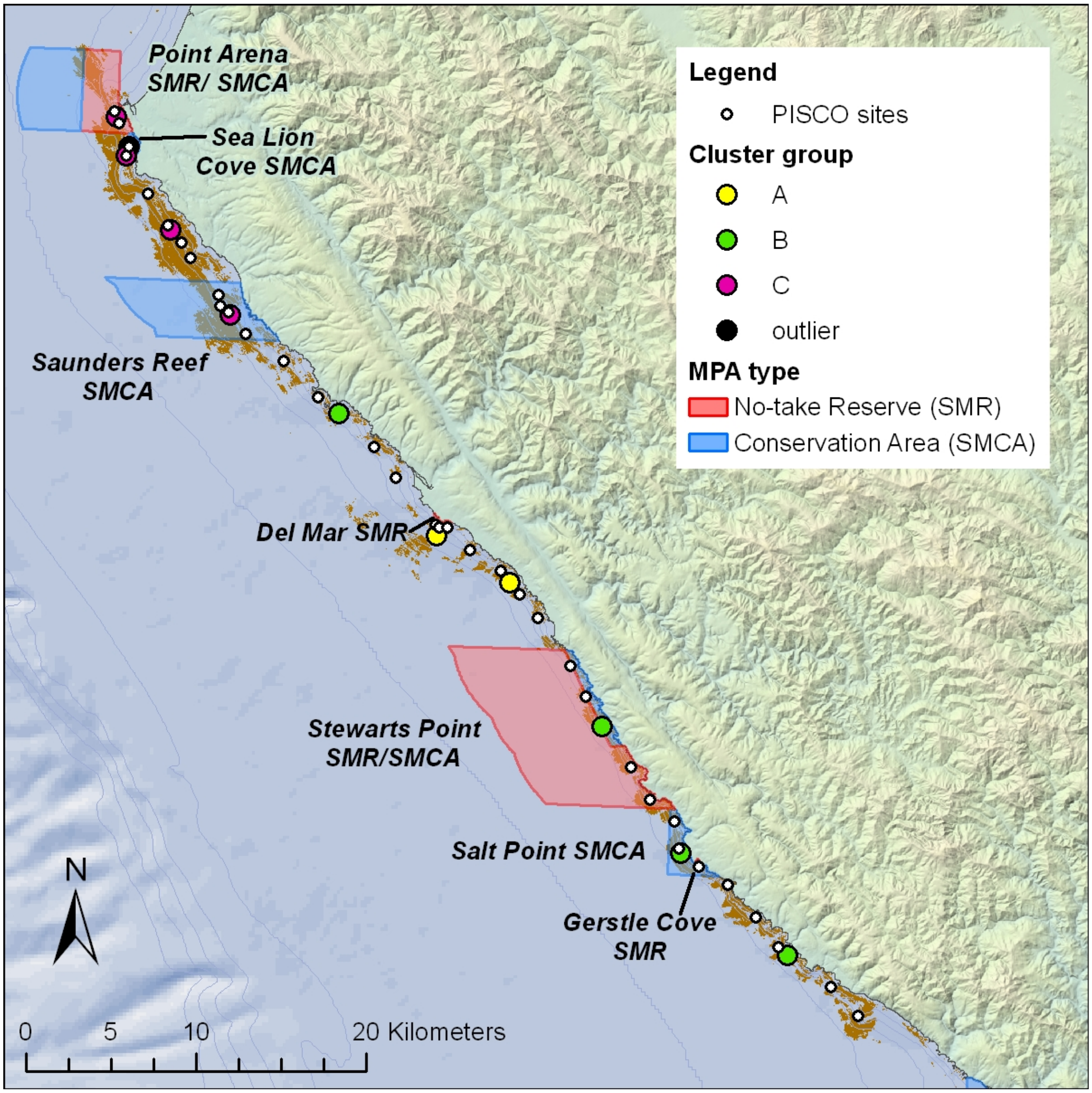


Figure 5. Locations of kelp forest survey sites ("PISCO sites") and distribution of the three distinct kelp forest communities ("A, B, C") defined by the clustering analysis.

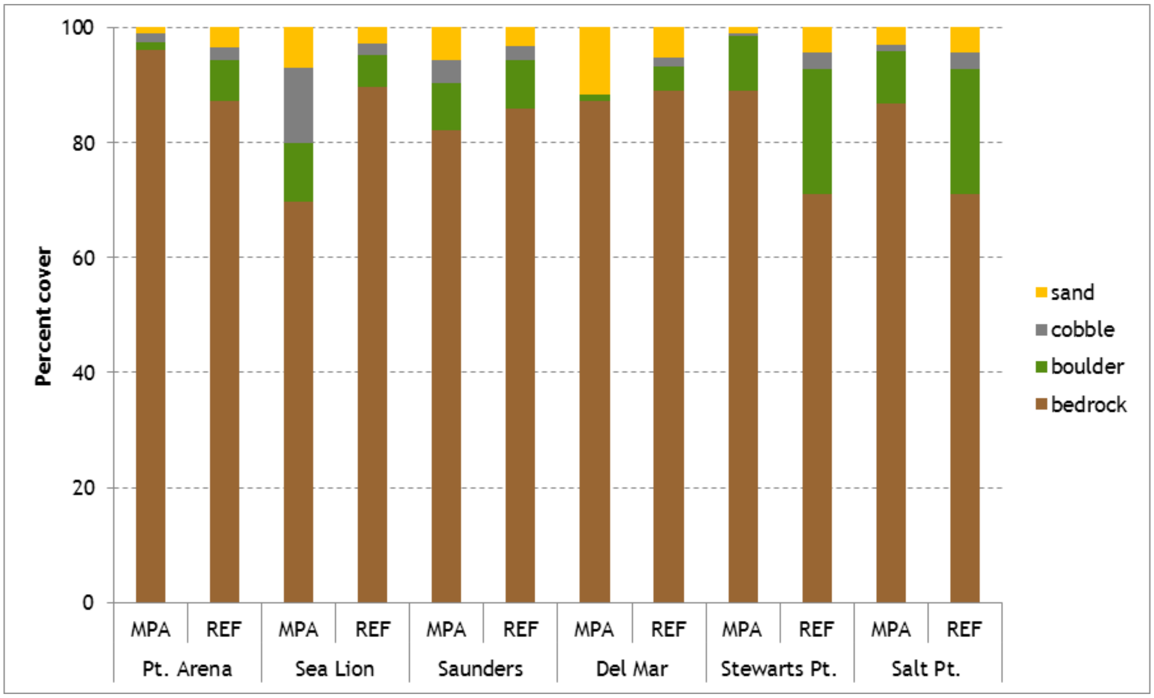


Figure 6. Mean percent cover of the four categories of substrate type surveyed by PISCO divers within MPAs and associated reference areas across 2010 and 2011.

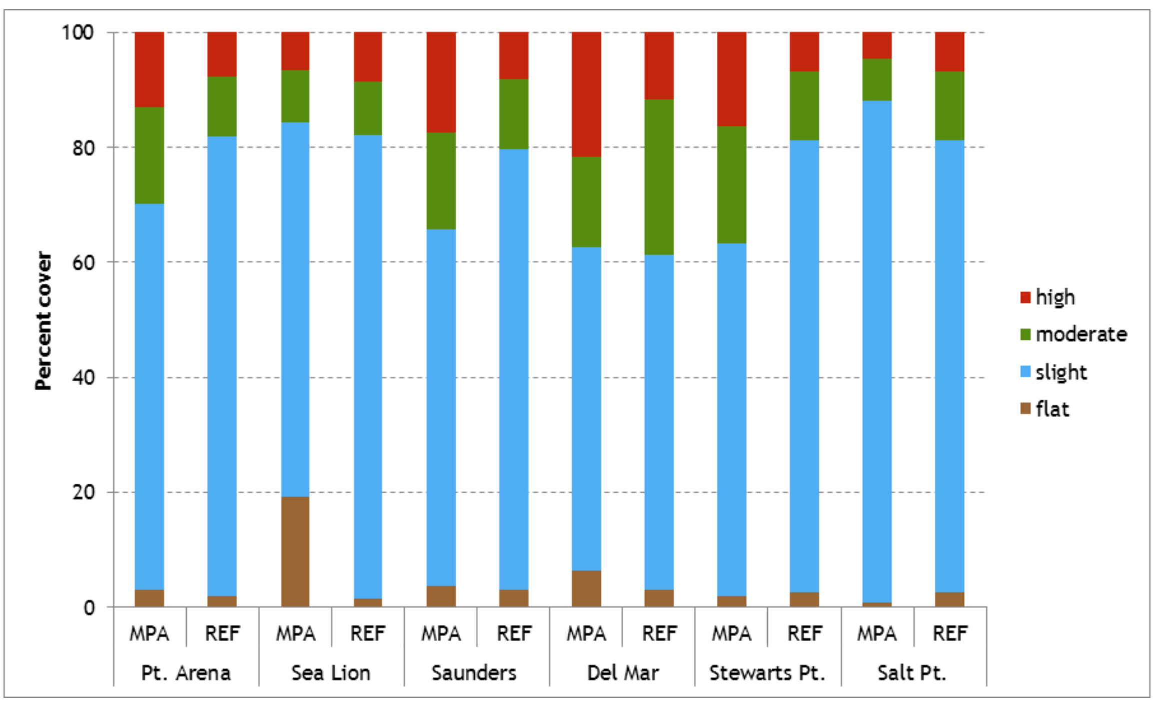


Figure 7. Mean percent cover of the four categories of vertical relief surveyed by PISCO divers within MPAs and associated reference areas across 2010 and 2011.

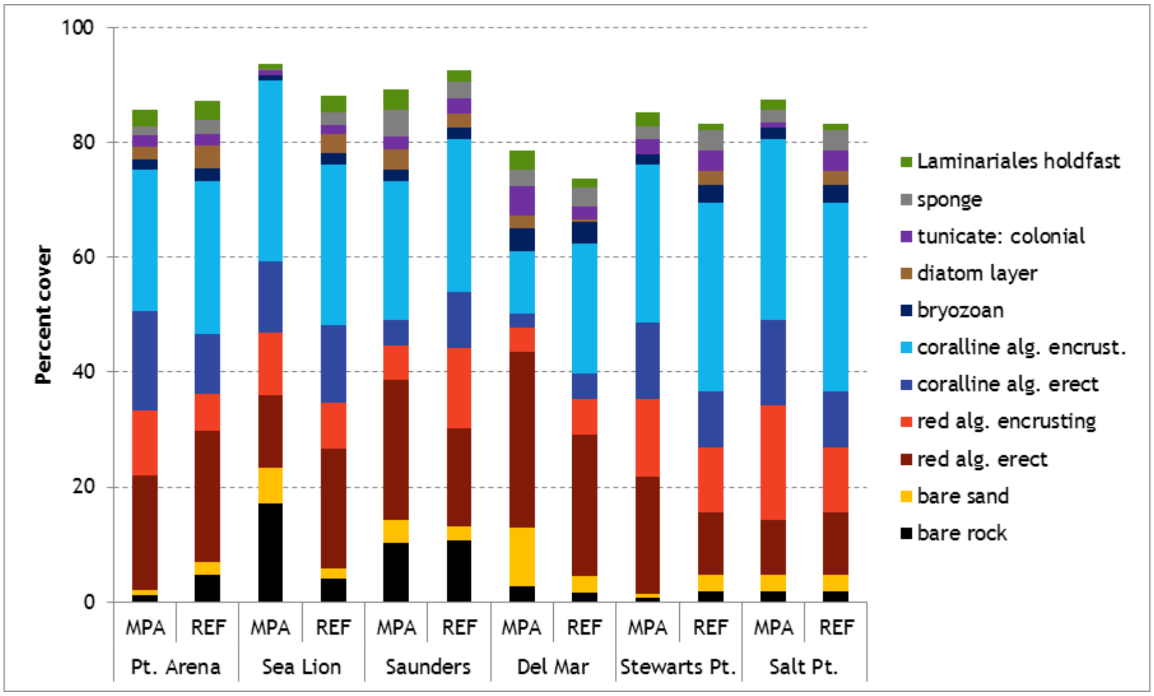


Figure 8. Mean percent cover of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups within MPAs and associated reference areas across 2010 and 2011.

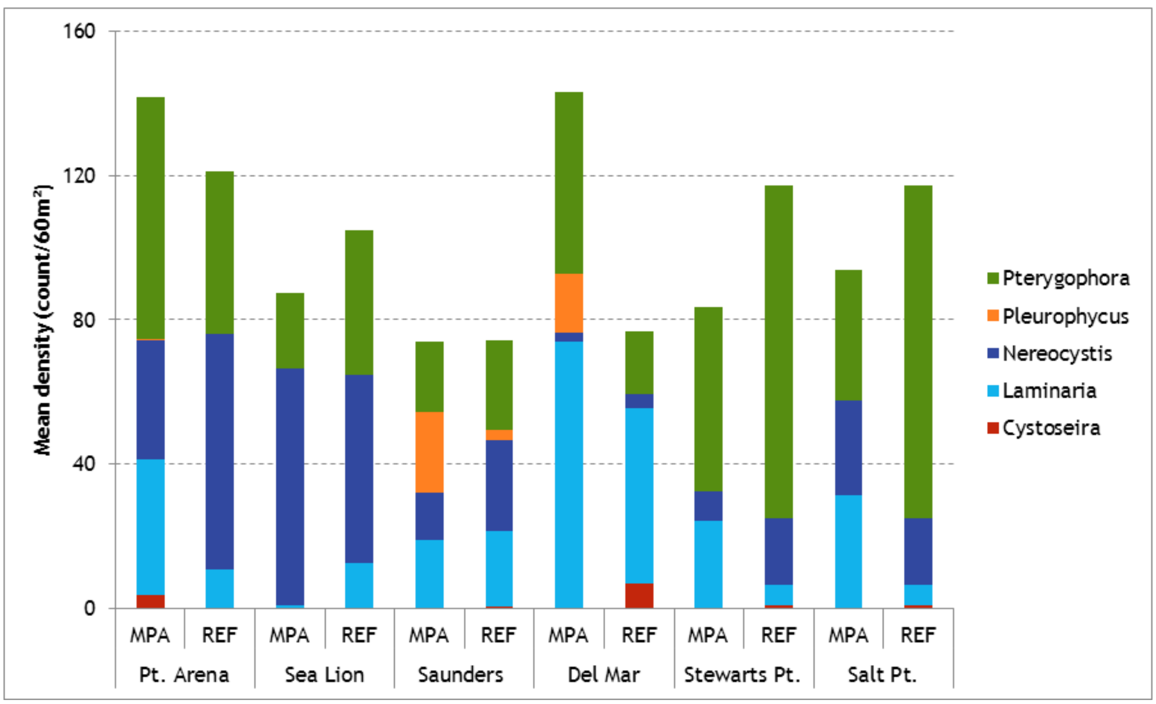


Figure 9. Mean densities of the five regionally most abundant stipitate algal groups within MPAs and associated reference areas across 2010 and 2011.

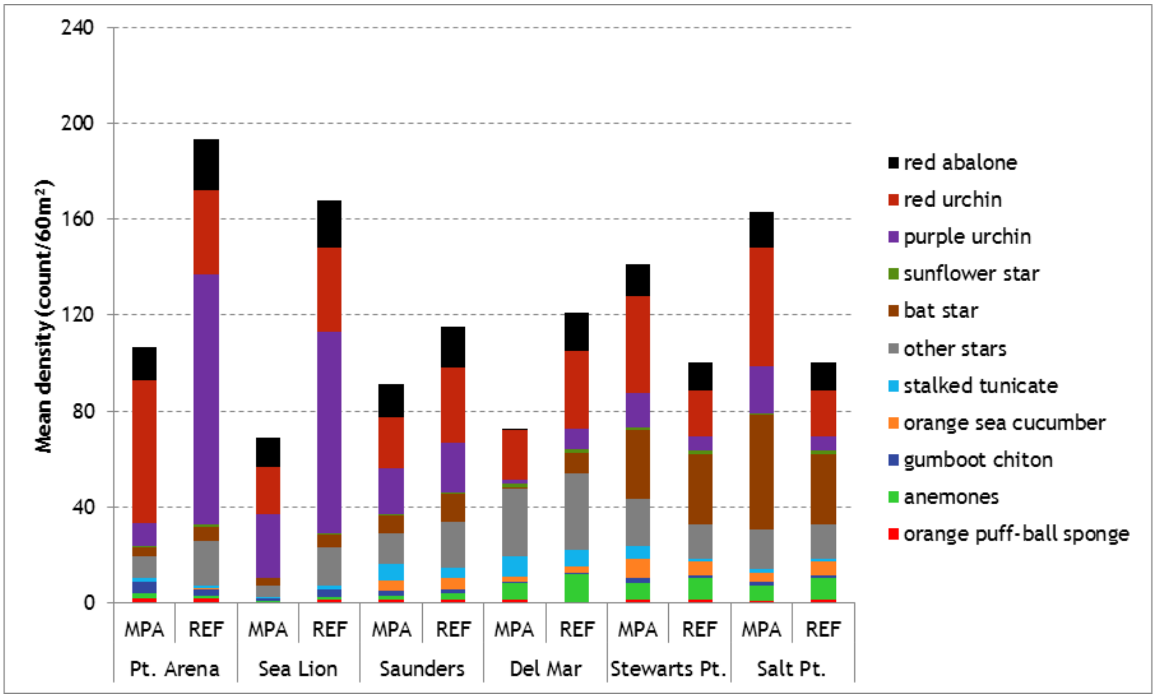


Figure 10. Mean densities of the 10 regionally most abundant macroinvertebrates within MPAs and associated reference areas across 2010 and 2011.

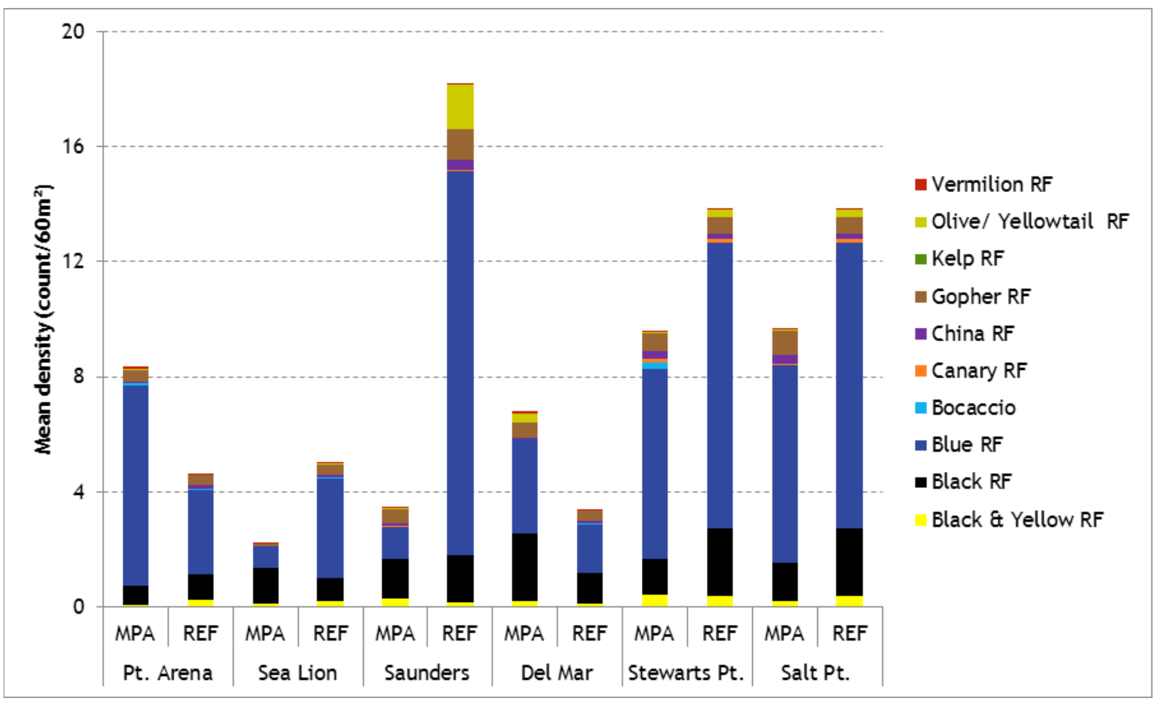


Figure 11. Mean densities of the 10 regionally most abundant rockfish species within MPAs and associated reference areas across 2010 and 2011. Data presented here do not include young-of-year rockfish.

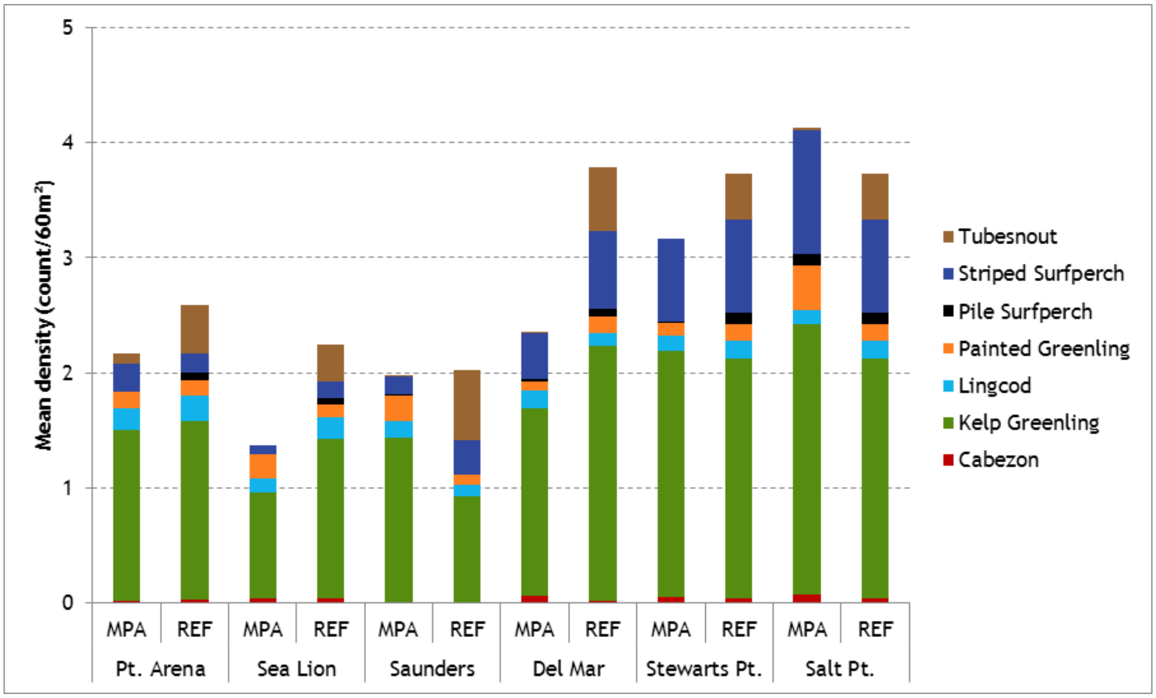


Figure 12. Mean densities of the seven regionally most abundant non-rockfish species within MPAs and associated reference areas across 2010 and 2011. Data presented here do not include young-of-year fish.

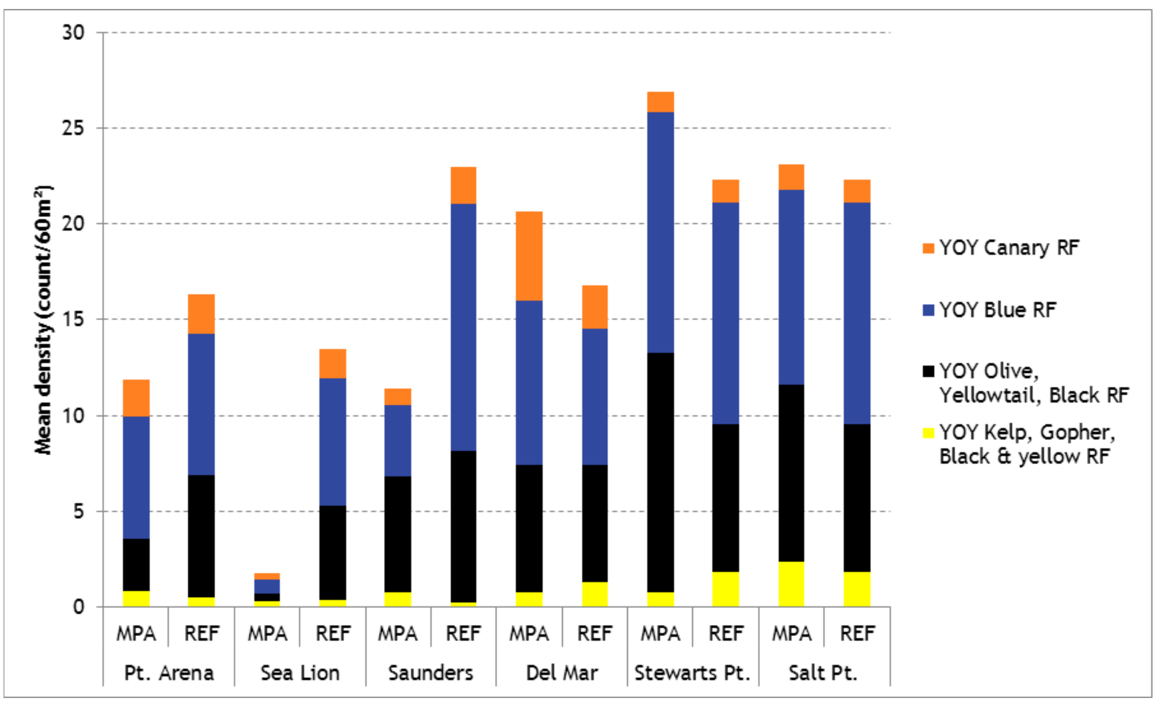


Figure 13. Mean densities of the four regionally most abundant young-of-year rockfish within MPAs and associated reference areas across 2010 and 2011.

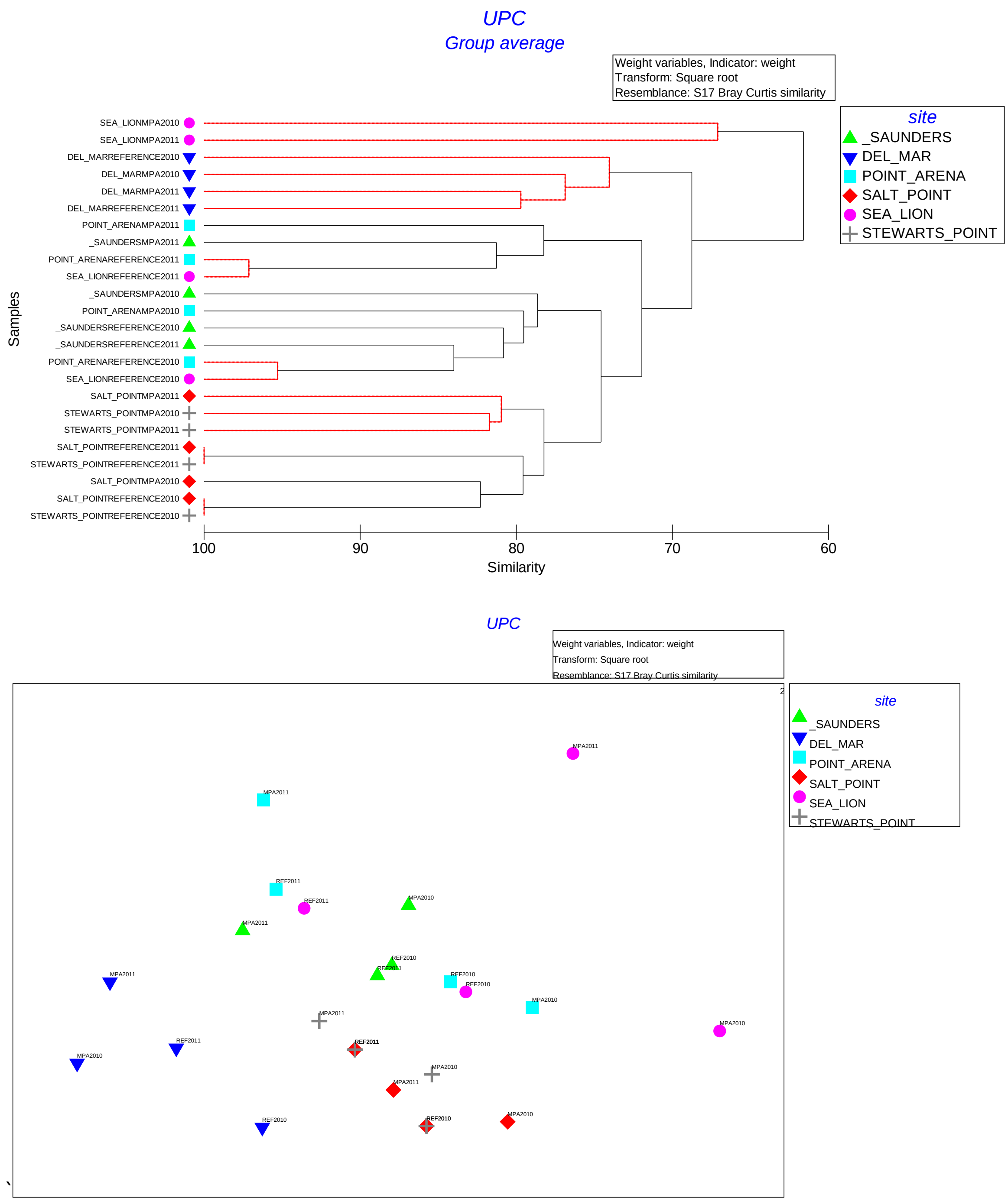
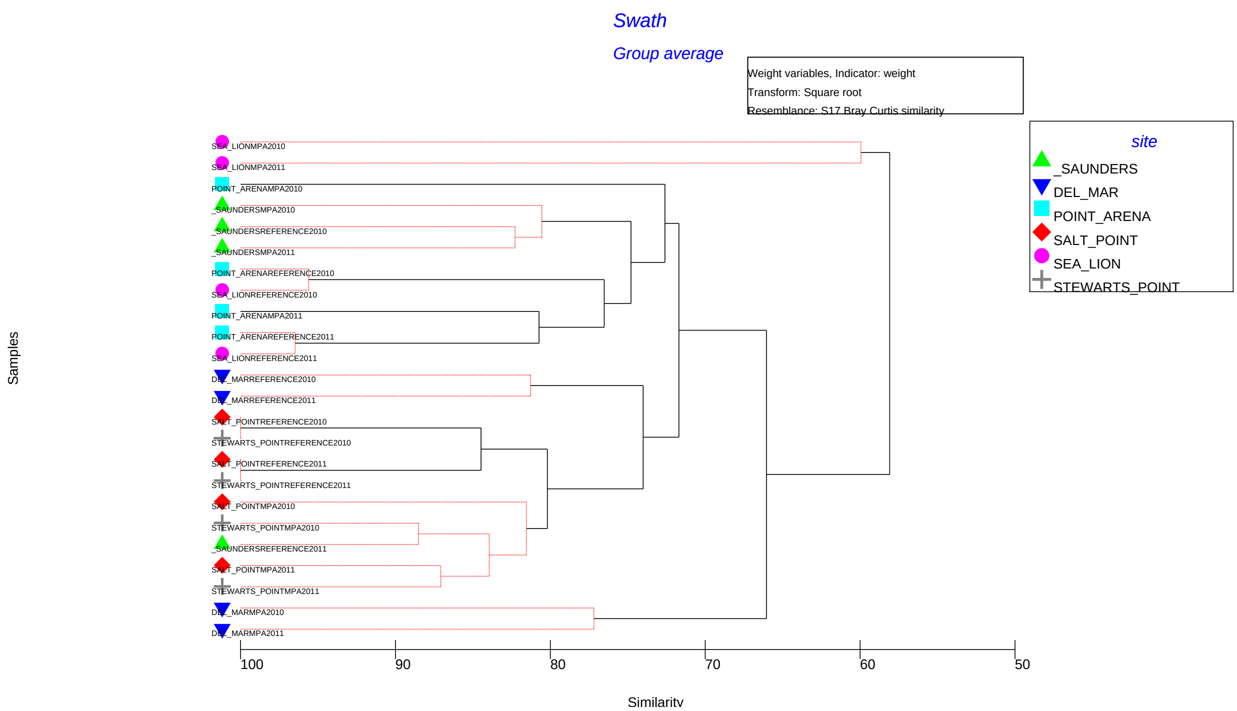


Figure 14. Cluster dendrogram and MDS (multi-dimensional scaling) plot based on the structure of the assemblage of sessile and colonial invertebrates and non-stipitate turf algal groups. Each line in the dendrogram and point on the MDS plot is the assemblage structure by MPA (or reference area) and year. Community similarity on the MDS plot is indicated by proximity of points; the closer the points, the more similar the communities.



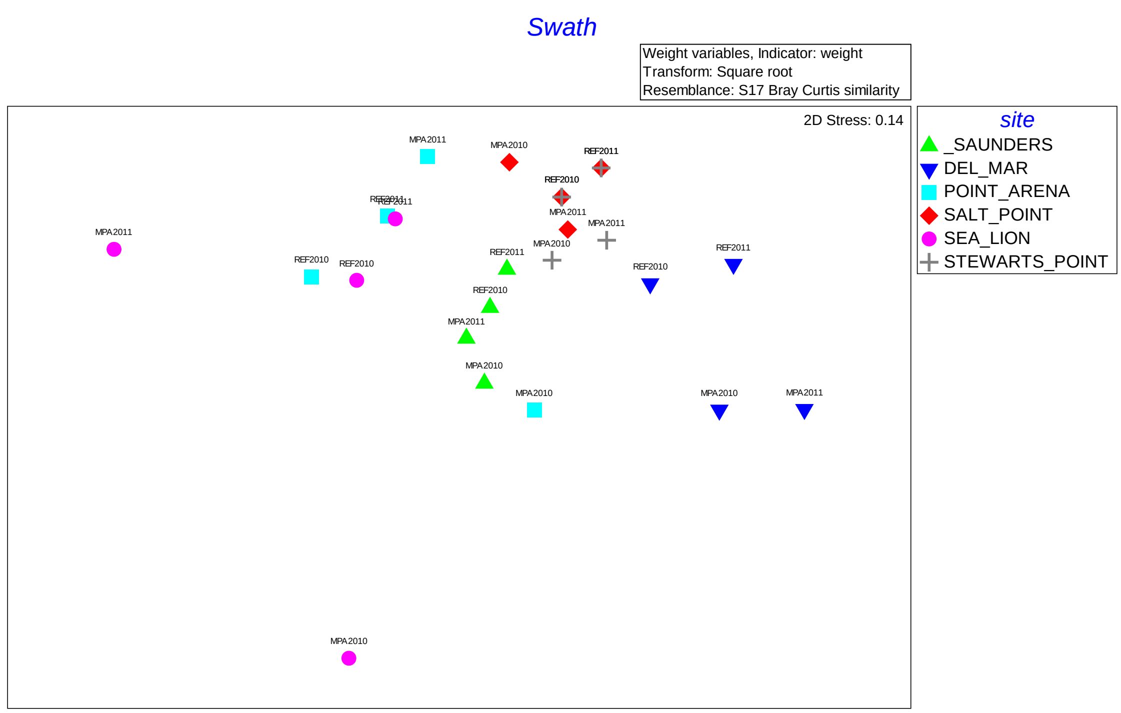


Figure 15. Cluster dendrogram and MDS (multi-dimensional scaling) plot based on the structure of the stipitate algae and macroinvertebrates recorded on benthic swath transects. Each line in the dendrogram and point on the MDS plot is the assemblage structure by MPA (or reference area) and year. Community similarity on the MDS plot is indicated by proximity of points; the closer the points, the more similar the communities.

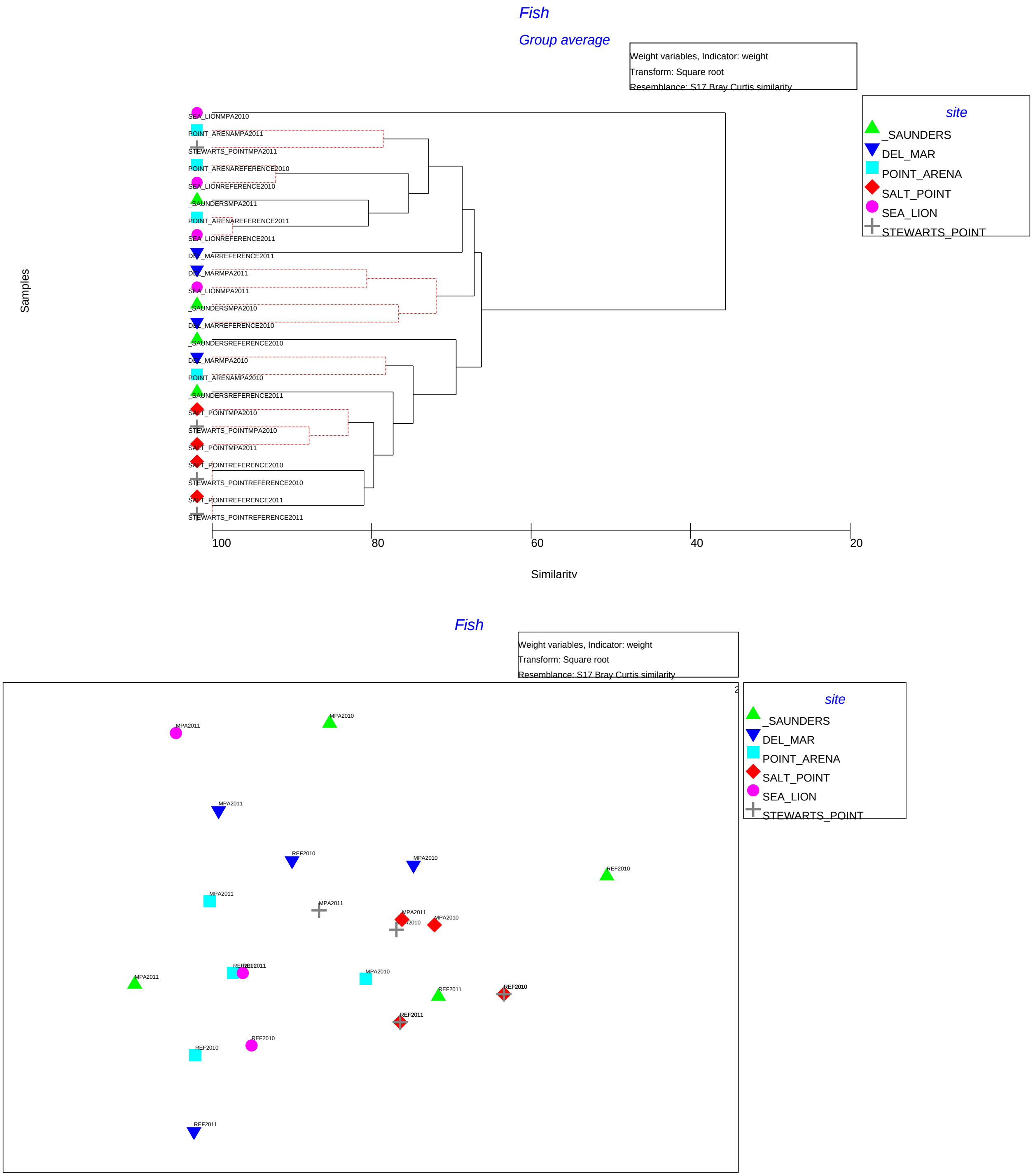


Figure 16. Cluster dendrogram and MDS (multi-dimensional scaling) plot based on the structure of the fish assemblage for sites and years. These analyses exclude juvenile rockfishes. Each line in the dendrogram and point on the MDS plot is the assemblage structure by MPA (or reference area) and year. Community similarity on the MDS plot is indicated by proximity of points; the closer the points, the more similar the communities.

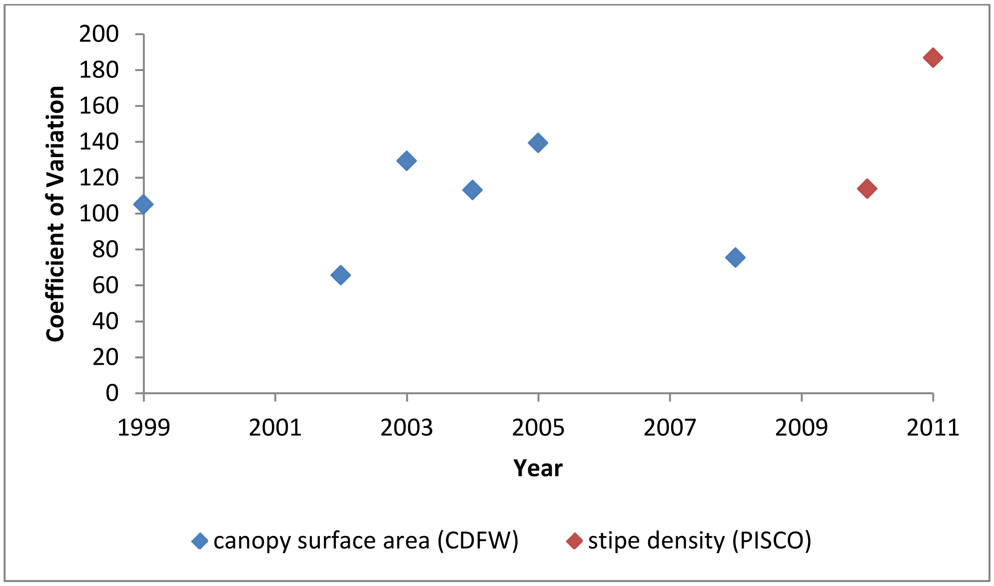


Figure 17. Spatial variation (Coefficient of variation) of bull kelp abundance among the 35 sites sampled for baseline characterization. Surface canopy estimated by CDFW aerial surveys (blue bullets). Stipe density estimated by PISCO SCUBA surveys (red bullets).

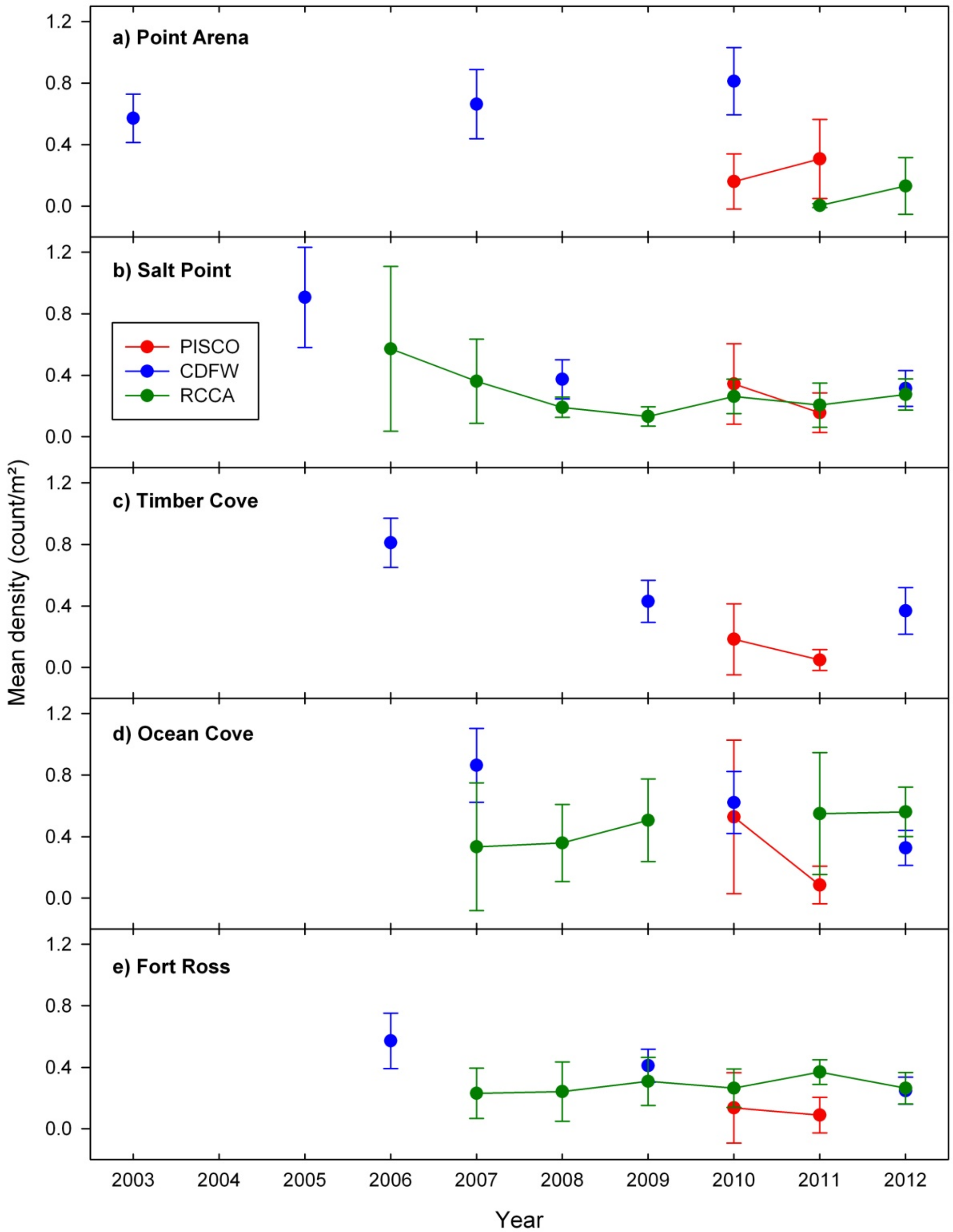


Figure 18. Density of red abalone (*Haliotis rufescens*) at five sites estimated by three different sampling programs (PISCO, California Department of Fish and Wildlife (CDFW), and Reef Check California (RCCA)) between 2003 and 2012. Error bars indicate the upper and lower limits of the 95% confidence interval.

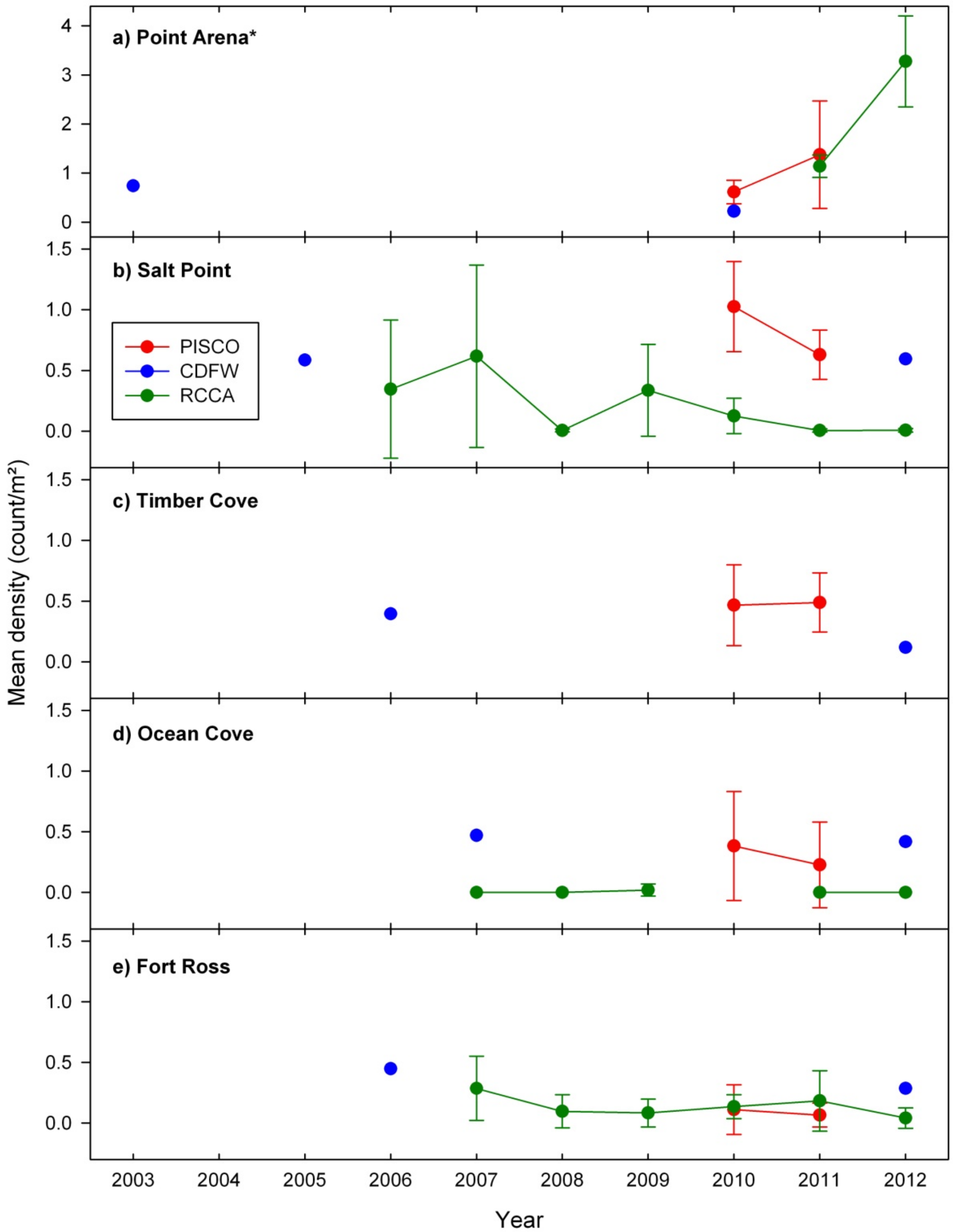


Figure 19. Density of red urchins (*Strongylocentrotus franciscanus*) at five sites estimated by three different sampling programs (PISCO, California Department of Fish and Wildlife (CDFW), and Reef Check California (RCCA)) between 2003 and 2012. Error bars indicate the upper and lower limits of the 95% confidence interval (not available from CDFG data). Note the higher densities at Point Arena (indicated with *) necessitating different y-axis scaling than the other plots on this graph.

Conclusions and Recommendations for Long-term Monitoring

Conclusion 1: Community structure differed significantly (though not dramatically) across the study region, falling out into three geographically cohesive clusters (with minor exceptions), with distinct fish, invertebrate, and algal assemblages. These clusters were distributed from north to south with one cluster including Point Arena SMR, Saunders Reef SMCA, and the reference areas between them; a second cluster occurring within the Del Mar SMR and reference areas to the south; and the final group occurring at sites to the south of Saunders Reef SMCA and including sites from Stewarts Point SMR, Salt Point SMCA, and reference areas to the south (Figure 1). The same analyses based on the separate species groups (fish, invertebrates, and algae) show generally similar geographic patterns.

Implication: The distribution of MPAs across the study region encompasses the geographic diversity of community structure within the kelp forest ecosystem. The differences found among geographic clusters imply that monitoring results generated within a cluster could only cautiously be extrapolated to MPAs in other clusters. Rather, long-term monitoring of MPAs should be distributed across the three distinct geographic clusters.

Conclusion 2: The observed geographic patterns of community structure suggest that the reference areas identified were generally well matched with associated MPAs.

Implication: With a few exceptions, these baseline reference areas seem appropriate for long-term monitoring studies. The exceptions (Saunders and Sea Lion reference areas) suggest that reference areas surveyed for other MPAs may serve as more appropriate reference areas or that alternative reference areas for these two MPAs need to be identified.

Conclusion 3: We examined six aspects of initial changes generated by the two years of monitoring data. Generally, we would not anticipate detectable changes in either community structure or metrics of species abundance (density or percent cover) or size that could be attributed to the establishment of the MPAs so soon after their establishment. The few "MPA effects" (i.e., significant year by MPA interactions) that were detected were very unlikely to be attributable to the presence of MPAs.

Implication: The life-history and population ecology of most kelp forest species would most likely require more than two years to exhibit a detectable response to the establishment of an MPA. Longer term monitoring will be necessary to detect these responses.

Conclusion 4: We detected significant differences in the abundances of several taxa between sampling years of the baseline characterization. For the three species examined for which longer time series exist (red abalone, red sea urchin, bull kelp) the inter-annual variability recorded in this study seems to be characteristic of those longer term time series from the region. For the vast majority of species, however, longer-term time series do not exist.

Implication: For the many species for which longer time series do not exist, there is no context for interpreting whether inter-annual variability observed during the baseline study is characteristic or anomalous for these species in this region. Nonetheless, we can use these estimates of inter-annual variability from the baseline characterization to inform power analyses to determine the frequency and duration of monitoring necessary to detect trends attributable to MPA effects.

Conclusion 5: We observed significant declines (40%) in red abalone densities both within and outside MPAs following the HAB event in 2011. At these same sites, 30% of the abalone shells recorded were empty. In combination, these observations suggest that these declines were attributable to the HAB event.

Implication: The time series of abalone densities observed by CDFW indicated significant declines prior to the HAB event. By monitoring abalone densities inside and outside of MPAs directly before and after this event, the baseline characterization provides an opportunity to distinguish the contribution of the HAB event relative to other sources of mortality (fishing and natural) and the observed decline. This illustrates one important role of long term MPA monitoring for both identifying episodic catastrophic natural perturbations and informing fisheries management.

Conclusion 6: Long term monitoring of abalone density showed higher densities for programs sampling in shallower depths. This difference in sampling design was intentional in order to use existing resources to sample across the entire species depth range.

Implication: The depth related differences in density estimates underscore the importance of designing complementary sampling programs and integrating monitoring results to comprehensively characterize population responses.

Site Descriptions

Included in the following pages are tables summarizing of the physical habitat characteristics (substrate type and relief) and the mean density or percent cover of the regionally most abundant species in MPAs and associated reference areas. For each MPA and associated reference area, there are four tables: 1) percent cover of substrate type and vertical relief, 2) the percent cover of sessile invertebrates and non-stipitate algal groups, 3) the density of stipitate algae and macroinvertebrates, and 4) the density of fishes. All tables indicate mean values and standard error separately for 2010 and 2011 across replicate sites associated with each MPA and reference area. At the end of this section, the data presented in the tables is summarized in a series of stacked bar graphs that compare abundance or percent cover for each MPA and reference area across the two years of study.

Physical Site Attributes

1. **Substrate Type:** describes the substrate type at each of 30 points on a UPC transect
    a. **bedrock:** rocks with any dimension greater than 1 m
    b. **boulder:** rocks with the largest dimension between 10 cm and 1 m
    c. **cobble:** rocks with the largest dimension less than 10 cm

   d. **sand:** persistent sand that cannot easily be brushed away from underlying substrate
2. **Vertical Relief:** describes the vertical distance between the lowest and highest points in a 2 m x 1 m area surrounding each point on a UPC transect
   a. **Flat relief:** 0 to 10 cm
   b. **slight relief:** 10cm to 1m
   c. **moderate relief:** 1m to 2m
   d. **high relief:** greater than 2m

Point Arena SMR

There are six sites associated with the Point Arena SMR: two are located within the reserve and four are located to the south (Figure 5).

Table 2. Mean percent cover and standard error of substrate characteristics at Point Arena MPA and reference sites in 2010 and 2011.

Point Arena									
Substrate characteristic		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
Substrate Type	bedrock	95.3	2.4	85.2	4.9	96.7	1.5	89.3	2.3
	boulder	1.1	0.6	9.7	3.9	1.7	0.8	4.3	1.5
	cobble	1.7	0.6	1.8	0.8	1.4	0.8	2.6	0.7
	sand	1.9	1.4	3.3	1.7	0.3	0.3	3.8	1.4
Vertical Relief	flat	5.6	2.8	2.1	1.8	0.3	0.3	1.8	0.8
	slight	80.8	5.6	89.3	2.8	53.6	8.8	70.6	5.9
	moderate	6.7	2.0	8.0	2.3	27.2	5.0	12.8	1.9
	high	6.9	4.5	0.6	0.5	18.9	5.9	14.9	6.3

Table 3. Mean percent cover and standard error of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups at Point Arena MPA and reference sites in 2010 and 2011.

Point Arena									
Sessile invertebrates and non-stipitate algae		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
bare rock		1.1	0.9	5.0	0.9	1.1	0.6	4.3	1.0
bare sand		1.7	1.4	3.3	1.7	0.0	0.0	1.1	0.7
red algae, erect	branching flat	10.0	4.0	11.0	2.5	4.7	1.4	9.3	1.8
	branching cylindrical	0.0	0.0	0.2	0.2	0.6	0.6	0.1	0.1
	lacy	0.6	0.6	4.7	1.4	0.6	0.4	2.7	1.1
	leaf-like	5.3	1.5	6.4	1.3	6.9	1.4	7.3	1.3
	filamentous turf	2.5	1.2	0.1	0.1	8.9	3.3	3.9	1.9

red algae, encrusting	13.9	4.1	9.8	1.5	8.9	1.9	3.3	1.1
coralline algae, erect	22.2	8.6	10.0	3.8	12.5	4.8	10.7	3.8
coralline algae, encrusting	33.1	7.3	33.0	3.9	16.1	3.1	20.1	2.6
Laminariales holdfast	1.7	0.9	1.1	0.4	3.9	1.3	5.6	1.4
bryozoan	1.9	0.6	2.9	1.0	1.7	0.6	1.8	0.6
diatom layer	2.5	1.8	2.4	1.5	1.7	0.9	5.5	1.4
tunicate: colonial	0.6	0.4	0.6	0.3	3.6	0.9	3.3	0.8
sponge	1.1	0.7	1.1	0.3	1.9	0.8	3.8	1.0

Table 4. Mean density and standard error of the 15 regionally most abundant stipitate algal and macroinvertebrate groups at Point Arena MPA and reference sites in 2010 and 2011.

Point Arena										
Swath invertebrate and algal species			2010				2011			
			MPA		Reference		MPA		Reference	
			Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Algae	*Cystoseira*		0.0	0.0	0.0	0.0	7.8	4.6	0.0	0.0
	Laminaria		48.8	23.8	7.5	2.1	26.3	10.4	14.5	3.9
	Nereocystis		9.2	4.0	19.7	8.5	56.8	27.7	110.8	51.0
	Pleurophycus		0.0	0.0	0.0	0.0	0.8	0.4	0.0	0.0
	Pterygophora		52.8	21.8	19.2	6.5	80.7	54.0	70.7	31.5
Mobile/solitary invertebrates	red abalone		9.6	4.9	21.8	5.0	18.4	7.0	21.1	4.8
	red urchin		36.9	6.5	33.4	6.9	82.4	29.8	36.4	5.9
	purple urchin		4.1	1.2	136.1	46.1	14.5	6.6	73.3	32.5
	sunflower star		0.8	0.4	0.5	0.3	0.9	0.5	0.8	0.3
	bat star		0.6	0.3	1.3	0.6	6.9	4.7	10.8	10.1
	Other stars	blood	1.9	0.6	3.0	0.7	2.9	0.7	4.4	1.1
		giant spined	2.3	0.5	4.8	1.0	2.9	0.7	4.1	0.9
		leather	1.0	0.4	1.8	0.4	1.8	0.5	1.8	0.4
		ochre	0.7	0.2	1.5	0.6	0.3	0.2	4.1	1.7
		rainbow	0.2	0.1	0.1	0.1	0.2	0.1	0.2	0.1
		short spined	1.2	0.4	6.1	1.1	2.8	1.2	4.4	0.9
	stalked tunicate		1.0	0.5	1.0	0.3	1.3	0.6	1.5	0.7
	orange sea cucumber		0.3	0.3	0.2	0.1	0.2	0.1	0.5	0.2
	gumboot chiton		4.4	2.0	2.1	0.5	5.7	1.4	3.7	0.9
	orange puff-ball sponge		2.3	1.0	2.2	0.7	1.8	1.1	1.2	0.3
	Anemones	Christmas	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.1
		fish-eating	0.5	0.2	0.5	0.2	0.4	0.3	0.4	0.2
		giant green	0.2	0.2	0.0	0.0	0.2	0.2	0.0	0.0
		strawberry	0.5	0.3	0.3	0.2	1.2	0.7	0.7	0.4
		Urticina spp.	0.3	0.3	0.3	0.2	0.0	0.0	0.1	0.1
		white plumed	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

Table 5. Mean densities and standard error of the 21 regionally most abundant fishes at Point Arena MPA and reference sites in 2010 and 2011.

Point Arena									
Fish species		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Rockfishes	Black and yellow	0.08	0.08	0.30	0.12	0.08	0.06	0.17	0.07
	Black	0.75	0.49	1.26	0.64	0.54	0.20	0.58	0.27
	Blue	9.58	6.51	2.33	0.95	4.33	2.46	3.44	1.57
	Bocaccio	0.08	0.08	0.15	0.07	0.08	0.08	0.00	0.00
	Canary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	China	0.00	0.00	0.15	0.07	0.13	0.07	0.06	0.04
	Gopher	0.42	0.26	0.33	0.13	0.33	0.12	0.42	0.16
	Kelp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Olive or yellowtail	0.08	0.08	0.00	0.00	0.00	0.00	0.04	0.04
	Vermilion	0.08	0.08	0.00	0.00	0.17	0.08	0.06	0.04
Other fishes	Lingcod	0.25	0.13	0.11	0.06	0.13	0.07	0.33	0.10
	Cabezon	0.00	0.00	0.04	0.04	0.04	0.04	0.02	0.02
	Kelp greenling	2.08	0.42	1.70	0.31	0.88	0.16	1.40	0.24
	Painted greenling	0.08	0.08	0.19	0.12	0.21	0.13	0.08	0.04
	Pile surfperch	0.00	0.00	0.11	0.11	0.00	0.00	0.02	0.02
	Striped surfperch	0.42	0.34	0.15	0.09	0.08	0.06	0.19	0.08
	Tubesnout	0.17	0.17	0.74	0.74	0.00	0.00	0.10	0.09
Young-of-year rockfishes	Kelp, gopher, or black & yellow	5.08	1.79	12.33	2.71	0.29	0.18	0.42	0.17
	Olive, yellowtail, or black	0.83	0.46	0.59	0.22	0.88	0.40	0.42	0.17
	Blue	12.50	7.25	13.07	3.90	0.33	0.21	1.67	0.59
	Canary	3.58	1.53	4.07	1.71	0.25	0.25	0.02	0.02

Sea Lion Cove SMCA

There are two sites associated with the Sea Lion Cove SMCA: one is located within the reserve and one is located to the south (Figure 5).

Table 6. Mean percent cover and standard error of substrate characteristics at Sea Lion Cove MPA and reference sites in 2010 and 2011.

Sea Lion Cove									
Substrate characteristic		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
Substrate Type	bedrock	81.1	11.0	88.2	4.0	58.3	13.1	90.9	2.0
	boulder	10.0	6.6	7.7	3.1	10.6	4.9	3.6	1.3
	cobble	7.2	6.0	1.4	0.6	18.9	8.7	2.6	0.7
	sand	1.7	0.7	2.6	1.4	12.2	5.0	3.0	1.2
Vertical Relief	flat	11.1	5.8	1.6	1.4	27.2	12.0	1.4	0.7
	slight	82.8	6.1	90.9	2.3	47.8	10.1	70.3	5.5
	moderate	5.6	2.7	7.0	1.9	12.2	6.1	11.6	1.7
	high	0.6	0.6	0.5	0.4	12.8	10.8	16.7	5.9

Table 7. Mean percent cover and standard error of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups at Sea Lion Cove MPA and reference sites in 2010 and 2011.

Sea Lion Cove									
Sessile invertebrates and non-stipitate algae		**2010**				**2011**			
		MPA		**Reference**		**MPA**		**Reference**	
		Mean % cov.	**Std. Err.**	**Mean % cov.**	**Std. Err.**	**Mean % cov.**	**Std. Err.**	**Mean % cov.**	**Std. Err.**
bare rock		15.5	6.3	4.2	0.8	18.9	6.2	4.1	0.8
bare sand		1.1	0.7	2.6	1.3	11.1	5.4	0.9	0.5
red algae, erect	branching flat	2.8	1.0	10.1	2.0	2.2	2.2	9.5	1.8
	branching cylindrical	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1
	lacy	0.6	0.6	3.7	1.1	1.7	1.1	2.2	0.9
	leaf-like	1.1	0.7	5.6	1.1	2.8	1.6	6.9	1.1
	filamentous turf	0.6	0.6	0.5	0.4	13.9	5.9	3.1	1.5
red algae, encrusting		14.9	4.5	12.6	2.1	6.7	2.9	3.4	0.9
coralline algae, erect		22.2	7.4	13.7	4.0	2.8	1.8	13.0	4.1
coralline algae, encrusting		35.3	4.3	32.2	3.9	27.8	4.3	24.0	3.5
Laminariales holdfast		1.1	1.1	0.8	0.3	0.6	0.6	5.0	1.2
bryozoan		0.5	0.5	2.4	0.8	1.1	1.1	1.4	0.5
diatom layer		0.0	0.0	1.9	1.2	0.0	0.0	4.9	1.2
tunicate: colonial		0.5	0.5	0.5	0.2	1.1	0.7	2.7	0.7
sponge		0.0	0.0	0.8	0.3	0.6	0.6	3.4	0.9

Table 8. Mean density and standard error of the 15 regionally most abundant stipitate algal and macroinvertebrate groups at Sea Lion Cove MPA and reference sites in 2010 and 2011.

Sea Lion Cove										
Swath invertebrate and algal species			2010				2011			
			MPA		Reference		MPA		Reference	
			Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Algae	*Cystoseira*		0.2	0.2	0.0	0.0	0.2	0.2	0.0	0.0
	Laminaria		0.7	0.5	11.4	2.9	1.0	0.6	13.5	3.4
	Nereocystis		9.0	4.3	15.9	6.8	122.0	95.2	89.0	41.4
	Pleurophycus		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pterygophora		31.7	12.4	21.0	5.5	10.5	5.3	58.8	25.5
Mobile/solitary invertebrates	red abalone		13.8	4.3	19.4	4.1	10.8	3.5	19.8	4.3
	red urchin		12.5	4.4	31.9	5.6	27.3	10.4	38.9	5.7
	purple urchin		0.2	0.2	108.4	37.5	52.0	32.9	59.3	26.4
	sunflower star		0.2	0.2	0.6	0.2	0.2	0.2	0.8	0.3
	bat star		3.3	1.7	1.0	0.5	3.3	2.8	8.7	8.1
	Other stars	blood	0.2	0.2	2.5	0.6	0.8	0.7	4.2	0.9
		giant spined	0.5	0.3	4.1	0.9	0.3	0.2	4.0	0.7
		leather	0.3	0.2	1.7	0.4	0.7	0.4	1.8	0.4
		ochre	0.0	0.0	1.4	0.5	0.3	0.2	3.4	1.4
		rainbow	0.0	0.0	0.1	0.1	0.0	0.0	0.3	0.1
		short spined	4.3	1.6	5.1	0.9	2.2	1.0	3.9	0.8
	stalked tunicate		0.7	0.7	1.0	0.3	0.2	0.2	1.7	0.6
	orange sea cucumber		0.0	0.0	0.1	0.1	0.0	0.0	0.5	0.2
	gumboot chiton		1.0	0.5	2.2	0.4	1.0	0.6	3.5	0.8
	orange puff-ball sponge		0.0	0.0	1.8	0.5	0.0	0.0	1.0	0.2
	Anemones	Christmas	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
		fish-eating	0.2	0.2	0.4	0.2	0.5	0.5	0.3	0.1
		giant green	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
		strawberry	0.0	0.0	0.2	0.1	0.3	0.3	0.6	0.3
		Urticina spp.	0.5	0.2	0.5	0.2	0.0	0.0	0.1	0.1
		white plumed	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

Table 9. Mean densities and standard error of the 21 regionally most abundant fishes at Sea Lion Cove MPA and reference sites in 2010 and 2011.

Sea Lion Cove									
Fish species		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Rockfishes	Black and yellow	0.00	0.00	0.25	0.09	0.25	0.13	0.13	0.06
	Black	0.08	0.08	0.97	0.49	2.42	2.33	0.62	0.24
	Blue	0.17	0.11	3.61	1.41	1.33	0.80	3.33	1.32
	Bocaccio	0.00	0.00	0.11	0.05	0.00	0.00	0.00	0.00
	Canary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	China	0.00	0.00	0.11	0.05	0.00	0.00	0.07	0.03
	Gopher	0.00	0.00	0.28	0.10	0.17	0.17	0.42	0.14
	Kelp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Olive or yellowtail	0.00	0.00	0.03	0.03	0.00	0.00	0.03	0.03
	Vermilion	0.00	0.00	0.00	0.00	0.08	0.08	0.05	0.03
Other fishes	Lingcod	0.25	0.18	0.08	0.05	0.00	0.00	0.30	0.09
	Cabezon	0.00	0.00	0.06	0.04	0.08	0.08	0.03	0.02
	Kelp greenling	0.83	0.24	1.47	0.26	1.00	0.28	1.28	0.20
	Painted greenling	0.00	0.00	0.14	0.09	0.42	0.29	0.08	0.04
	Pile surfperch	0.00	0.00	0.08	0.08	0.00	0.00	0.02	0.02
	Striped surfperch	0.00	0.00	0.14	0.07	0.17	0.11	0.17	0.06
	Tubesnout	0.00	0.00	0.56	0.56	0.00	0.00	0.08	0.07
Young-of-year rockfishes	Kelp, gopher, or black & yellow	0.75	0.75	9.42	2.20	0.08	0.08	0.33	0.13
	Olive, yellowtail, or black	0.00	0.00	0.44	0.17	0.58	0.58	0.33	0.14
	Blue	1.00	0.62	11.67	3.16	0.50	0.36	1.68	0.51
	Canary	0.00	0.00	3.06	1.31	0.58	0.58	0.02	0.02

Saunders Reef SMCA

There are eight sites associated with the Saunders Reef SMCA: four are located within the SMCA and four are located to the south (Figure 5).

Table 10. Mean percent cover and standard error of substrate characteristics at Saunders Reef MPA and reference sites in 2010 and 2011.

Saunders Reef									
Substrate characteristic		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
Substrate Type	bedrock	75.3	6.6	86.1	3.2	88.9	2.8	85.6	4.0
	boulder	11.0	3.7	8.6	2.2	5.6	2.0	8.3	3.1
	cobble	5.8	2.7	3.6	1.7	2.1	1.1	1.4	0.6
	sand	7.9	4.7	1.7	0.6	3.5	1.1	4.7	2.3
Vertical Relief	flat	6.0	3.8	3.5	1.6	1.4	1.0	2.6	2.1
	slight	61.1	7.1	72.2	6.1	63.1	7.3	81.1	5.3
	moderate	15.8	3.2	12.5	2.8	17.6	3.3	11.7	3.3
	high	17.1	5.9	11.8	5.7	17.9	6.1	4.6	1.9

Table 11. Mean percent cover and standard error of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups at Saunders Reef MPA and reference sites in 2010 and 2011.

Saunders Reef									
Sessile invertebrates and non-stipitate algae		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
bare rock		14.7	3.0	16.7	5.9	6.0	1.5	4.7	1.2
bare sand		4.6	2.7	1.0	0.5	3.2	0.9	3.9	2.0
red algae, erect	branching flat	13.2	3.8	11.0	2.2	16.1	2.7	9.4	2.7
	branching cylindrical	0.4	0.2	0.0	0.0	0.3	0.2	0.1	0.1
	lacy	2.0	0.8	1.3	0.5	5.0	1.7	3.0	1.0
	leaf-like	3.7	1.2	4.3	1.6	5.3	1.6	3.8	1.2
	filamentous turf	2.6	1.8	1.1	0.6	0.1	0.1	0.1	0.1
red algae, encrusting		5.8	1.3	14.7	2.9	6.1	0.9	13.0	2.2
coralline algae, erect		3.8	1.6	9.5	3.8	5.3	1.5	10.4	4.0
coralline algae, encrusting		29.6	5.0	20.1	3.3	18.7	3.2	32.7	3.7
Laminariales holdfast		1.8	0.6	1.6	0.5	5.4	1.4	2.5	0.9
bryozoan		1.8	0.7	2.9	0.8	2.4	0.8	1.3	0.5
diatom layer		2.9	1.1	2.1	1.2	4.2	1.2	2.9	1.5
tunicate: colonial		1.4	0.7	3.6	1.3	3.2	0.8	1.4	0.3
sponge		2.9	0.7	2.4	1.1	6.2	1.1	3.5	0.7

Table 12. Mean density and standard error of the 15 regionally most abundant stipitate algal and macroinvertebrate groups at Saunders Reef MPA and reference sites in 2010 and 2011.

Saunders Reef										
Swath invertebrate and algal species			2010				2011			
			MPA		Reference		MPA		Reference	
			Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Algae	*Cystoseira*		0.2	0.1	0.2	0.1	0.0	0.0	1.0	0.5
	Laminaria		14.8	4.0	27.8	17.8	22.8	8.1	14.2	4.5
	Nereocystis		9.5	4.8	38.0	13.6	17.0	7.8	12.3	4.2
	Pleurophycus		9.2	4.0	5.3	3.1	35.7	14.7	0.2	0.1
	Pterygophora		27.0	12.0	28.0	9.1	12.1	3.2	21.5	7.5
Mobile/solitary invertebrates	red abalone		13.8	4.5	19.8	9.1	14.0	4.4	13.9	4.3
	red urchin		14.2	4.6	28.8	5.9	28.0	4.2	34.5	4.4
	purple urchin		9.7	4.2	22.1	7.6	29.1	19.8	18.7	10.1
	sunflower star		0.6	0.2	0.5	0.2	0.4	0.2	0.6	0.2
	bat star		11.7	6.8	5.2	2.2	3.4	1.7	18.6	13.5
	Other stars	blood	2.1	0.5	2.4	0.5	3.2	0.7	2.5	0.6
		giant spined	2.7	0.8	4.9	0.9	3.9	0.9	4.9	0.9
		leather	2.3	0.4	2.6	1.1	1.6	0.3	1.1	0.3
		ochre	0.8	0.3	6.7	4.6	0.6	0.2	3.0	1.5
		rainbow	0.1	0.1	0.5	0.2	0.3	0.1	0.5	0.2
		short spined	4.2	0.9	4.8	0.8	3.7	0.9	4.1	1.0
	stalked tunicate		9.8	3.7	6.0	2.5	3.9	1.6	3.2	1.8
	orange sea cucumber		0.3	0.2	1.2	0.7	8.0	6.9	7.4	2.8
	gumboot chiton		2.3	0.6	2.1	0.6	2.3	0.5	2.0	0.6
	orange puff-ball sponge		1.3	0.4	1.9	0.6	1.1	0.4	0.8	0.2
	Anemones	Christmas	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
		fish-eating	0.2	0.1	1.4	0.4	0.7	0.2	1.2	0.4
		giant green	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		strawberry	0.4	0.2	0.5	0.2	1.6	0.6	0.8	0.3
		Urticina spp.	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.2
		white plumed	0.0	0.0	0.6	0.5	0.0	0.0	0.0	0.0

Table 13. Mean densities and standard error of the 21 regionally most abundant fishes at Saunders Reef MPA and reference sites in 2010 and 2011.

Saunders Reef									
Fish species		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Rockfishes	Black and yellow	0.38	0.15	0.03	0.03	0.17	0.06	0.31	0.09
	Black	2.38	0.73	1.40	0.51	0.38	0.12	1.81	0.31
	Blue	0.25	0.17	17.20	4.21	1.98	1.26	9.50	2.20
	Bocaccio	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00
	Canary	0.04	0.04	0.07	0.05	0.00	0.00	0.00	0.00
	China	0.17	0.12	0.47	0.20	0.08	0.04	0.31	0.10
	Gopher	0.38	0.26	1.17	0.24	0.58	0.15	0.90	0.17
	Kelp	0.00	0.00	0.03	0.03	0.00	0.00	0.02	0.02
	Olive or yellowtail	0.04	0.04	3.03	2.47	0.00	0.00	0.02	0.02
	Vermilion	0.04	0.04	0.03	0.03	0.00	0.00	0.04	0.03
Other fishes	Lingcod	0.13	0.07	0.03	0.03	0.17	0.06	0.17	0.06
	Cabezon	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00
	Kelp greenling	2.13	0.34	1.03	0.17	0.73	0.15	0.81	0.12
	Painted greenling	0.38	0.21	0.07	0.05	0.06	0.04	0.13	0.06
	Pile surfperch	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00
	Striped surfperch	0.21	0.10	0.23	0.09	0.10	0.05	0.35	0.09
	Tubesnout	0.00	0.00	0.00	0.00	0.02	0.02	1.23	1.19
Young-of-year rockfishes	Kelp, gopher, or black & yellow	12.00	3.73	15.37	3.63	0.08	0.04	0.42	0.14
	Olive, yellowtail, or black	1.46	0.42	0.33	0.18	0.15	0.07	0.13	0.06
	Blue	6.96	2.90	22.33	5.50	0.50	0.20	3.54	1.13
	Canary	1.63	1.00	3.90	1.47	0.06	0.06	0.00	0.00

Del Mar SMR

There are seven sites associated with the small Del Mar SMR: three are located within the reserve and four are located to the south (Figure 5).

Table 14. Mean percent cover and standard error of substrate characteristics at Del Mar MPA and reference sites in 2010 and 2011.

Del Mar									
Substrate characteristic		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
Substrate Type	bedrock	80.4	5.2	88.3	3.3	94.3	1.8	89.4	2.7
	boulder	1.3	0.6	5.4	1.9	0.7	0.3	3.2	1.4
	cobble	0.2	0.2	2.2	1.2	0.0	0.0	0.7	0.4
	sand	18.1	5.2	4.0	1.1	5.0	1.8	6.7	2.5
Vertical Relief	flat	11.5	5.1	3.1	1.7	1.3	1.1	2.9	1.8
	slight	48.0	8.3	55.6	6.3	64.6	7.4	61.2	6.5
	moderate	10.4	2.9	29.6	5.0	20.9	5.7	24.5	5.0
	high	30.2	8.2	11.8	3.6	13.1	4.7	11.4	3.5

Table 15. Mean percent cover and standard error of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups at Del Mar MPA and reference sites in 2010 and 2011.

Del Mar									
Sessile invertebrates and non-stipitate algae		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
bare rock		5.6	2.0	2.2	0.8	0.0	0.0	0.9	0.4
bare sand		14.7	5.0	1.9	0.9	5.6	1.9	4.1	2.0
red algae, erect	branching flat	14.3	3.7	18.9	4.5	26.3	4.9	17.9	3.9
	branching cylindrical	0.6	0.6	0.0	0.0	0.2	0.2	0.5	0.4
	lacy	4.3	1.3	2.2	1.5	1.3	0.5	0.8	0.4
	leaf-like	4.8	1.4	3.2	0.8	9.3	2.0	5.1	1.5
	filamentous turf	0.0	0.0	0.0	0.0	0.4	0.4	0.3	0.2
red algae, encrusting		4.3	1.5	8.1	1.6	3.9	1.5	4.6	1.1
coralline algae, erect		2.8	1.3	6.0	3.0	2.2	1.0	2.9	1.2
coralline algae, encrusting		6.9	2.0	24.4	3.9	14.8	3.6	20.5	3.3
Laminariales holdfast		2.6	1.0	1.0	0.4	3.7	1.1	2.2	0.7
bryozoan		2.8	0.9	5.0	1.5	5.4	1.6	2.8	1.0
diatom layer		1.3	1.1	0.0	0.0	3.0	0.8	0.8	0.6
tunicate: colonial		5.2	1.4	1.7	0.4	5.0	1.8	2.6	0.9
sponge		2.8	0.7	2.8	0.9	3.1	1.0	4.0	0.8

Table 16. Mean density and standard error of the 15 regionally most abundant stipitate algal and macroinvertebrate groups at Del Mar MPA and reference sites in 2010 and 2011.

Del Mar										
Swath invertebrate and algal species			2010				2011			
			MPA		Reference		MPA		Reference	
			Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Algae	*Cystoseira*		0.5	0.4	7.2	3.2	0.2	0.2	7.0	2.9
	Laminaria		21.3	7.9	30.4	13.6	125.8	52.1	66.8	28.6
	Nereocystis		2.8	1.2	4.0	1.3	1.9	1.9	3.2	1.4
	Pleurophycus		9.7	5.6	0.0	0.0	23.0	11.4	0.0	0.0
	Pterygophora		39.0	17.8	29.8	19.1	62.0	30.4	5.0	1.6
Mobile/solitary invertebrates	red abalone		0.6	0.4	19.8	5.5	0.4	0.4	12.1	3.7
	red urchin		11.0	3.8	25.1	4.8	30.4	10.9	39.5	6.3
	purple urchin		2.5	1.0	3.4	1.1	0.5	0.5	13.0	5.9
	sunflower star		2.0	0.6	1.7	0.4	1.2	0.4	1.5	0.5
	bat star		0.8	0.3	8.8	2.8	0.4	0.2	8.5	2.9
	Other stars	blood	3.3	0.8	1.5	0.2	3.2	0.9	2.5	0.6
		giant spined	10.3	3.3	12.2	2.1	8.2	1.9	22.0	5.0
		leather	2.6	0.6	2.2	0.4	2.9	0.7	5.1	1.5
		ochre	5.9	1.6	3.5	0.9	6.3	1.8	4.9	1.4
		rainbow	1.2	0.3	1.5	0.4	0.8	0.2	2.5	0.5
		short spined	4.8	1.2	2.3	0.7	6.1	1.7	3.2	0.7
	stalked tunicate		4.8	2.2	3.5	1.0	12.5	4.2	10.0	3.3
	orange sea cucumber		1.4	0.6	2.5	0.8	3.3	1.6	3.0	1.1
	gumboot chiton		0.4	0.2	0.4	0.2	0.8	0.3	1.0	0.3
	orange puff-ball sponge		1.4	0.5	0.1	0.1	1.3	0.6	0.5	0.2
	Anemones	Christmas	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.1
		fish-eating	1.4	0.6	1.9	0.4	2.3	0.9	2.0	0.6
		giant green	0.1	0.1	0.3	0.2	0.2	0.2	0.1	0.1
		strawberry	3.5	1.4	3.4	1.6	3.2	2.1	8.8	4.1
		Urticina spp.	0.1	0.1	0.4	0.2	0.0	0.0	0.0	0.0
		white plumed	1.4	0.9	4.4	4.2	0.6	0.6	1.8	1.2

Table 17. Mean densities and standard error of the 21 regionally most abundant fishes at Del Mar MPA and reference sites in 2010 and 2011.

Del Mar									
Fish species		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Rockfishes	Black and yellow	0.07	0.05	0.13	0.06	0.31	0.12	0.10	0.05
	Black	2.23	0.62	1.24	0.33	2.50	0.79	0.83	0.28
	Blue	5.37	2.29	1.53	0.42	1.17	0.31	1.90	1.07
	Bocaccio	0.00	0.00	0.04	0.03	0.03	0.03	0.00	0.00
	Canary	0.00	0.00	0.02	0.02	0.03	0.03	0.00	0.00
	China	0.07	0.05	0.16	0.07	0.00	0.00	0.02	0.02
	Gopher	0.50	0.22	0.47	0.13	0.53	0.18	0.27	0.10
	Kelp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Olive or yellowtail	0.67	0.67	0.00	0.00	0.00	0.00	0.00	0.00
	Vermilion	0.10	0.06	0.04	0.03	0.06	0.04	0.00	0.00
Other fishes	Lingcod	0.10	0.06	0.09	0.05	0.22	0.08	0.15	0.05
	Cabezon	0.03	0.03	0.00	0.00	0.08	0.05	0.04	0.03
	Kelp greenling	2.03	0.33	3.36	0.43	1.22	0.24	1.06	0.18
	Painted greenling	0.13	0.06	0.16	0.08	0.03	0.03	0.13	0.07
	Pile surfperch	0.00	0.00	0.07	0.07	0.03	0.03	0.06	0.05
	Striped surfperch	0.37	0.16	0.29	0.09	0.44	0.15	1.06	0.73
	Tubesnout	0.00	0.00	0.04	0.03	0.03	0.03	1.06	1.04
Young-of-year rockfishes	Kelp, gopher, or black & yellow	12.97	4.38	10.58	2.68	0.31	0.14	1.60	1.00
	Olive, yellowtail, or black	1.37	0.49	2.49	0.89	0.19	0.09	0.13	0.06
	Blue	15.07	3.85	13.27	2.63	2.14	0.48	0.96	0.36
	Canary	9.03	2.65	3.93	1.50	0.22	0.11	0.63	0.32

Stewarts Point

There are nine sites associated with the Stewarts Point SMR: four are located within the reserve and five are located to the south of the Salt Point SMCA (Figure 5). These reference sites are shared by both Salt Point and Stewarts Point MPAs.

Table 18. Mean percent cover and standard error of substrate characteristics at Stewarts Point MPA and reference sites in 2010 and 2011.

Stewarts Point									
Substrate characteristic		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
Substrate Type	bedrock	86.3	3.7	56.9	8.1	91.7	3.5	85.3	3.8
	boulder	11.4	3.7	36.3	8.5	7.8	3.6	7.1	1.8
	cobble	0.7	0.4	2.2	1.0	0.1	0.1	3.5	1.4
	sand	1.7	0.6	4.6	2.1	0.4	0.2	4.2	2.6
Vertical Relief	flat	4.0	1.7	4.4	1.9	0.0	0.0	0.6	0.6
	slight	62.9	7.2	83.5	4.5	59.6	7.1	73.8	6.4
	moderate	13.8	2.8	9.4	3.8	27.1	4.9	14.6	3.2
	high	19.3	6.1	2.6	1.9	13.3	5.2	11.1	3.9

Table 19. Mean percent cover and standard error of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups at Stewarts Point MPA and reference sites in 2010 and 2011.

Stewarts Point									
Sessile invertebrates and non-stipitate algae		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
bare rock		1.0	0.4	1.5	0.7	0.4	0.3	2.2	0.7
bare sand		0.5	0.3	3.1	1.8	0.8	0.4	2.5	2.2
red algae, erect	branching flat	10.6	2.6	4.3	1.3	13.2	3.1	4.6	1.4
	branching cylindrical	1.3	1.0	0.0	0.0	0.4	0.2	0.0	0.0
	lacy	1.5	0.6	0.7	0.6	3.1	2.0	0.6	0.3
	leaf-like	1.8	0.9	3.3	1.0	3.5	1.2	2.6	0.7
	filamentous turf	2.4	1.2	2.2	1.4	3.1	1.2	3.3	1.5
red algae, encrusting		16.7	2.0	11.1	1.7	10.4	1.6	11.8	2.6
coralline algae, erect		13.4	4.6	10.0	4.9	13.1	4.1	9.6	4.1
coralline algae, encrusting		30.8	4.7	34.0	4.4	24.1	4.2	31.7	4.9
Laminariales holdfast		1.5	0.6	0.6	0.3	3.3	0.9	1.9	0.6
bryozoan		1.9	0.8	3.1	1.4	1.5	0.7	2.8	0.8
diatom layer		0.0	0.0	0.0	0.0	0.3	0.2	5.1	2.4
tunicate: colonial		3.3	1.0	5.2	1.4	1.9	0.6	1.9	0.6
sponge		2.1	0.7	2.2	0.9	2.5	0.7	4.6	1.3

Table 20. Mean density and standard error of the 15 regionally most abundant stipitate algal and macroinvertebrate groups at Stewarts Point MPA and reference sites in 2010 and 2011.

Stewarts Point										
Swath invertebrate and algal species			2010				2011			
			MPA		Reference		MPA		Reference	
			Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Algae	*Cystoseira*		0.4	0.2	1.4	1.0	0.2	0.1	0.2	0.1
	Laminaria		20.3	8.6	4.5	1.7	28.1	10.3	7.5	2.1
	Nereocystis		9.8	4.4	20.3	7.7	6.4	2.6	16.1	6.5
	Pleurophycus		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pterygophora		29.0	9.7	100.3	31.8	72.6	28.8	84.0	21.5
Mobile/solitary invertebrates	red abalone		16.9	5.5	16.5	4.3	10.0	3.0	6.6	2.2
	red urchin		40.2	6.0	18.3	4.0	41.0	12.4	19.4	4.0
	purple urchin		16.1	5.0	10.7	4.4	12.1	6.1	1.5	0.6
	sunflower star		2.0	0.5	2.2	0.5	1.0	0.2	0.7	0.2
	bat star		25.2	10.0	27.3	7.8	31.8	13.3	31.5	11.0
	Other stars	blood	2.5	0.6	2.7	0.7	2.7	0.7	2.1	0.5
		giant spined	6.3	1.2	6.6	1.5	10.7	3.0	7.2	1.6
		leather	1.4	0.5	1.5	0.4	2.3	0.9	1.0	0.2
		ochre	3.1	1.1	0.7	0.3	4.7	2.0	1.0	0.4
		rainbow	1.4	0.4	0.8	0.4	1.1	0.2	0.9	0.2
		short spined	1.7	0.5	1.9	0.6	1.3	0.4	2.5	0.6
	stalked tunicate		2.7	0.9	0.8	0.3	7.8	2.5	0.5	0.2
	orange sea cucumber		9.5	2.8	6.0	2.2	7.0	2.8	5.7	1.6
	gumboot chiton		2.0	0.7	1.6	0.3	1.4	0.4	0.5	0.1
	orange puff-ball sponge		1.0	0.3	1.5	0.4	1.6	0.6	1.2	0.3
	Anemones	Christmas	0.0	0.0	0.0	0.0	0.2	0.1	0.3	0.1
		fish-eating	1.8	0.5	3.0	0.8	1.1	0.4	1.9	0.4
		giant green	0.9	0.4	0.1	0.1	0.8	0.6	0.2	0.1
		strawberry	1.9	0.5	1.0	0.3	1.8	0.4	0.7	0.2
		Urticina spp.	1.5	0.5	0.7	0.2	1.0	0.6	0.4	0.2
		white plumed	0.0	0.0	0.8	0.6	3.3	3.3	9.8	7.8

Table 21. Mean densities and standard error of the 21 regionally most abundant fishes at Stewarts Point MPA and reference sites in 2010 and 2011.

		Stewarts Point							
Fish species		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Rockfishes	Black and yellow	0.54	0.14	0.46	0.11	0.27	0.08	0.27	0.09
	Black	1.15	0.26	3.19	0.58	1.38	0.34	1.52	0.35
	Blue	7.13	2.03	10.35	3.41	6.13	1.92	9.55	2.14
	Bocaccio	0.00	0.00	0.00	0.00	0.38	0.35	0.00	0.00
	Canary	0.06	0.05	0.11	0.07	0.23	0.21	0.10	0.06
	China	0.35	0.12	0.22	0.08	0.15	0.06	0.13	0.05
	Gopher	0.79	0.17	0.76	0.13	0.50	0.12	0.45	0.10
	Kelp	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00
	Olive or yellowtail	0.04	0.03	0.43	0.26	0.00	0.00	0.03	0.02
	Vermilion	0.04	0.03	0.07	0.04	0.06	0.04	0.00	0.00
Other fishes	Lingcod	0.13	0.05	0.17	0.06	0.15	0.05	0.15	0.05
	Cabezon	0.08	0.04	0.06	0.03	0.02	0.02	0.02	0.02
	Kelp greenling	2.85	0.27	2.81	0.31	1.42	0.16	1.35	0.16
	Painted greenling	0.08	0.05	0.26	0.11	0.15	0.06	0.03	0.02
	Pile surfperch	0.02	0.02	0.06	0.03	0.00	0.00	0.15	0.06
	Striped surfperch	1.19	0.35	1.04	0.21	0.25	0.08	0.57	0.12
	Tubesnout	0.00	0.00	0.63	0.42	0.00	0.00	0.18	0.17
Young-of-year rockfishes	Kelp, gopher, or black & yellow	24.46	7.01	14.91	1.75	0.44	0.15	0.55	0.15
	Olive, yellowtail, or black	1.50	0.43	3.52	0.87	0.08	0.06	0.18	0.08
	Blue	21.81	4.59	19.54	2.65	3.38	0.65	3.55	0.90
	Canary	2.02	0.81	2.31	0.78	0.17	0.10	0.03	0.03

Salt Point

There are eight sites associated with the Salt Point SMR: three are located within the SMCA and five are located to the south (Figure 5). These reference sites are shared by both Salt Point and Stewarts Point MPAs.

Table 22. Mean percent cover and standard error of substrate characteristics at Salt Point MPA and reference sites in 2010 and 2011.

Salt Point									
Substrate characteristic		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
Substrate Type	bedrock	82.4	3.6	56.9	8.1	91.0	2.5	85.3	3.8
	boulder	12.6	2.8	36.3	8.5	5.5	2.0	7.1	1.8
	cobble	2.2	0.8	2.2	1.0	0.3	0.2	3.5	1.4
	sand	2.8	1.2	4.6	2.1	3.2	1.2	4.2	2.6
Vertical Relief	flat	1.1	0.6	4.4	1.9	0.3	0.3	0.6	0.6
	slight	87.4	3.5	83.5	4.5	87.4	3.0	73.8	6.4
	moderate	7.5	2.0	9.4	3.8	7.1	1.6	14.6	3.2
	high	4.0	2.0	2.6	1.9	5.3	2.0	11.1	3.9

Table 23. Mean percent cover and standard error of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups at Salt Point MPA and reference sites in 2010 and 2011.

Point Arena									
Sessile invertebrates and non-stipitate algae		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.	Mean % cov.	Std. Err.
bare rock		1.1	0.6	1.5	0.7	2.4	0.9	2.2	0.7
bare sand		2.8	1.6	3.1	1.8	3.2	1.3	2.5	2.2
red algae, erect	branching flat	2.8	1.5	4.3	1.3	6.1	1.5	4.6	1.4
	branching cylindrical	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	lacy	0.8	0.4	0.7	0.6	1.9	1.0	0.6	0.3
	leaf-like	1.5	0.7	3.3	1.0	1.8	0.8	2.6	0.7
	filamentous turf	2.1	0.9	2.2	1.4	1.8	0.9	3.3	1.5
red algae, encrusting		22.1	2.4	11.1	1.7	17.8	3.1	11.8	2.6
coralline algae, erect		14.1	4.6	10.0	4.9	15.6	5.4	9.6	4.1
coralline algae, encrusting		33.2	4.1	34.0	4.4	29.7	3.6	31.7	4.9
Laminariales holdfast		1.0	0.5	0.6	0.3	2.2	0.8	1.9	0.6
bryozoan		2.9	1.0	3.1	1.4	0.8	0.4	2.8	0.8
diatom layer		0.0	0.0	0.0	0.0	0.1	0.1	5.1	2.4
tunicate: colonial		0.4	0.3	5.2	1.4	1.5	0.7	1.9	0.6
sponge		2.2	0.6	2.2	0.9	2.4	0.8	4.6	1.3

Table 24. Mean density and standard error of the 15 regionally most abundant stipitate algal and macroinvertebrate groups at Salt Point MPA and reference sites in 2010 and 2011.

Salt Point										
Swath invertebrate and algal species			2010				2011			
			MPA		Reference		MPA		Reference	
			Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Algae	*Cystoseira*		0.5	0.4	1.4	1.0	0.1	0.1	0.2	0.1
	Laminaria		40.6	19.7	4.5	1.7	21.5	13.3	7.5	2.1
	Nereocystis		43.8	22.5	20.3	7.7	8.9	6.3	16.1	6.5
	Pleurophycus		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pterygophora		16.4	10.7	100.3	31.8	55.8	25.0	84.0	21.5
Mobile/solitary invertebrates	red abalone		20.6	7.5	16.5	4.3	9.4	3.6	6.6	2.2
	red urchin		61.5	10.6	18.3	4.0	37.8	5.8	19.4	4.0
	purple urchin		24.8	13.8	10.7	4.4	13.9	5.4	1.5	0.6
	sunflower star		1.2	0.4	2.2	0.5	0.1	0.1	0.7	0.2
	bat star		58.1	38.5	27.3	7.8	37.8	15.5	31.5	11.0
	Other stars	blood	0.9	0.4	2.7	0.7	3.3	0.9	2.1	0.5
		giant spined	7.4	1.5	6.6	1.5	8.6	2.7	7.2	1.6
		leather	0.8	0.2	1.5	0.4	1.7	0.7	1.0	0.2
		ochre	1.3	0.4	0.7	0.3	2.3	0.9	1.0	0.4
		rainbow	1.0	0.3	0.8	0.4	1.0	0.4	0.9	0.2
		short spined	2.1	0.8	1.9	0.6	1.8	0.5	2.5	0.6
	stalked tunicate		2.4	1.0	0.8	0.3	0.7	0.4	0.5	0.2
	orange sea cucumber		3.2	1.4	6.0	2.2	4.9	1.2	5.7	1.6
	gumboot chiton		1.0	0.3	1.6	0.3	1.9	0.7	0.5	0.1
	orange puff-ball sponge		1.1	0.5	1.5	0.4	0.9	0.3	1.2	0.3
	Anemones	Christmas	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.1
		fish-eating	2.2	0.6	3.0	0.8	1.3	0.4	1.9	0.4
		giant green	2.9	1.3	0.1	0.1	0.1	0.1	0.2	0.1
		strawberry	0.9	0.3	1.0	0.3	3.1	1.1	0.7	0.2
		Urticina spp.	0.7	0.4	0.7	0.2	0.5	0.4	0.4	0.2
		white plumed	0.0	0.0	0.8	0.6	0.2	0.2	9.8	7.8

Table 25. Mean densities and standard error of the 21 regionally most abundant fishes at Salt Point MPA and reference sites in 2010 and 2011.

		Salt Point							
Fish species		2010				2011			
		MPA		Reference		MPA		Reference	
		Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.	Mean dens.	Std. Err.
Rockfishes	Black and yellow	0.31	0.10	0.46	0.11	0.11	0.05	0.27	0.09
	Black	1.19	0.33	3.19	0.58	1.50	0.42	1.52	0.35
	Blue	3.61	1.40	10.35	3.41	10.08	2.99	9.55	2.14
	Bocaccio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Canary	0.03	0.03	0.11	0.07	0.03	0.03	0.10	0.06
	China	0.36	0.14	0.22	0.08	0.25	0.10	0.13	0.05
	Gopher	0.89	0.23	0.76	0.13	0.83	0.18	0.45	0.10
	Kelp	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00
	Olive or yellowtail	0.03	0.03	0.43	0.26	0.06	0.06	0.03	0.02
	Vermilion	0.03	0.03	0.07	0.04	0.03	0.03	0.00	0.00
Other fishes	Lingcod	0.06	0.04	0.17	0.06	0.19	0.07	0.15	0.05
	Cabezon	0.08	0.06	0.06	0.03	0.06	0.04	0.02	0.02
	Kelp greenling	2.58	0.32	2.81	0.31	2.11	0.29	1.35	0.16
	Painted greenling	0.42	0.15	0.26	0.11	0.36	0.12	0.03	0.02
	Pile surfperch	0.08	0.06	0.06	0.03	0.11	0.08	0.15	0.06
	Striped surfperch	0.94	0.23	1.04	0.21	1.22	0.24	0.57	0.12
	Tubesnout	0.03	0.03	0.63	0.42	0.00	0.00	0.18	0.17
Young-of-year rockfishes	Kelp, gopher, or black & yellow	17.56	3.84	14.91	1.75	0.97	0.32	0.55	0.15
	Olive, yellowtail, or black	4.69	1.95	3.52	0.87	0.03	0.03	0.18	0.08
	Blue	14.31	3.52	19.54	2.65	6.00	1.52	3.55	0.90
	Canary	2.61	1.46	2.31	0.78	0.03	0.03	0.03	0.03

Year-to-year variation in survey results by site

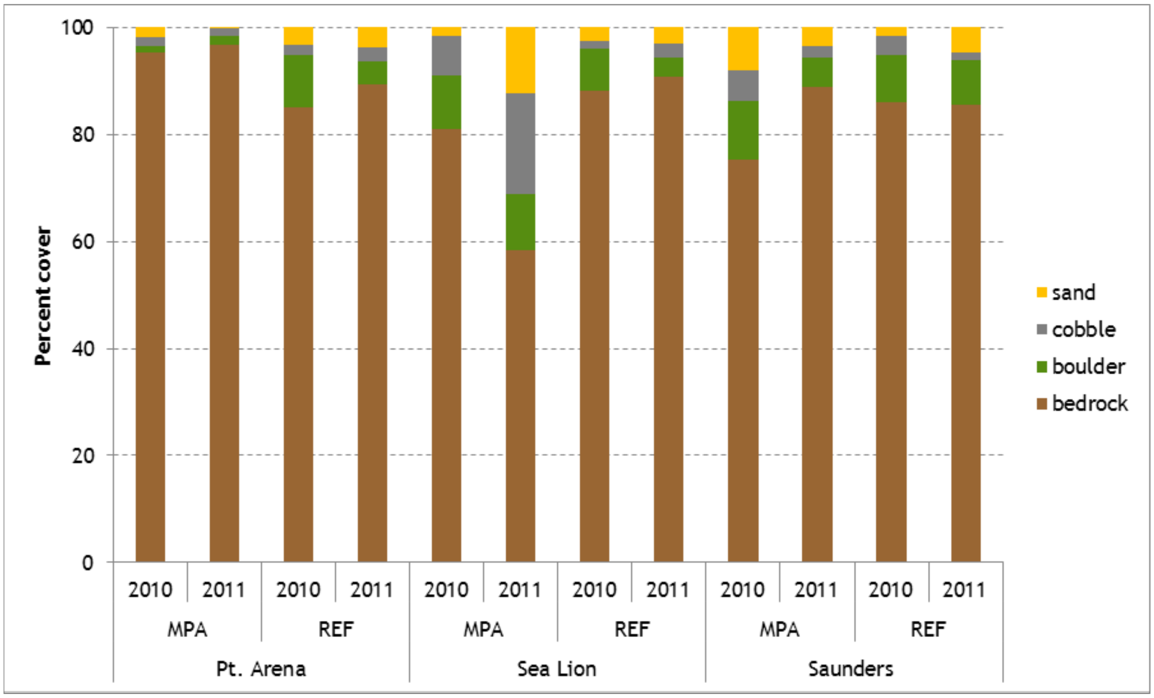


Figure 20. Comparison of year-to-year variation in the mean percent cover of the four categories of substrate type surveyed by PISCO divers within Pt. Arena, Sea Lion Cove, and Saunders Reef MPAs and associated reference areas.

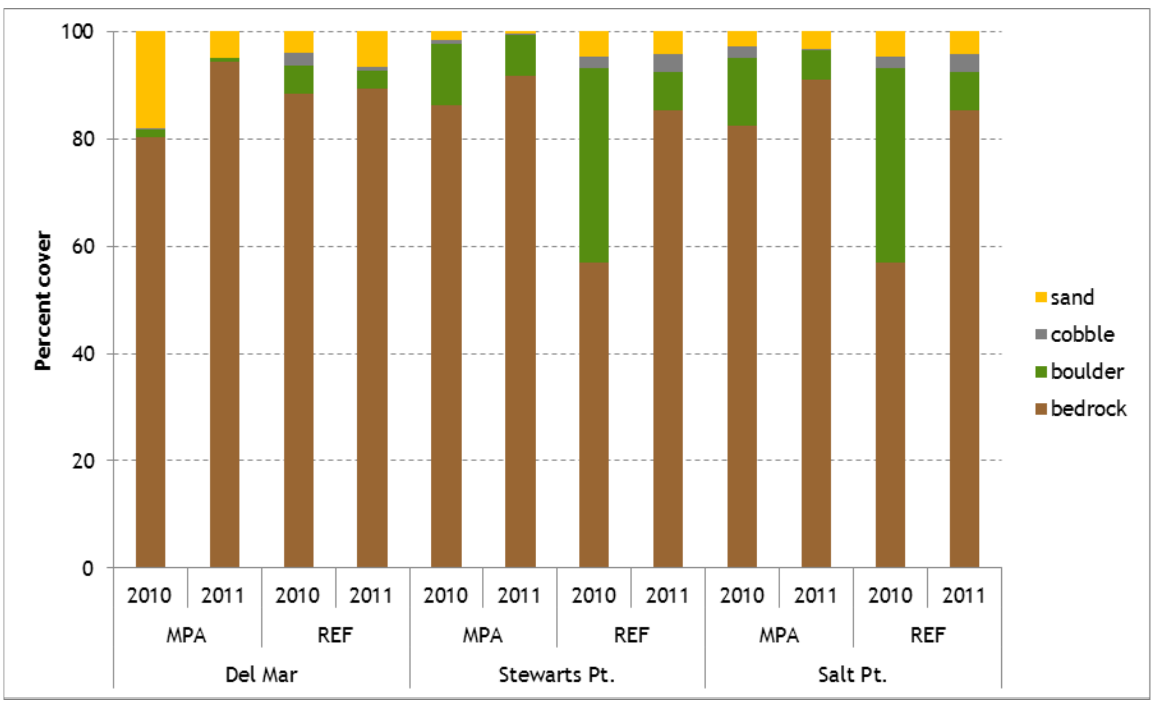


Figure 21. Comparison of year-to-year variation in the mean percent cover of the four categories of substrate type surveyed by PISCO divers within Del Mar, Stewarts Pt. and Salt Pt. MPAs and associated reference areas.

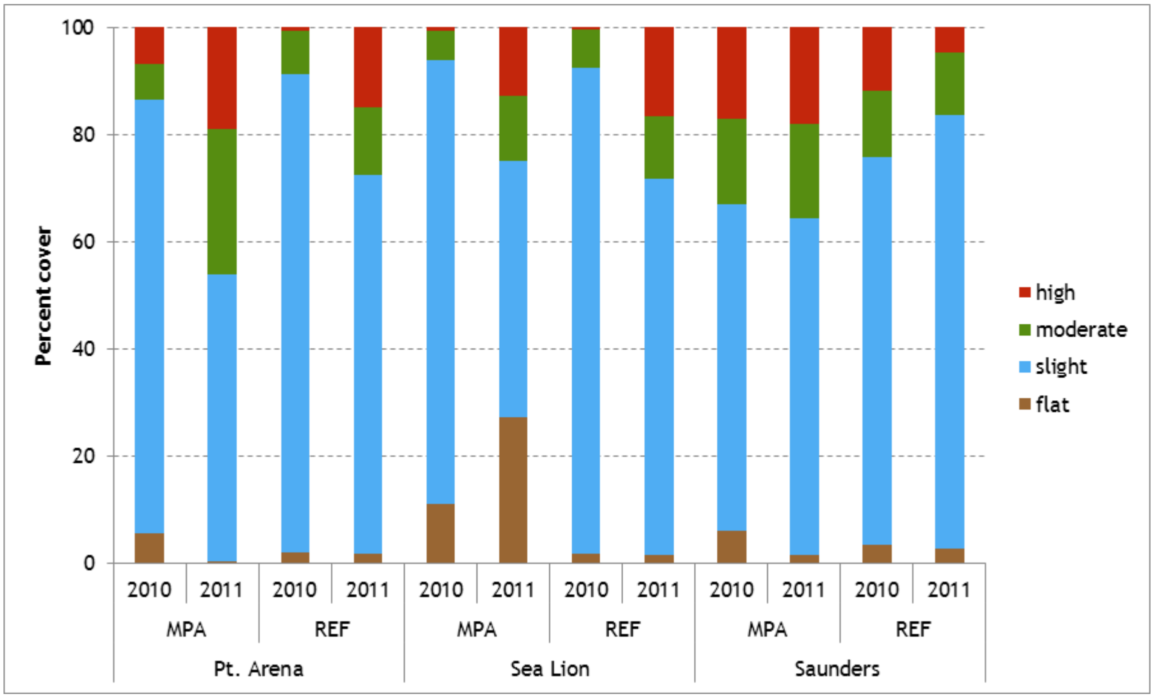


Figure 22. Comparison of year-to-year variation in the mean percent cover of the four categories of vertical relief surveyed by PISCO divers within Pt. Arena, Sea Lion Cove, and Saunders Reef MPAs and associated reference areas.

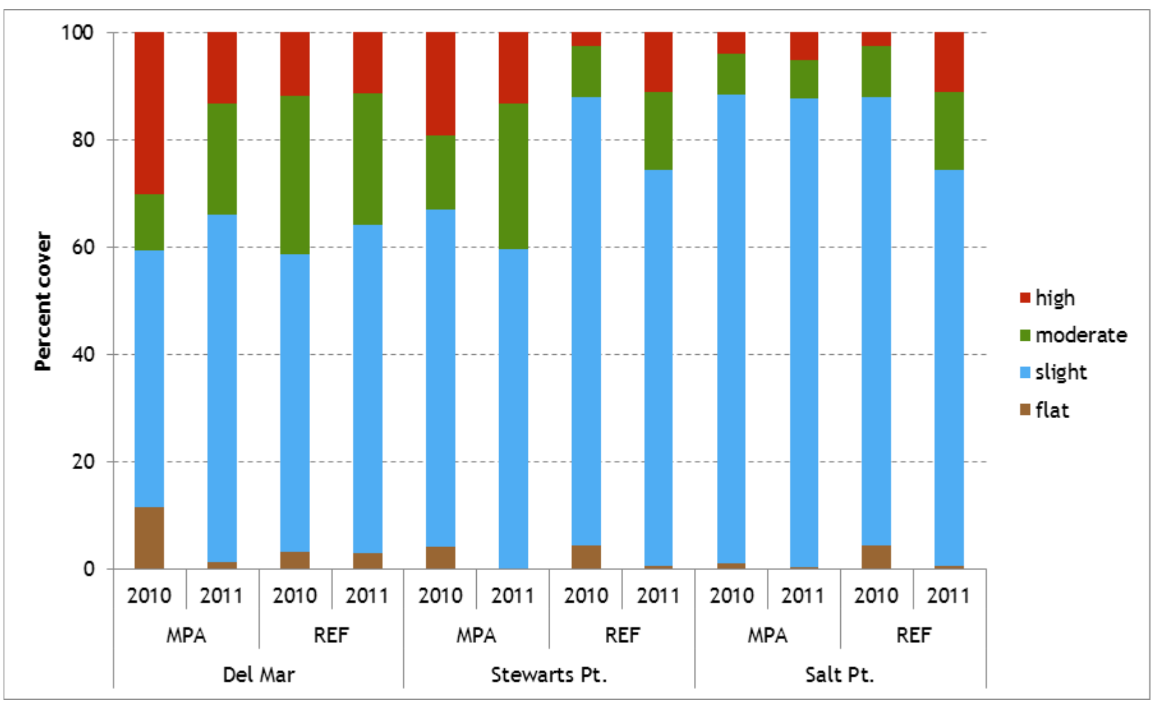


Figure 22. Comparison of year-to-year variation in the mean percent cover of the four categories of vertical relief surveyed by PISCO divers within Del Mar, Stewarts Pt. and Salt Pt. MPAs and associated reference areas.

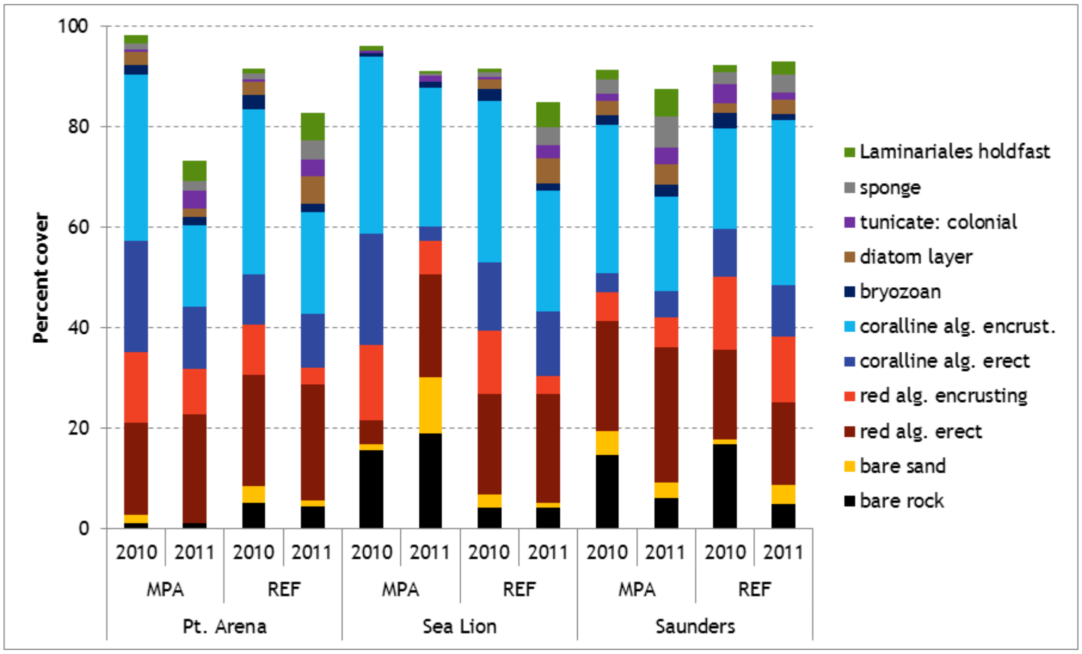


Figure 23. Comparison of year-to-year variation in the mean percent cover of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups within Pt. Arena, Sea Lion Cove, and Saunders Reef MPAs and associated reference areas.

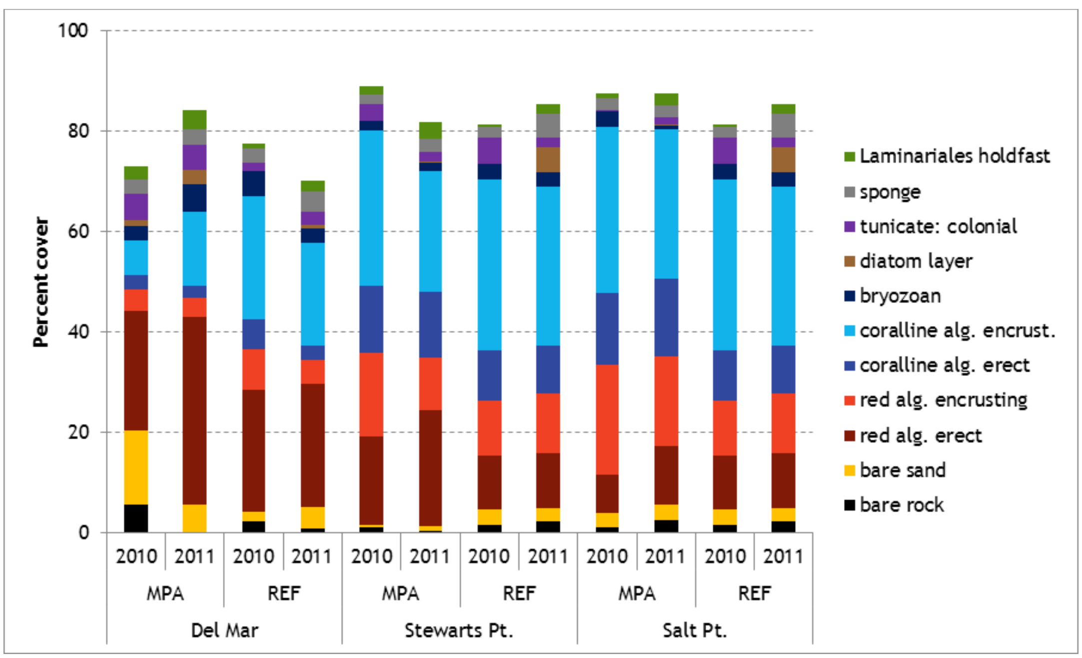


Figure 24. Comparison of year-to-year variation in the mean percent cover of the 11 regionally most abundant sessile and colonial invertebrate and non-stipitate turf algal groups within Del Mar, Stewarts Pt. and Salt Pt. MPAs and associated reference areas.

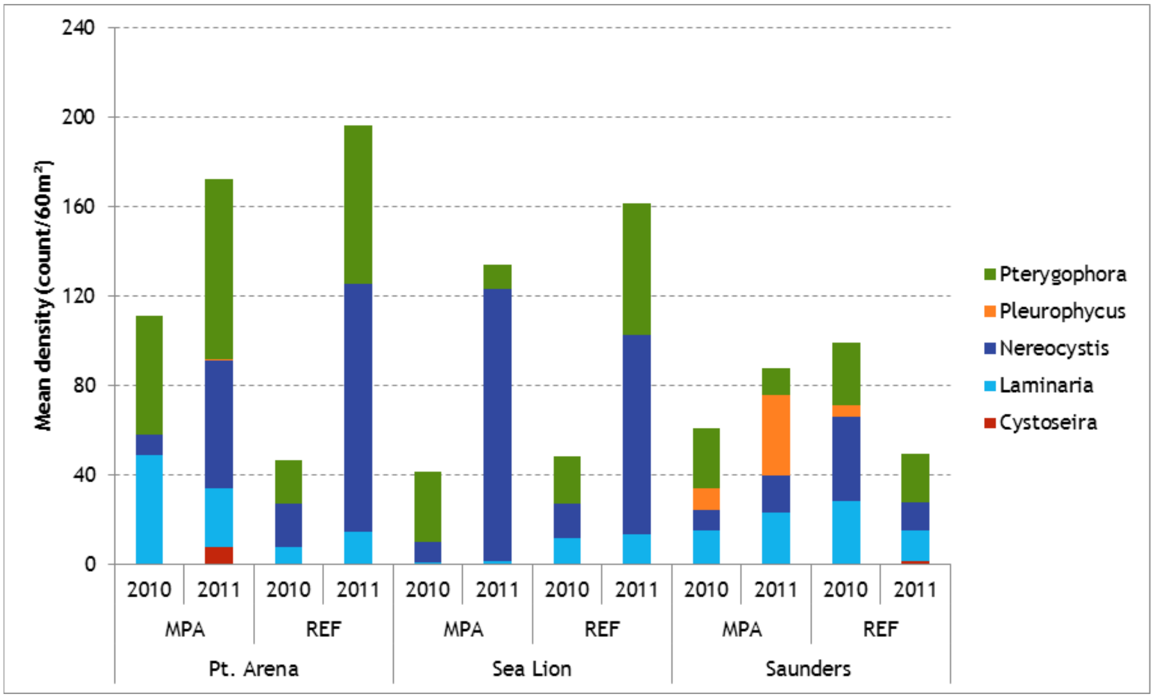


Figure 25. Comparison of year-to-year variation in the mean densities of the 5 regionally most abundant stipitate algal groups within Pt. Arena, Sea Lion Cove, and Saunders Reef MPAs and associated reference areas.

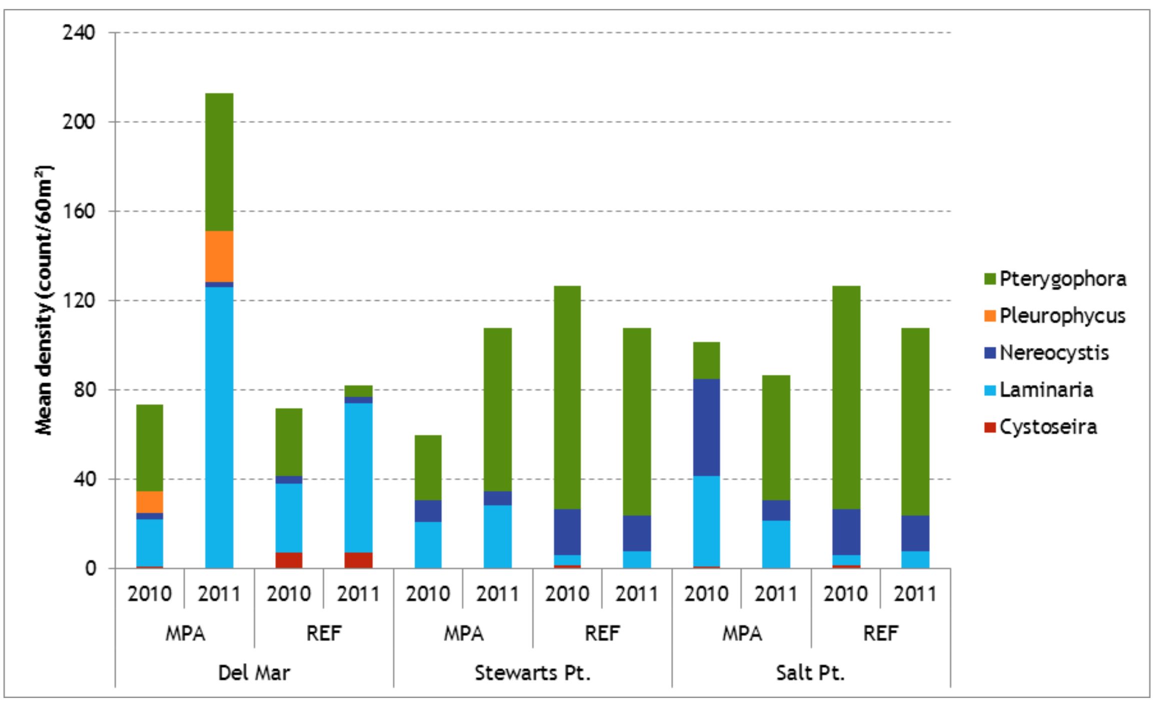


Figure 26. Comparison of year-to-year variation in the mean densities of the five regionally most abundant stipitate algal groups within Del Mar, Stewarts Pt. and Salt Pt. MPAs and associated reference areas.

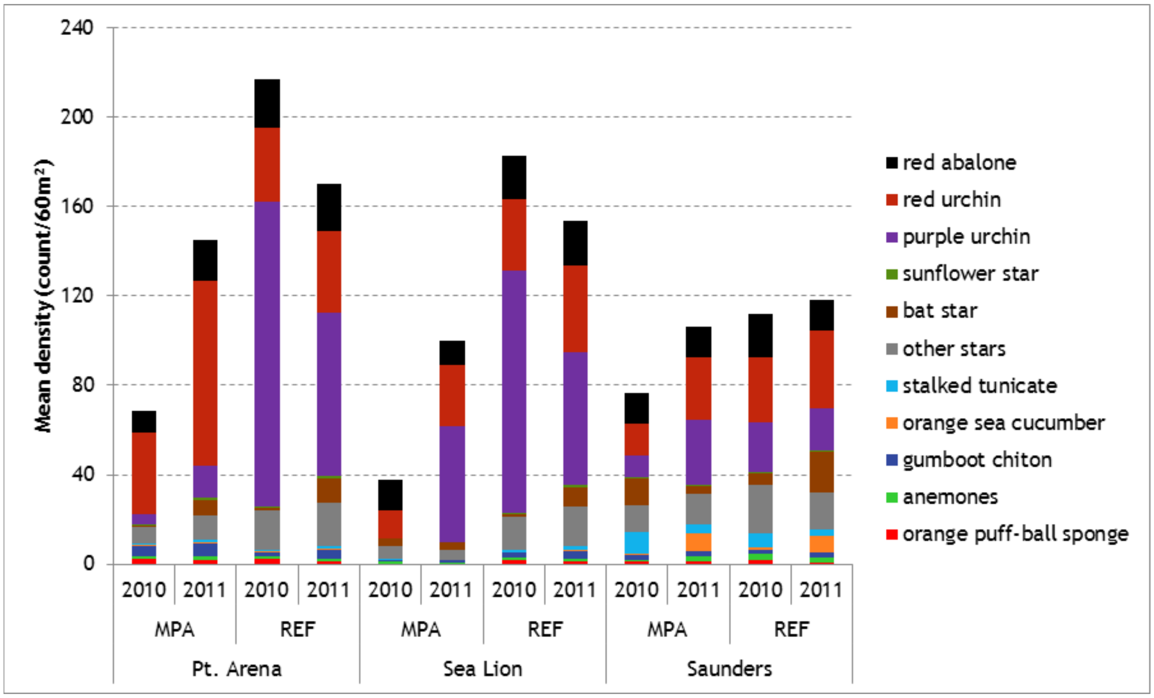


Figure 27. Comparison of year-to-year variation in the mean densities of the 10 regionally most abundant macroinvertebrates within Pt. Arena, Sea Lion Cove, and Saunders Reef MPAs and associated reference areas.

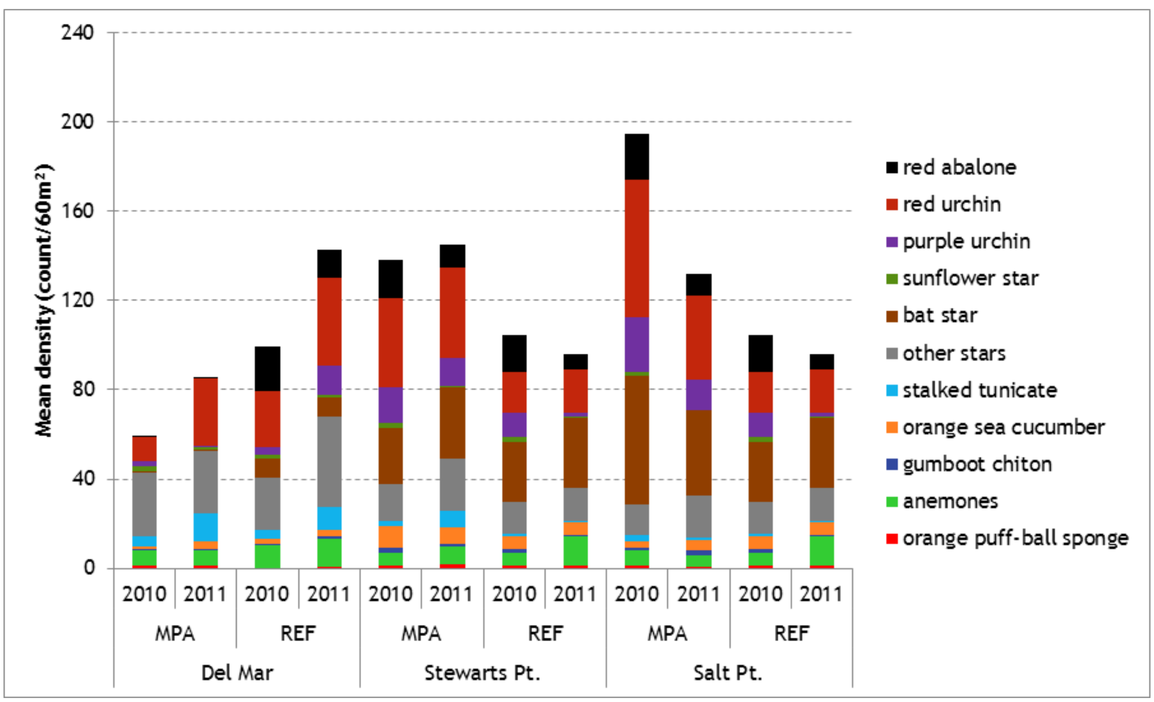


Figure 28. Comparison of year-to-year variation in the mean densities of the 10 regionally most abundant macroinvertebrates within Del Mar, Stewarts Pt. and Salt Pt. MPAs and associated reference areas.

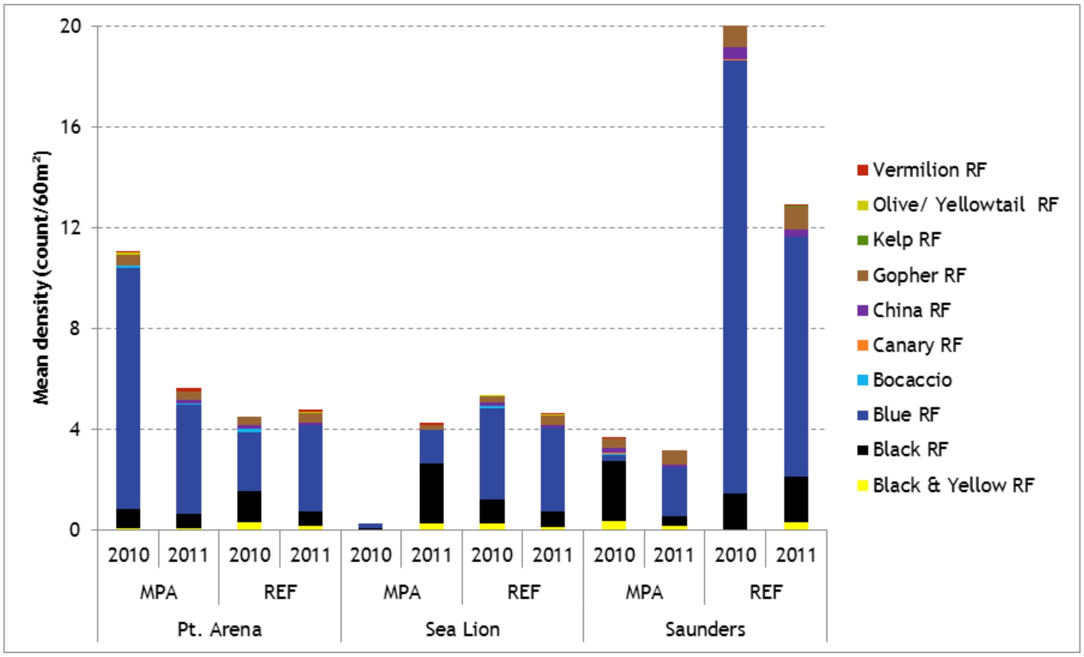


Figure 29. Comparison of year-to-year variation in the mean densities of the 10 regionally most abundant rockfish species within Pt. Arena, Sea Lion Cove, and Saunders Reef MPAs and associated reference areas. Data presented here do not include young-of-year rockfish.

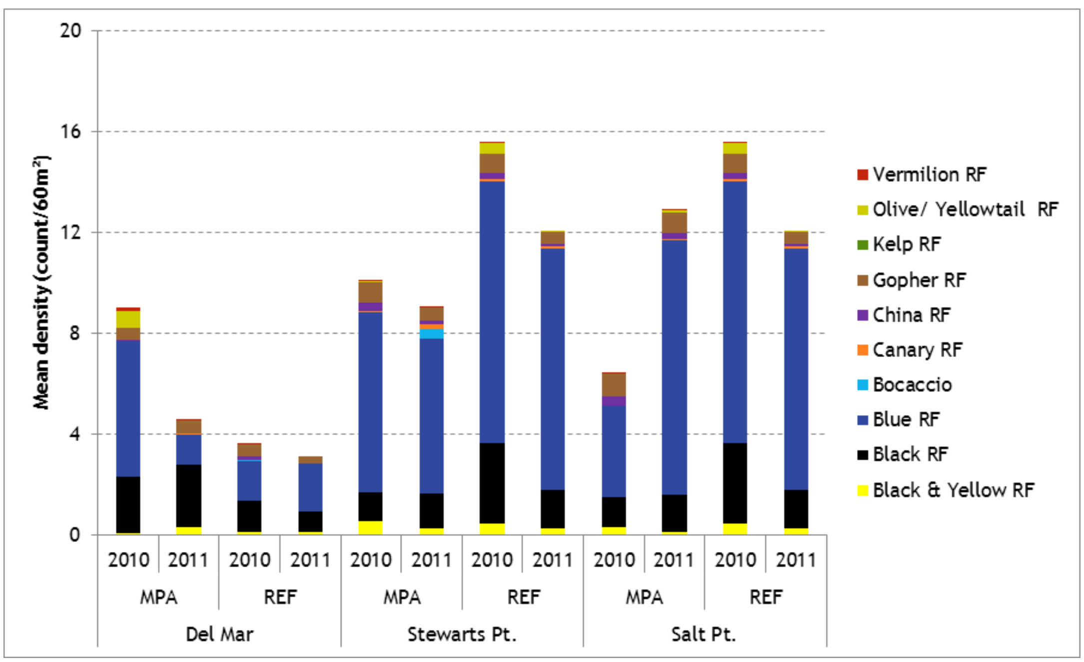


Figure 30. Comparison of year-to-year variation in the mean densities of the 10 regionally most abundant rockfish species within Del Mar, Stewarts Pt. and Salt Pt. MPAs and associated reference areas. Data presented here do not include young-of-year rockfish.

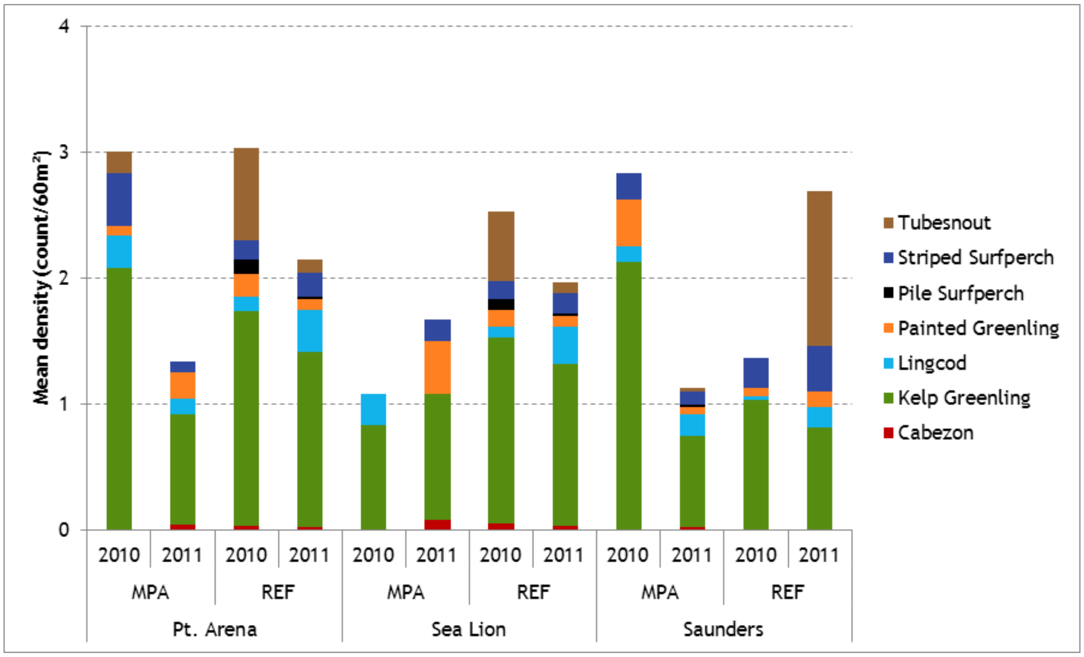


Figure 31. Comparison of year-to-year variation in the mean densities of the 7 regionally most abundant non-rockfish species within Pt. Arena, Sea Lion Cove, and Saunders Reef MPAs and associated reference areas. Data presented here do not include young-of-year fish.

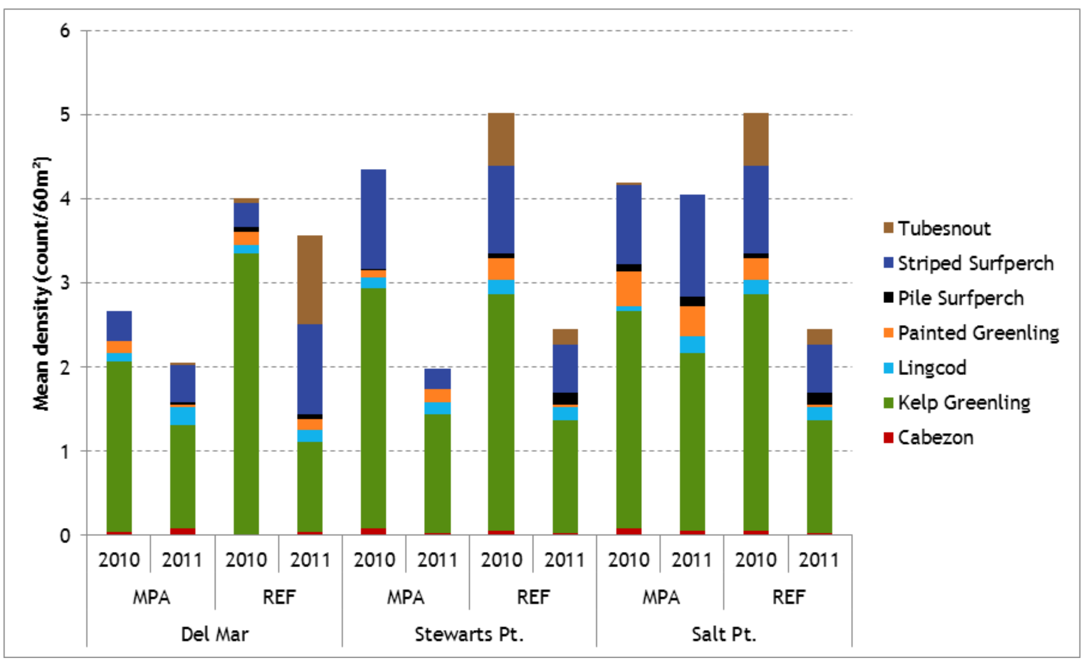


Figure 32. Comparison of year-to-year variation in the mean densities of the seven regionally most abundant non-rockfish species within Del Mar, Stewarts Pt. and Salt Pt. MPAs and associated reference areas. Data presented here do not include young-of-year fish.

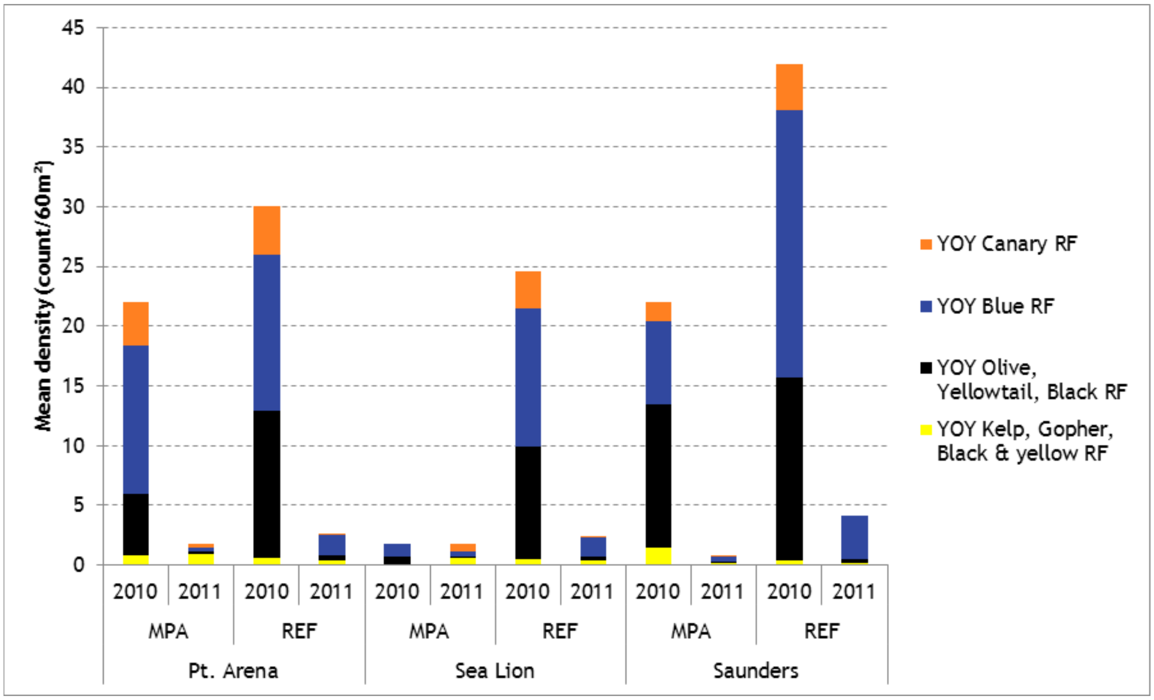


Figure 33. Comparison of year-to-year variation in the mean densities of the 4 regionally most abundant young-of-year rockfish within Pt. Arena, Sea Lion Cove, and Saunders Reef MPAs and associated reference areas.

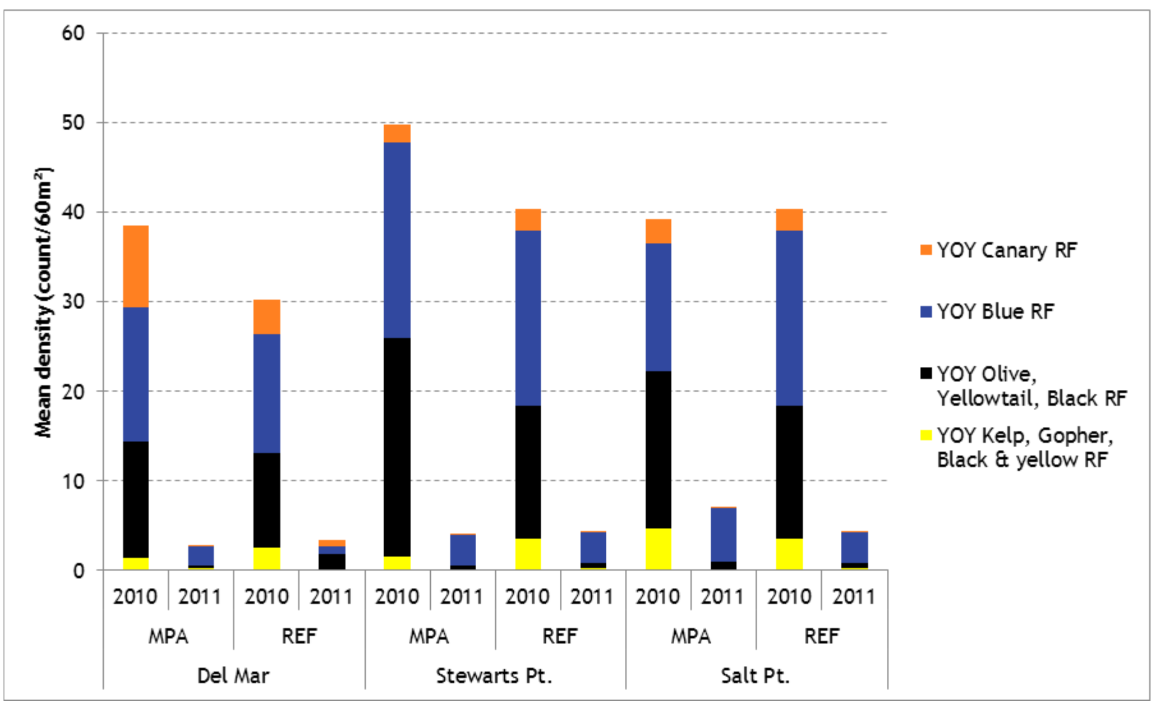


Figure 34. Comparison of year-to-year variation in the mean densities of the four regionally most abundant young-of-year rockfish within Del Mar, Stewarts Pt. and Salt Pt. MPAs and associated reference areas.

Results of Statistical Analyses

Table 26. PERMANOVA results for all taxa surveyed by PISCO divers, excluding young-of-year fish.

Source	Degrees of freedom	Sum of squares	Mean square error	Pseudo-F	P(perm)	No. of unique permutations
Site	5	12430	2486.1	4.0623	0.001	997
MPA	1	1010.3	1010.3	1.6509	0.036	997
Year	1	2644.1	2644.1	4.3205	0.001	999
Site*MPA	5	5330.2	1066	1.742	0.001	998
Error	64	39167	611.98			
Total	76	61178				

Table 27. PERMANOVA results for fish surveyed by PISCO divers, excluding young-of-year fish.

Source	Degrees of freedom	Sum of squares	Mean square error	Pseudo-F	P(perm)	No. of unique permutations
Site	5	13073	2614.6	2.5642	0.001	999
MPA	1	1447.2	1447.2	1.4193	0.174	999
Year	1	2462.2	2462.2	2.4147	0.029	999
Error	69	70356	1019.7			
Total	76	87531				

Table 28. PERMANOVA results for macroinvertebrates surveyed by PISCO divers.

Source	Degrees of freedom	Sum of squares	Mean square error	Pseudo-F	P(perm)	No. of unique permutations
Site	5	12813	2562.7	5.291	0.001	999
MPA	1	807.12	807.12	1.6664	0.089	998
Year	1	2292.3	2292.3	4.7328	0.001	997
Site*MPA	5	5383.3	1076.7	2.2229	0.001	997
Error	64	30998	484.35			
Total	76	53391				

Table 29. PERMANOVA results for stipitate algal groups surveyed by PISCO divers.

Source	Degrees of freedom	Sum of squares	Mean square error	Pseudo-F	P(perm)	No. of unique permutations
Site	5	13325	2664.9	3.5276	0.001	998
MPA	1	2033.7	2033.7	2.692	0.041	998
Year	1	1302.3	1302.3	1.7238	0.141	999
Site*MPA	5	6474.9	1295	1.7141	0.033	998
Error	64	48350	755.46			

Total	76	71672				

Table 30. PERMANOVA results for sessile and colonial invertebrate and non-stipitate turf algal groups surveyed by PISCO divers.

Source	Degrees of freedom	Sum of squares	Mean square error	Pseudo-F	P(perm)	No. of unique permutations
Site	5	13325	2664.9	3.5276	0.001	998
MPA	1	2033.7	2033.7	2.692	0.041	998
Year	1	1302.3	1302.3	1.7238	0.141	999
Error	64	48350	755.46			
Total	76	71672				

Table 31. ANOVA results. Only significant results are shown. * indicates results that cannot be readily interpreted due to interaction effects.

		Main Effects			Interaction Terms			
	Species or group	**Site**	**Year (direction)**	**MPA (direction)**	**Site x MPA**	**Year x MPA**	**Site x Year**	**Site x Year x MPA**
Rockfishes	Black	0.0038	N.S.	N.S.				
	Black and yellow	N.S.	N.S.	N.S.				
	Blue	N.S.	N.S.	N.S.				
	Bocaccio	N.S.	N.S.	N.S.		0.0237		
	Canary	0.0066	N.S.	N.S.				
	China	0.0015	N.S.	N.S.				
	Copper	N.S.	N.S.	N.S.				
	Flag	N.S.	N.S.	N.S.				
	Gopher	<0.0001	N.S.	N.S.				
	Grass	N.S.	N.S.	N.S.				
	Kelp	N.S.	N.S.	N.S.				
	Olive or Yellowtail	N.S.	0.0098 (2011>2010)	N.S.				
	Quillback	0.0071*	N.S.	N.S.	0.0071	0.0813	0.0071	0.0071
	Vermilion	N.S.	N.S.	N.S.			0.0314	
Young-of-year rockfishes	Blue	0.0009	<0.0001 (2011>2010)	N.S.				
	Canary	N.S.	<0.0001 (2011>2010)	N.S.				
	Kelp, gopher, or black & yellow	N.S.	<0.0001*	N.S.			0.0010	
	Olive, yellowtail, or black	N.S.	<0.0001 (2011>2010)	N.S.				
Other Fishes	Cabezon	N.S.	N.S.	0.033 (MPA>REF)				
	Goby, blackeye	N.S.	N.S.	N.S.	0.0156			
	Greenling, kelp	0.0040	<0.0001 (2011>2010)	N.S.				
	Greenling, lingcod	N.S.	N.S.	N.S.				
	Greenling, painted	N.S.	N.S.	N.S.				
	Greenling, rock	N.S.	N.S.	N.S.				
	Gunnels	N.S.	N.S.	N.S.				
	Kelpfish	N.S.	N.S.	N.S.				
	Ronquil, stripefin	N.S.	N.S.	N.S.				
	Sculpin, buffalo	N.S.	N.S.	N.S.				
	Sculpin, grunt	N.S.	N.S.	N.S.				

		Main Effects			Interaction Terms			
	Species or group	**Site**	**Year (direction)**	**MPA (direction)**	**Site x MPA**	**Year x MPA**	**Site x Year**	**Site x Year x MPA**
Other Fishes	Sculpin, longfin	N.S.	0.0012 (2011>2010)	N.S.				
	Sculpin, manacled or kelp	N.S.	0.0301 (2010>2011)	N.S.				
	Sculpin, other	N.S.	N.S.	N.S.	0.4899	0.1148	0.5670	0.0413
	Sculpin, red Irish lord	N.S.	N.S.	N.S.				
	Surfperch, kelp	0.0329	N.S.	N.S.				
	Surfperch, other	N.S.	N.S.	N.S.				
	Surfperch, pile	0.0028	N.S.	0.0081 (REF>MPA)				
	Surfperch, rainbow	N.S.	0.0236 (2011>2010)	N.S.				
	Surfperch, striped	<0.0001*	N.S.	N.S.			0.0459	
	Surfperch, white	N.S.	N.S.	N.S.				
	Tubesnout	N.S.	N.S.	0.0149 (REF>MPA)				
	Wolf eel	N.S.	N.S.	N.S.				
Swath Algae	*Alaria*	N.S.	N.S.	N.S.				
	Costaria	N.S.	N.S.	N.S.				
	Cystoseira	0.0377*	N.S.	N.S.	0.0016			
	Laminaria	0.0007	N.S.	0.0032 (MPA>REF)				
	Macrocystis	N.S.	N.S.	N.S.				
	Nereocystis	0.0065*	N.S.	N.S.			0.0131	
	Pleurophycus	<0.0001*	N.S.	0.0006*	0.0004			
	Pterygophora	N.S.	N.S.	N.S.				
Swath invertebrates	Abalone, flat	N.S.	0.0038 (2011>2010)	N.S.				
	Abalone, pinto	0.0266	N.S.	N.S.				
	Abalone, red	0.0073*	0.0494 (2011>2010)	0.0159*	0.0011			
	Anemone,	0.0004	0.0036 (2011>2010)	N.S.				

		Main Effects			Interaction Terms			
	Species or group	**Site**	**Year (direction)**	**MPA (direction)**	**Site x MPA**	**Year x MPA**	**Site x Year**	**Site x Year x MPA**
	Anemone, Christmas	N.S.	<0.0001 (2010>2011)	N.S.				
	Anemone, fish-eating	<0.0001	N.S.	0.0082 (REF>MPA)				
	Anemone, giant green	0.0406	N.S.	0.0051 (MPA>REF)				
Swath invertebrates	Anemone, green	N.S.	N.S.	N.S.				
	Anemone, strawberry	<0.0001	0.0328 (2010>2011)	N.S.				
	Anemone, white plumed	N.S.	N.S.	N.S.				
	Barnacle, giant acorn	N.S.	0.0267 (2010>2011)	N.S.				
	California hydrocoral	N.S.	0.0223*	N.S.			0.0312	
	Chiton, gumboot	<0.0001*	N.S.	N.S.			0.0187	
	Crab, cancer spp.	0.0298*	N.S.	0.0204*	0.3515	0.0065	0.1238	0.0321
	Crab, cryptic kelp	N.S.	N.S.	N.S.				
	Crab, decorator	N.S.	N.S.	N.S.				
	Crab, mimicking	N.S.	N.S.	N.S.				
	Crab, northern kelp	N.S.	N.S.	N.S.				
	Crab, Puget Sound king	N.S.	N.S.	N.S.				
	Crab, sheep	N.S.	N.S.	N.S.				
	Scallop, rock	N.S.	N.S.	0.0482 (MPA>REF)				
	Sea cucumber, California	0.0019	N.S.	N.S.				
	Sea cucumber, orange	<0.0001	0.0272 (2010>2011)	N.S.				
	Snail, leafy hornmouth	N.S.	0.0197*	N.S.	0.0666	0.9485	0.1421	0.0010
	Snail, red turban	N.S.	N.S.	N.S.				
	Sponge, grey tennis-ball	N.S.	<0.0001 (2010>2011)	N.S.				
	Sponge, orange puff-ball	0.0238*	N.S.	N.S.	0.0074			

		Main Effects			Interaction Terms			
	Species or group	**Site**	**Year (direction)**	**MPA (direction)**	**Site x MPA**	**Year x MPA**	**Site x Year**	**Site x Year x MPA**
Swath invertebrates	Star, bat	<0.0001	N.S.	N.S.				
	Star, blood	N.S.	0.0496 (2010>2011)	N.S.	0.0453			
	Star, cushion	N.S.	N.S.	N.S.				
	Star, Dawson's sun	N.S.	0.0331*	N.S.		0.0029		
	Star, giant spined	<0.0001	N.S.	N.S.				
	Star, leather	0.0057	N.S.	N.S.				
	Star, mottled	N.S.	0.0005 (2010>2011)	N.S.				
	Star, ochre	0.0164	N.S.	N.S.				
	Star, rainbow	<0.0001*	N.S.	0.0411*	0.0117			
	Star, red	N.S.	N.S.	N.S.				
	Star, short-spined	0.0003*	N.S.	N.S.	0.0323			
	Star, spiny	N.S.	N.S.	N.S.				
	Star, Stimpson's sun	N.S.	0.0022 (2010>2011)	N.S.				
	Star, sunflower	0.0002*	0.0027*	N.S.			0.0006	
	Tunicate, stalked	<0.0001*	N.S.	0.0075 (MPA>REF)			0.0445	
	Urchin, purple	0.0002*	N.S.	0.0224*	0.0012			
	Urchin, red	N.S.	0.0403 (2010>2011)	N.S.	0.0002			
UPC Algae	Acidic seaweed	N.S.	N.S.	N.S.				
	Brown algae	N.S.	N.S.	N.S.				
	Coralline algae, erect	0.0012	N.S.	N.S.				
	Coralline algae, encrusting	0.0058	N.S.	N.S.				
	Cystoseira	N.S.	N.S.	0.0169 (REF>MPA)				
	Diatom layer	N.S.	0.0308 (2010>2011)	N.S.				
	Dictyoneurum	0.0002*	0.0032*	N.S.	0.0474	0.2921	0.0030	0.0406
	Dictyotales	N.S.	N.S.	N.S.				
	Egregia	N.S.	N.S.	N.S.				
	Green algae	N.S.	N.S.	N.S.				
	Laminaria farlowii	N.S.	N.S.	N.S.				
	Laminariales	N.S.	<0.0001	N.S.				

		Main Effects			Interaction Terms			
	Species or group	**Site**	**Year (direction)**	**MPA (direction)**	**Site x MPA**	**Year x MPA**	**Site x Year**	**Site x Year x MPA**
UPC Algae	holdfast		(2010>2011)					
	Laminariales recruit	N.S.	0.0004 (2010>2011)	N.S.				
	Macrocystis holdfast	N.S.	N.S.	N.S.				
	Red algae, encrusting	0.0007*	0.0181 (2011>2010)	N.S.	0.0125			
	Red algae, erect branching cylindrical	N.S.	N.S.	N.S.				
	Red algae, erect branching flat	<0.0001	N.S.	N.S.				
	Red algae, erect branching lacy	N.S.	N.S.	N.S.				
	Red algae, erect filamentous turf	N.S.	N.S.	N.S.				
	Red algae, erect leaf-like	0.0006	N.S.	N.S.				
	Surfgrass	0.0085	N.S.	N.S.				
UPC Invertebrates	Anemone	N.S.	0.0006 (2010>2011)	0.0317 (REF>MPA)				
	Anemone, strawberry	N.S.	N.S.	N.S.				
	Barnacle	0.0003*	0.0065*	0.0013*		0.0111	0.0037	
	Bryozoan	0.0252	N.S.	N.S.				
	California hydrocoral	N.S.	0.0008*	N.S.			0.0281	
	Clam	0.0079*	0.0003*	N.S.			0.0056	
	Cup coral	0.0032	0.0001 (2010>2011)	0.0355 (REF>MPA)				
	Hydroid	0.0360	N.S.	N.S.				
	Sea cucumber	N.S.	0.0017 (2010>2011)	N.S.				
	Sponge	N.S.	0.0028 (2010>2011)	N.S.				
	Tube snail	N.S.	N.S.	N.S.				
	Tubeworm	0.0299*	0.0063*	0.0148*	0.0090	0.3960	0.0033	0.0050
	Tubeworm mat	N.S.	N.S.	N.S.				
	Tubeworm, colonial sand	N.S.	N.S.	N.S.				

		Main Effects			Interaction Terms			
	Species or group	**Site**	**Year (direction)**	**MPA (direction)**	**Site x MPA**	**Year x MPA**	**Site x Year**	**Site x Year x MPA**
	Tubeworm, *Dodecaceria*	N.S.	N.S.	N.S.				
	Tubeworm, fragile	N.S.	N.S.	N.S.				
	Tubeworm, ornate	<0.0001*	N.S.	N.S.			0.0213	
	Tunicate, colonial	N.S.	N.S.	N.S.	0.0261		0.0219	
	Tunicate, solitary	0.0002	0.0103 (2010>2011)	N.S.				
UPC non-living	Bare rock	0.0079	N.S.	N.S.				
	Bare sand	N.S.	N.S.	N.S.				
	Detritus	N.S.	0.008 (2010>2011)	N.S.				
	Macrocystis dead holdfast	N.S.	N.S.	N.S.				
	Sediment	N.S.	N.S.	N.S.				
	Shell debris	N.S.	N.S.	N.S.				

Table 32. ANOVA results for fish size. Only significant results are shown.

		Main Effects			Interaction Terms
	Species or group	**Site**	**Year (direction)**	**MPA (direction)**	**Site x MPA**
Fishes	Greenling, kelp	0.0296	<0.0001 (2011>2010)	N.S.	
	Greenling, lingcod	N.S.	N.S.	N.S.	0.0419
	Rockfish, black and yellow	N.S.	N.S.	N.S.	
	Rockfish, gopher	N.S.	N.S.	N.S.	
	Rockfish, black	<0.0001	0.0003 (2011>2010)	N.S.	
	Rockfish, blue	N.S.	N.S.	N.S.	

Financial Report

A financial report showing budgeted and actual costs and variances, with explanations of any positive or negative variances of greater than 10% of the budgeted amount.

BUDGET CATEGORY	BUDGETED AMOUNT	ACTUAL EXPENDITURES	BALANCE	VARIANCE
SALARY & WAGES	$ 178,829.00	$ 179,575.29	$ (746.29)	-0.4%
FRINGE BENEFITS	$ 53,925.00	$ 43,905.65	$ 10,019.35	19%
SUPPLIES	$ 52,630.00	$ 64,194.61	$ (11,564.61)	-22%
EQUIPMENT	$ -	$ -	$ -	
DOMESTIC TRAVEL	$ 17,000.00	$ 17,422.94	$ (422.94)	-2%
FOREIGN TRAVEL	$ -	$ -	$ -	
FEE OFFSET/GSHIP	$ 5,088.00	$ 2,331.58	$ 2,756.42	54%
DIRECT COST TOTAL	$ 307,472.00	$ 307,430.07	$ 41.93	
INDIRECT COSTS	$ 76,866.00	$ 76,857.52	$ 8.48	
TOTAL	$ 384,338.00	$ 384,287.59	$ 50.41	

Salary and benefits - Spending on salary closely matched the budgeted amount over the course of the grant period (3/1/10-present); however, benefits were paid at a lower rate than anticipated due to the short term seasonal employment of most of the field technicians resulting in a positive balance and a 19% variance in this category. Salaries were paid to the PI for project supervision and oversight, to research specialists for data management, analysis, and reporting, and to field technicians who conducted SCUBA surveys, data entry and QA/QC checking of baseline survey data.

Supplies & Expenses –More was spent of supplies during the grant period than budgeted resulting in a negative balance and a 22% variance in this category. This increased spending reflects higher than anticipated fuel cost for vessels to reach remote survey sites on the Sonoma coast, and vessel repairs incurred while working in these locations.

Travel - Expenses in this category closely matched the budgeted amount resulting in a negligible variance in this category.

Tuition Remission – (Fee Offset/GSHIP) Graduate student tuition expenses were included in the budget after the grant was awarded to support a graduate student doing GIS analyses of bathymetric data to be used in the integrated assessment of baseline characterization data. Originally two quarters of support for this student were budgeted, but the work was completed in only one quarter resulting in a positive balance and variance in this category.